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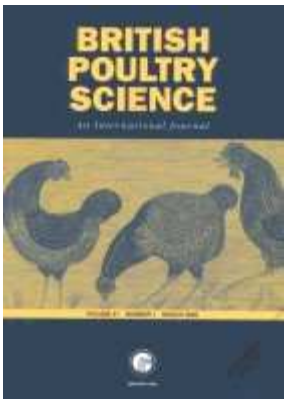

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Carcase characteristics and qualitative meat traits of three Italian local chicken breeds

E. ZANETTI, M. DE MARCHI, C. DALVIT, C. MOLETTE[1,2], H. REMIGNON[2,3] AND M. CASSANDRO

Department of Animal Science, University of Padova, Viale dell'Università 16, 35020 Legnaro, Padova, Italy, [1]INRA, Castanet-Tolosan, France, [2]Université de Toulouse, France and [3]ENVT, Toulouse, France

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Correspondence to: Dr M. De Marchi, Department of Animal Science, University of Padova, Viale dell'Università 16, 35020 Legnaro, Padova, Italy.
E-mail: massimo.demarchi@unipd.it

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Abstract 1. An experiment involving 60 male chickens reared in an organic production system was carried out in order to investigate carcase characteristics and qualitative meat traits of three slow-growing Italian local breeds of chicken (Ermellinata, Padovana and Pépoi).

2. Chicks were randomly selected at hatch, raised together under the same conditions, slaughtered at 190 d of age, dissected for carcase traits, and meat (breast and thigh) stored for subsequent analysis of quality parameters.

3. Ermellinata chickens were significantly different from Padovana and Pépoi chickens for live, carcase and thigh weights. Breeds were also different for breast muscle protein content (Ermellinata > Pépoi and Padovana), shear force (Padovana < Ermellinata and Pépoi) and cooking loss (Pépoi > Padovana and Ermellinata) values.

4. The CIE system values of lightness (L*), redness (a*), and yellowness (b*) evidenced a distinctive darker meat and lighter skin colour of Padovana breast meat.

5. Polyunsaturated fatty acids composition of breast meat was similar among the analysed breeds. Ermellinata had significantly higher saturated but significantly lower monounsaturated fatty acid contents than the other two breeds.

INTRODUCTION

Consumer interest is growing in specialty poultry products, particularly in Europe. Examples exist in France, with 'Label Rouge' (Westgren, 1999) and Poulet de Bresse, and in Italy with Padovana chicken (De Marchi *et al*., 2005). Production systems require extensive rearing conditions with outdoor access. Despite a higher retail price than conventional poultry products, these types of chicken have aroused lively interest in national markets (Westgren, 1999; Fanatico and Born, 2001). In Italy, among those slow-growing genotypes there are several local chicken breeds that showed interesting meat quality traits (*e.g.* colour and flavour) (De Marchi *et al*., 2006*a*). Fast-growing meat strains of chicken are characterised by a very low degree of adaptation and resistance to natural environment (Reiter and Bessei, 1996); in contrast, the slow-growing strains can fully benefit from organic system (pasture availability, older age). Several studies have investigated differences in the sensory quality of meat from fast- and slow-growing birds, but there was a wide variation in breed (purebred, broiler or layer), slaughter age and production system (standard, extensive or organic) (Touraille *et al*., 1981; Brown *et al.,* 2008; Jaturasitha *et al*., 2008; Sandercock *et al.*, 2009). This has produced contrasting results regarding consumer preference and acceptance, but reports have generally been more favorable for slower-growing birds than conventional products.

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In the Veneto region of Italy, the increasing interest in the conservation of bovine, ovine and poultry local breeds (De Marchi *et al*., 2006*a,b*; Dalvit *et al*., 2008, 2009; Zanetti *et al*., 2010) is due to historical, social and economical reasons. A few breeds of chicken, Padovana (PA), Ermellinata (EA), and Pépoi (PI), which are typically reared in extensive systems, provide interesting alternatives to commercial broilers. The recent development of organic animal production and consumer requests for food safety and sustainable systems of production might encourage the use of local chicken breeds for several niche markets. Previous research has been focused on the carcase characteristics and quality meat traits of the Padovana breed of chicken (De Marchi *et al*., 2005) because it has been in great demand.

The interest in local genotypes has increased noticeably in the last decade, mostly because biodiversity conservation and management has become an important issue for the international scientific community (Fao, 2007). Productive performance analysis and phenotypic traits, together with genetic diversity, reproductive and adaptative performances, and historical interest, are therefore highly relevant to the inclusion of local breeds in conservation programmes (Ruane, 1999).

The objective of this research was to describe carcase characteristics and qualitative meat traits of three local Italian chicken breeds at maturity, as well as at a light, medium or heavy body weight.

MATERIALS AND METHODS

Animals, diets and experimental procedures

A trial was conducted at the Duca degli Abruzzi Agricultural High School in Padova. Three slow-growing genotypes were compared, Pépoi (PI), Padovana (PA) and Ermellinata (EA), and categorised according to the weight they reached at 190 d (market weight): PI had a live weight of 1400 -1600 g, PA a live weight of 2000 - 2200 g and EA a live weight of 2800 - 3000 g (De Marchi *et al*., 2006*a*). Twenty 30-d male birds were obtained from each breed and housed together in an indoor pen (5 birds/m^2) which had access to a grass paddock (4 m^2/bird). All birds were provided with a grower diet (210 g CP/kg, 50 g/kg lipids, 40 g/kg fibre, 70 g/kg ash, and 13.39 MJ ME/kg) from 2 d before the trial commenced until slaughter at 190 d. Ingredients for the grower diet were maize flour, toasted soybean meal, maize gluten meal, maize gluten, soybean oil, dicalcium phosphate, calcium carbonate, sodium chloride and DL-methionine. Feed and water were supplied *ad libitum*. The diets were crumbled vegetable diet without animal products, antibiotics or coccidiostats. A total of 60 birds (20 males for each breed) were slaughtered at 190 d of age. Feed was withdrawn 18 h prior to slaughter, and the birds weighed, electronically stunned, plucked and eviscerated.

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The carcases were cooled in a tunnel, refrigerated at 4° C for 24 h and weighed. The breast and thigh meat from all chickens were then harvested and processed for meat quality parameters determination. Other breast meat samples were also collected and stored at -20°C for further analyses.

Analytical determinations

Breast (*Pectoralis superficialis)* and thigh (*Peroneus longus)* muscle pH were measured 24 h *post-mortem* using a Delta Ohm HI-8314 pH-meter (Delta Ohm, Padova Italy). Colour, tenderness and cooking loss were also determined 24 h *post-mortem*. Colour parameters were measured using a Minolta CM-508c (illuminate: D65, observer: 10°) on thigh and breast skin and on breast meat. Breast meat colour was taken immediately after skin removal. Readings were performed at the same anatomical positions for all breast and thigh samples. For each sample, three measurements were performed and the final value for each chicken was the average of those readings. Skin colour of breast and thigh and meat colour of breast were expressed in the CIELab colour space by reporting L*, a* and b* values (CIE, 1978).

Cooking loss percentage (CL%), expressed as the ratio of the weight before and after cooking, was measured on the left part of the breast muscle without the skin using 2-cm thick samples sealed in a polyethylene bag and heated in a water bath to an internal temperature of 70°C for 40 min (ASPA, 1996). Shear force (SF) on breast muscle was measured on 5 cylindrical cores, 1.13 cm in diameter and taken parallel to muscle fibres, using a TA-HDi Texture Analyser (Stable Macro System, London, Great Britain) with a Warner-Bratzler shear attachment (10 N load cell, crosshead speed of 2 mm/s) and interpreted using texture expert software (ASPA, 1996).

All chemical analyses were performed on the right breast, without skin, and were in accordance with AOAC (1990) standards. Moisture was determined after drying at 102°C for 16 h, ash was determined after mineralisation at 525°C for 6 h and total lipids analysed by extraction with petroleum ether (Soxhlet method). Protein content was estimated by difference. For the determination of total fatty acids composition, lipids were extracted according to the method of Folch *et al*. (1957). A 5-g homogenised meat sample was blended twice with extraction solvent chloroform/methanol (1:2, v/v), filtered, placed in separator funnels and mixed with saline solution (0.88% KCl). After separation in two phases, the methanol aqueous fraction was discarded and the lipid chloroform fraction washed with distilled water/methanol (1:1, v/v). Following a further filtration and evaporation in a rotary evaporator, lipid extracts were prepared for trans-esterification in n-Heptane according by Christie (1982) and transferred to test tubes for subsequent gas chromatographic analysis,

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which was conducted on a Thermo Quest (model 8000 Series Top, Milan, Italy) instrument equipped with a Omegawax 250 capillary column (length 30 m, internal diameter 0.25 mm, Supelco, Bellafonte, PA, USA).

Statistical analysis

Data were subjected to ANOVA by the GLM procedure considering breed as a fixed effect using SAS® software (1997, SAS Institute, Cary, NC). For breed effect, a multiple comparison of means was performed using the Bonferroni's test ($P < 0.05$).

RESULTS

The least square means of carcase composition, pH values, breast chemical composition, shear force and cooking loss values are shown in Table 1. Final live weights of the three breeds at 190 d of age (just before slaughter) were significantly different. Ermellinata had heavier live, carcase and thigh weights than PA and PI, while PI had lighter breast weight than PA and EA. Breast weight and total dressing did not differ statistically for PA and EA, while the incidence of breast on carcase weight was similar for PA and PI. Dressing percentage was greater for PA and EA than PI, while PA and PI had greater breast percentage than EA.

Table 1 near here

Dry matter, protein and lipid contents of the breast muscle differed only slightly among breeds (Table 1). Maximum shear force values for PA birds, as measured on cooked breast muscle, were significantly different from the other breeds (Table 1). The pH values measured in the breast muscle were significantly higher for PA than the other two breeds, while, the thigh pH of PI birds had the highest values. The PA breed showed the highest tenderness followed by EA and PI, while cooking loss values were higher for PI breed relative to PA and EA birds.

Tables 2 & 3 near here

Breast and thigh colour values are shown in Table 2. PA breed showed a significantly higher L* value of breast skin than PI or EA, while the PI showed significantly lower a* and b* values than PA or EA. The L* value of thigh skin for PI was significantly higher than either PA or EA, a* indices were not significantly different for the three breeds, while the b* index was significantly higher for EA than either PI or PA. The breast meat colour for PA had a significantly lower L* value than for EA or PI, while EA b* values were significantly lower than PA or PI.

Raw breast meat (without the skin) fatty acid compositions are shown in Table 3. Ermellinata breed had a significantly higher content of saturated (SFA) but lower amount of monounsaturated (MUFA) fatty acids than either PA or PI. There were no significant differences between breeds for n-3 and n-6 polyunsaturated fatty acids. Ermellinata differed

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from the other breeds because of a higher $C_{16:0}$ content and a lower production of $C_{18:1cis\ n-9}$ and $C_{18:2cis\ n-6}$ fatty acids (Table 4). There were no significant differences in DPA nor CLA fatty acids among breeds but PI breast meat had a significantly higher content of DHA than PA.

Table 4 near here

DISCUSSION

The EA, PA and PI chickens exhibited medium, light and very light carcase weights respectively. The dressing and breast percentages of PA were slightly lower than those reported for the same breed by De Marchi et *al*. (2005). Dressing percentages for PA, EA and PI breeds were also slightly lower than those reported for local Thai chicken genotypes (Jasurasitha *et al*., 2008) and markedly lower than that reported for commercial broilers (Havenstein *et al*., 2003; Cortinas *et al*., 2004). These results indicate that the Italian local chicken breeds have relatively low carcase weights, and inferior dressing and breast percentages to other meat-type genotypes.

Contrastingly, the pH values were higher than expected; possible reasons are slaughter stress and a higher content of oxidative muscle fibre in other common slow-growing genotypes (Dransfield and Sosnicki, 1999). Regarding the first hypothesis, it is likely that the old unselected breeds have a more aggressive and alert behaviour than the modern broilers (Jaturasitha *et al*., 2004; Debut *et al*., 2005); this higher sensibility to the stressful conditions before slaughter can lead to poor glycogen content in muscle at the time of death. However, no other information is available concerning muscle fibre analysis for these breeds. Nevertheless, the breast pH values of the PA breed were lower than those reported previously by De Marchi *et al*. (2005) for the PA breed.

Dry matter, protein and lipid contents of the breast muscles differed slightly among breeds. The chemical composition of the PA breed breast was consistent with values reported by De Marchi *et al*. (2005). The dry matter and protein contents of these three local Italian breeds were similar to those reported for other organic chickens (Castellini *et al*., 1994; Castellini *et al*., 2002). In contrast, protein, lipids and ash contents were higher for the Italian local breeds than for Thai indigenous chickens or normal commercial broilers (Wattanachant *et al*., 2004). As expected, local chicken muscle contains a high proportion of protein and low fat and ash contents, which agrees with previously reported findings from Wattanachant *et al*. (2005). The PA and EA breeds showed a greater cooking loss compared with the values reported by De Marchi *et al*. (2005) and Rizzi *et al*. (2007).

Low L* values are associated to a higher ultimate pH value because of the weak light scattering in high-pH chicken meat (Swatland, 2008). The darker breast muscle of the PA breed can thus reflect differences in the muscle fibre composition and in the glycogen content

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of the muscle. For this reason, the analysis of breast meat L* values were also conducted using the fixed effect of breed and the effect of pH as co-variate. In the preliminary analysis, the interaction between breed and pH was not significant. Furthermore, the PA had the lowest L* value of breast meat.

The fatty acid composition of the breast meat in this study was similar to that reported by De Marchi *et al*. (2005) and Castellini *et al*. (2006) for Ross 205 and Kabir chickens reared in an organic rearing system. The observed differences in SFA and MUFA among the three breeds in this study can be attributed only to their genetic make-up, because diets and rearing system were identical for all breeds throughout the experimental period. Even the highest saturated fatty acid contents of the EA breed were still lower than those reported for organic (38%) and Thai local chickens (62%) (Wattanachant *et al.,* 2004). Among SFA, palmitic (C16:0) and stearic (C18:0) acids were the most abundant, as generally observed in chicken breast meat.

In conclusion, the study demonstrated significant differences in meat quality traits among the three breeds studied, for example in carcase yield, colour, tenderness and fatty acid composition. From a consumer point of view, each breed offers unique features. Besides a greater traditional interest and a high historical and cultural value, the tenderness of the PA meat and its distinctively darker colour differentiated it from the other breeds. In contrast, none of the meat quality traits of EA and PI showed the meat of these breeds to be significantly distinctive from other meat-type genotypes. Additionally, adaptability features, traits of scientific and economic interests, cultural\historical value, strong links to local traditions and its ability to generate incomes from tourism justify the efforts for their conservation and characterisation (Ruane, 1999). The commercialisation and capitalisation of local markets represent an opportunity for future added value and development of these local genetic resources. Alternative strategies, such as the use of crosses of these breeds with more productive commercial breeds, are currently under evaluation to enhance their use for niche and regional markets.

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Table 1. *Least square means of carcase composition, pH values, breast chemical composition, shear force and cooking loss values of Ermellinata, Padovana and Pépoi slow-growing chicken at 190 d of age*

	Breed			r^2	Res MS
	Padovana	Ermellinata	Pèpoi		
- Live weight (LW), g	2144[b]	2718[a]	1434[c]	0.89	187
- Carcase weight (CW), g	1346[b]	1726[a]	879[c]	0.88	125
- Breast weight (BW), g	225[a]	243[a]	140[b]	0.72	29
- Thigh weight (TW), g	478[b]	667[a]	322[c]	0.89	50
Dressing (CW/LW), %	63[a]	64[a]	61[b]	0.27	1.59
Breast (BW/CW), %	17[a]	14[b]	16[a]	0.27	1.88
Thigh (TW/CW), %	35[c]	38[a]	36[b]	0.39	1.60
Breast meat pH	6.18[a]	5.97[b]	5.99[b]	0.21	0.18
Thigh meat pH	6.19[b]	6.15[b]	6.30[a]	0.16	0.15
Breast muscle chemical composition					
- Dry matter (%)	24.85[b]	26.18[a]	25.45[ab]	0.26	0.95
- Total proteins (%)	23.23[b]	24.65[a]	23.89[b]	0.11	0.79
- Total lipids (%)	0.61[a]	0.29[b]	0.48[ab]	0.37	0.28
- Ash (%)	1.08	1.12	1.10	0.20	0.05
Shear Force (N)	12.51[a]	16.76[b]	15.84[b]	0.19	3.82
Cooking loss (%)	18.20[b]	19.31[b]	22.34[a]	0.29	2.81

[a,b,c] Within a row, means not sharing a common superscript are significantly different at $P < 0.05$.

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Table 2. *Breast and thigh colour values of Ermellinata, Padovana and Pépoi slow-growing chicken at190 d of age.*

Item	Breed			r^2	Res MS
	Padovana	Ermellinata	Pepoì		
Skin colour					
Breast					
- L*	62.41[a]	56.96[b]	59.20[b]	0.32	3.27
- a*	-2.15[a]	-2.42[a]	-3.07[b]	0.25	0.69
- b*	1.91[a]	1.06[a]	-1.47[b]	0.21	2.84
Thigh					
- L*	62.08[b]	62.35[b]	63.81[a]	0.15	1.89
- a*	-2.19	-1.99	-2.47	0.08	0.69
- b*	-1.97[c]	3.94[a]	0.01[b]	0.62	1.94
Meat colour					
Breast					
- L*	46.00[a]	48.41[b]	49.84[b]	0.35	2.38
- a*	-1.42	-1.72	-1.39	0.11	0.42
- b*	-0.45[a]	-1.64[b]	0.04[a]	0.14	1.75

[a,b] Within a row, means not sharing a common superscript are significantly different at $P < 0.05$.

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Table 3. *Least square means of raw breast (without skin) fatty acid composition of Ermellinata, Padovana and Pépoi slow-growing chicken at 190 d of age*

	Breed			r^2	Res MS
	Padovana	Ermellinata	Pépoi		
Breast muscle	% of total analysed fatty acid				
Total SFA	33.88[b]	35.59[a]	32.82[b]	0.46	1.29
Total MUFA	23.45[a]	20.21[b]	24.92[a]	0.39	2.55
Total PUFA	40.24	41.38	40.09	0.05	2.71
Total n-6 FA	36.63	37.74	36.23	0.08	2.27
Total n-3 FA	3.60	3.64	3.85	0.02	0.73
n-6/n-3	10.51	10.93	9.66	0.06	2.19

[a,b] Within a row, means not sharing a common superscript are significantly different at $P < 0.05$.

SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; FA: fatty acid.

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Table 4. *Least square means of raw breast (without skin) detailed fatty acid composition of Ermellinata, Padovana and Pépoi slow-growing chicken at 190 d of age*

Fatty acid	Breed			r^2	Res MS
	Padovana	Ermellinata	Pépoi		
Breast muscle	% of total analysed fatty acid				
C6:0	0.02	0.02	0.01	0.18	0.02
C8:0	0.06[b]	0.10[a]	0.11[a]	0.40	0.03
C10:0	0.06	0.08	0.07	0.08	0.02
C12:0	0.03	0.02	0.02	0.08	0.02
C14:0	0.44[a]	0.29[b]	0.28[b]	0.28	0.12
C15:0	0.09	0.08	0.07	0.08	0.02
C16:0	20.65[a]	21.40[a]	19.50[b]	0.34	1.13
C17:0	0.28[a]	0.25[ab]	0.24[b]	0.16	0.04
C18:0	11.51[b]	12.64[a]	11.86[b]	0.27	0.81
C20:0	0.08[ab]	0.06[b]	0.09[a]	0.15	0.04
C21:0	0.01	0.01	0.01	0.10	0.01
C22:0	0.01[b]	0.01[b]	0.02[a]	0.21	0.02
C10:1 n-1	0.05	0.04	0.04	0.05	0.02
C14:1 n-1	0.01	0.01	0.01	0.01	0.01
C16:1 n-9	0.20	0.16	0.18	0.09	0.05
C16:1 n-7	0.39	0.34	0.46	0.08	0.17
C17:1 n-9	0.03	0.07	0.11	0.09	0.10
C17:1 n-7	0.01[b]	0.01[ab]	0.02[a]	0.38	0.01
C18:1 n-7 trans	0.04	0.03	0.02	0.13	0.02
C18:1 n-9 trans	0.01[b]	0.02[ab]	0.02[a]	0.17	0.01
C18:1 n-9 cis	20.69[a]	17.79[b]	21.53[a]	0.33	2.38
C18:1 n-7 cis	1.73[b]	1.46[c]	2.18[a]	0.68	0.21
C20:1 n-9	0.19[a]	0.13[b]	0.22[a]	0.34	0.05
C18:2 n-6 trans	0.01	0.01	0.01	0.04	0.01
C18:2 n-6 cis	25.25[a]	21.79[b]	21.84[b]	0.18	3.52
C18:3 n-6	0.08[a]	0.04[b]	0.05[b]	0.32	0.03
C18:3 n-3	0.93[a]	0.56[b]	0.61[b]	0.26	0.28
CLA	0.01	0.01	0.01	0.06	0.01
C20:2 n-6	0.45[a]	0.39[b]	0.43[ab]	0.15	0.05
C20:3 n-6 cis	0.41[b]	0.73[a]	0.54[b]	0.43	0.16
C20:4 n-6	9.06[b]	13.11[a]	11.78[ab]	0.19	3.64
C22:1 n-9 cis	0.01	0.01	0.01	0.03	0.01
C20:5 n-3 cis	0.06	0.05	0.08	0.03	0.06
C22:2 n-6	0.17	0.29	0.22	0.10	0.16
C22:4 n-6	0.01	0.03	0.01	0.14	0.04
C22:5 n-6	1.19	1.33	1.36	0.04	0.34
C24:1 n-9 cis	0.30	0.29	0.34	0.02	0.13
C22:5 n-3 DPA	1.19	1.37	1.26	0.04	0.41
C22:6 n-3 DHA	1.42[b]	1.66[ab]	1.90[a]	0.13	0.53

[a,b] Within a row, means not sharing a common superscript are significantly different at $P < 0.05$.

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