Carcass characteristics and meat quality traits of the Padovana chicken breed, a commercial line, and their cross

Martino Cassandro, Massimo De Marchi, Mauro Penasa, Chiara Rizzi
Dipartimento di Agronomia, Animali, Alimenti, Risorse naturali e Ambiente, University of Padua, Italy

Abstract

The objective of this study was to compare the Padovana Camosciata local chicken breed (PC; n=59), the slow-growing line Berlanda-Gaina (BG; n=62), and their cross (BGxPC; n=57) for carcass and meat quality features. Animals were reared under the same experimental conditions and slaughtered at 3 different ages. An analysis of variance was performed on carcass and meat traits using a linear model that included fixed effects of genotype, sex, age at slaughter, and interactions between them. The PC local breed was approximately 1 kg lighter (P<0.001) at slaughter and exhibited greater dressing percentage (+1.50%; P<0.05) than BG. Breast skin of PC was bluer (-2.74; P<0.001), and breast muscle was darker (-2.65; P<0.001) and redder (+0.48; P<0.001) than that of BG. The pH (+0.16; P<0.001), thawing (+0.90%; P<0.01) and cooking (+2.28%; P<0.001) losses determined on breast muscle were higher for PC than BG. Crossbred animals performed better than the average of BG and PC chickens for breast weight (+22.81 g; P<0.01) and dressing percentage (+1.38%; P<0.05). Breast skin of BGxPC was darker (-1.74; P<0.05), less red (-0.23; P<0.05), and bluer (-1.54; P<0.01) than the average of BG and PC, and breast muscle was more yellow (+0.64; P<0.05) for BGxPC. Cooking losses were lower (-0.99%; P<0.05) for crossbred than the average of BG and PC chickens. Results confirmed the specificity of meat characteristics of PC local breed and demonstrated the potential benefit of cross-breeding to improve production traits of PC breed without compromising the peculiar quality of its meat.

Introduction

Intensive poultry meat industry relies on commercial animals (hybrids) obtained from few selected lines; this results in a loss of biodiversity and limits the preservation of several local populations to hobby or fancy farmers (Hoffmann, 2009). Local chicken breeds may, however, represent a source of genes for future breeding strategies and research (De Marchi et al., 2006), and their conservation has become an important issue for the international scientific community (FAO, 2007). Different in situ and ex situ conservation programmes have been planned in Europe, but one of the most effective strategies to safeguard biodiversity consists of including local breeds in the commercial production chain (FAO, 2007). Fortunately, the expectation of modern consumers has evolved toward the demand of traditional products, usually more respectful of the environment and of animal welfare; therefore, rural poultry production is gaining more and more interest (Castellini et al., 2002, 2006). Productive performance along with genetic diversity, reproductive and adaptive characteristics, and historical interest, are highly relevant to the inclusion of local breeds in conservation programmes (Ruane, 1999; FAO, 2007).

The Padovana is a local breed of chicken reared in northeast Italy, mostly in the Veneto region; it is a slow-growing animal, with an increasing interest in the Italian food service markets (De Marchi et al., 2005). Several studies demonstrated that differences in meat quality between fast- and slow-growing chicken breeds, particularly in terms of chemical composition and physical traits, and consumer preferences exist (Fanatico et al., 2005; Jaturasitha et al., 2008). The recent development of organic animal production and consumer demand for food safety and sustainability of production systems might encourage the use of local chicken breeds for niche markets. Previous research has focused on the carcass and meat quality traits of purebred Padovana breed (De Marchi et al., 2005; Verdiglione and Cassandro, 2013). However, no studies are currently available in the literature investigating the characteristics of meat quality features of crossbred animals originated from the mating of Italian local breeds with slow-growing commercial lines. Therefore, the aim of this study was to compare the Padovana chicken breed, a slow-growing line, and their cross for carcass and meat quality traits.

Materials and methods

Animals and experimental procedures

The project was approved by the Ethical Committee for the Care and Use of Experimental Animals of the University of Padova, Italy. One hundred and seventy-eight birds were reared from May to December 2009 at the experimental farm of the Department of Agronomy, Food, Natural resources, Animals...
Quality characteristics of chicken meat

and Environment (Legnaro, Italy). Chickens were from 3 genotypes, the Padovana Camosciata local breed (PC; 31 males and 28 females), an Italian commercial slow-growing line (Berlanda-Gaina, BG; 32 males and 30 females), and their cross (BGxPC; 28 males and 29 females). All birds were born on the same day, sexed at 1 d of life, and reared in indoor pens separately by genotype and sex until slaughter, which occurred at 3 different ages (131, 180, and 201 d). The three dates of slaughtering were chosen because genotypes had different growth patterns and thus we wanted all chickens to have the opportunity to reach the mature weight at slaughtering. Animals were fed ad libitum the same commercial diet, which was crumbled for the first 8 weeks of age and pelleted thereafter (for full details on formulation and composition of the diet, and environmental and rearing conditions, see Rizzi et al., 2013). Feed was withdrawn between 9 and 11 h prior to slaughter, and animals were weighed before transportation to the abattoir. After slaughtering procedures, carcasses were weighed and immediately refrigerated at 4°C.

Laboratory analyses

After 48 h post mortem, the breast muscle (Pectoralis superficialis) with skin was removed from the carcass, weighed, and analysed for colour and pH. Colour was assessed on the breast with and without skin using a Minolta® colorimeter (CM_508c, D65 illuminant and 10° observer; Konica-Minolta Sensing Inc., Ramsey, NJ, USA) and was expressed in terms of CIELab colour space by reporting values for lightness (L*), redness (a*), and yellowness (b*) (Commission Internationale de l’Eclairage, 1978). Measurements of pH 48 h post mortem were collected using a portable pH-meter (Crisson Basic 20 electrode; Crison Instruments, Barcelona, Spain).

The muscle without skin was frozen at -20°C for 12 d and then evaluated for thawing and cooking losses, and shear force. Part of the meat was minced and stored again at -20°C for subsequent determination of fatty acid (FA) profile, as described below. Thawing and cooking losses were measured following ASPA (1996) procedures. Frozen breasts were weighed and left at room temperature for 15 h, extracted from the bag, blotted dry, and weighed again; thawing losses were the difference of weight before and after thawing. Breast muscles were weighed, inserted in plastic bags, cooked in water bath at 75°C for 60 min, cooled, dried, and weighed again; cooking losses were the difference of weight before and after cooking. Finally, shear force was assessed on 3 cylindrical cores (1.13 cm of diameter) of each breast cooked sample according to ASPA (1996) procedures and by using a TA-HDi Texture Analyser (Stable Micro System, London, UK) with a Warner-Batzler shear attachment (10 N load cell, crosshead speed of 2 mm/s). Results were interpreted using texture expert software (Joseph, 1979). The average peak shear force from the 3 replicates was taken as the final shear force value.

The procedure to determine FA content of breast muscle started with the extraction of lipid following the procedure of the rapid determination of fat in meat using accelerated solvent extraction (ASE, Application note 334; Dionex, Waltham, MA, USA) according to Klaus (1998). After extraction, lipids were transferred to test tubes for subsequent gas chromatographic analysis, performed on a Thermo Quest instrument (model 8000 Series Top, Milan, Italy) equipped with a HP 88 fuse silica capillary column (Agilent Technologies, Santa Clara, USA). The column was 100 m in length with an internal diameter of 0.25 mm and film thickness of 0.2 μm. Oven temperature was initially 100°C for 5 min and then increased at 4°C/min until 218°C and held for 4 min. The temperature of injector and detector was kept at 250°C. Hydrogen was the carrier gas and flowed at 2.68 ml/min. The pressure of hydrogen and airflow was set at 75 and 110 kPa, respectively. Identification and quantification of peaks were made by comparison with commercial methyl esters standards (Nu-Chek Prep, Elysian, MN, USA). A solution with 1 mg/l in hexane of methyl nonadecanoate (C19:0) was used as internal standard. Unidentified peaks represented 1.9% of total chromatographic areas. Twenty-one out of 31 FA were selected according to their concentration in breast meat (≥0.1% of total fat). However, all of them (31) were used to define the main FA classes: saturated FA (SFA), which were the sum of C4:0, C6:0, C8:0, C10:0, C12:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0, C22:0, and C23:0; monounsaturated FA (MUFA), which were the sum of C14:1, C15:1, C16:1, C17:1, C18:1 (n9 and n11), C20:1n9, and C22:1n9; and polyunsaturated FA (PUFA), which were the sum of C18:2 (n6c, n9c11, 11c12), C18:3 (n6 and n3), C20:2, C20:3n6, C20:4n6, C20:5n3 (EPA), and C22:6n3 (DHA).

Statistical analysis

An ANOVA was performed on weights, dressing percentage, breast incidence, quality traits, and FA profile with the GLM procedure (SAS Inst. Inc., Cary, NC), according to the following fixed effect linear model:

$$y_{ijk} = \mu + \text{Genotype}_i + \text{Sex}_j + \text{Age}_k + (\text{Genotype} \times \text{Sex})_{ij} + (\text{Genotype} \times \text{Age})_{ik} + (\text{Sex} \times \text{Age})_{jk} + \epsilon_{ijkl},$$

where $\epsilon_{ijkl}$ is the dependent variable; $\mu$ is the overall intercept of the model; Genotype is the fixed effect of the $i$th genotype of the bird ($i=$PC, BG, BGxPC); Sex is the fixed effect of the $j$th sex of the bird ($j=$male, female); Age, $k$ is the fixed effect of the $k$th age of bird at slaughter ($k=131, 180, 201$ d); (Genotype $\times$ Sex)$_{ij}$ is the fixed interaction effect between genotype and sex; (Genotype $\times$ Age)$_{ik}$ is the fixed interaction effect between genotype and age at slaughter; (Sex $\times$ Age)$_{jk}$ is the fixed interaction effect between sex and age at slaughter; and $\epsilon_{ijkl}$ is the random residual $N (0, \sigma^2)$. Contrast estimates (±SE) between BG and PC, and between BGxPC and the average of BG and PC for weights, dressing percentage, breast incidence, quality traits, and selected FA were obtained. The first contrast allowed us to compare the two parental genotypes and the second contrast allowed us to identify if crossbreds (BGxPC) deviated significantly from the average of the two parental genotypes.

Results and discussion

Carcass characteristics and physical quality traits

Live weight, carcass weight, breast weight, dressing percentage, and breast incidence averaged 2414±704 g, 1889±615 g, 356±104 g, 76.80±5.30%, and 19.16±2.64%, respectively (Table 1), and mean values for L*, a*, thawing losses, cooking losses, and shear force measured on breast without skin were comparable with those reported by De Marchi et al. (2011), who used a sample of chicken from the same trial to study the ability of near-infrared reflectance spectroscopy to predict physical and colour characteristics of chicken meat by directly applying a fiberoptic probe to the breast muscle. The coefficients of determination were medium to high for live weight (0.90), carcass weight (0.89), breast weight (0.76), and dressing percentage (0.64), and medium to low for other traits (Table 1). Genotype, sex, and age effects were significant ($P<0.05$) in explaining the variability of live weight, carcass characteristics, and a* value, thawing losses, and cooking losses measured on breast muscle. All traits, except for colour indexes of breast with skin, and L* value and shear force of breast muscle exhibited sexual
dimorphism. Overall, fixed interaction effects were important (P<0.05) for live weight and carcass traits, except for breast incidence, whereas significance for physical traits was rarely detected (Table 1).

Contrast estimates for live weight, carcass characteristics, and quality aspects of breast skin and breast muscle for genotype effect are reported in Table 2. The differences between PC and BG were -1038.66, -776.18, and -156.02 g for live weight, carcass weight, and breast weight, respectively (P<0.001). Dressing percentage of PC was 1.50% higher (P<0.05) and breast incidence was 1.14% lower (P<0.01) than the same traits measured on BG. Breast skin of PC was more blue (-2.74; P<0.001) than that of BG chickens, and breast muscle of PC was darker (-2.65; P<0.001) and more red (+0.48; P<0.001) than that of BG animals. The latter results confirm findings of Jaturasitha et al. (2008), who reported darker and redder meat colour for local compared to imported breeds. Overall, least squares means for colour indexes, thawing and cooking losses, and shear force from the present study differed from values reported by Jaturasitha et al. (2008). Chickens used by the latter authors were of different genotypes and age at slaughter than chickens of our work. Regarding technological traits, breast muscle of PC showed statistically greater pH (+0.16; P<0.01), thawing losses (+0.99%; P<0.05), and cooking losses (+2.28%; P<0.001) than that of BG chickens. As reported by Jaturasitha et al. (2004), local breeds have a more aggressive and alert behaviour than commercial lines, and thus pH after slaughter is expected to be greater. Moreover, values of pH measured on PC were higher than those reported by De Marchi et al. (2005) for the same breed and by Rizzi et al. (2009), who investigated slaughter performance and meat quality of female chickens belonging to three Italian local breeds, which did not include PC. Rizzi et al. (2007) studied the effect of organic production on local and commercial lines and reported similar cooking and thawing losses than findings from the present work.

The differences between crossbred and the average of BG and PC genotypes may be useful for the valorization of the PC breed (Table 2). Crossbred animals performed similarly for live and carcass weight to the average of BG and PC chickens, whereas they performed better for breast weight (+22.81 g; P<0.01), dressing percentage (+1.38%; P<0.05), and breast incidence (+0.99%; P<0.01). Breast skin of BGxPC was darker (-1.74; P<0.05), less red (-0.23; P<0.05), and more blue (-1.54; P<0.01) than the average of BG and PC, whereas breast muscle was more yellow for BGxPC animals (+0.64; P<0.05). Regarding processing traits, no significant differences were found between crossbreds and the average of BG and PC chickens, except for cooking losses which were lower (-0.99%; P<0.05) for BGxPC. These findings showed that it is possible to improve the productive performances of the local breed without compromising the peculiar quality of its meat by means of crossbreeding strategies.

Least squares means for live weight, carcass characteristics, and quality traits of breast skin and breast muscle for sex and slaughtering age effects are presented in Table 3. Males were 38% heavier (P<0.05) and exhibited 53 and 31% greater carcass and breast weights (P<0.05) than females, respectively. Dressing percentage was 9% greater for males than females (P<0.05), whereas breast incidence was 15% greater for females (P<0.05). No significant differences between sexes were found for colour of breast skin and L* value measured on breast muscle, whereas a* and b* measured on breast muscle differed significantly between sexes (P<0.05). In particular, breast muscle of females was less red and more yellow than that of males. Finally, thawing and cooking losses measured on breast muscle were 46 and 18% greater for females than males, respectively (P<0.05).

Live, carcass, and breast weights increased as age at slaughtering increased, whereas dressing percentage and breast incidence decreased with age (P<0.05; Table 3). Breast skin of animals slaughtered at 201 d of age was lighter and more yellow than that of animals slaughtered at 131 d of age (P<0.05), and breast muscle of chickens slaughtered at 201 d of age was redder than that of chickens slaughtered at 131 d of age (P<0.05). Thawing and cooking losses decreased as age at slaughter increased, whereas shear force increased with

Table 1. Descriptive statistics and results from analysis of variance for weights, dressing percentage, breast incidence, and quality traits.

| Trait                      | n  | Mean | SD  | R²  | RMSE | P value |
|----------------------------|----|------|-----|-----|------|---------|
|                            | G  | S    | A   | GxS | GxA  | SxA     |
| Live weight, g             | 173| 2414 | 704 | 0.90| 233  | ***     |
|                            |    |      |     |     |      | ***     |
| Carcass weight, g          | 172| 1898 | 615 | 0.89| 214  | ***     |
|                            |    |      |     |     |      | ***     |
| Breast weight, g           | 177| 356  | 104 | 0.76| 53   | ***     |
|                            |    |      |     |     |      | ***     |
| Dressing percentage, %     | 168| 76.80| 5.30| 0.64| 0.03 | ***     |
|                            |    |      |     |     |      | ***     |
| Breast incidence, %        | 172| 19.16| 2.64| 0.37| 0.02 | ***     |
|                            |    |      |     |     |      | ***     |
| Breast skin L*             | 178| 61.49| 4.66| 0.13| 4.51 | *       |
|                            |    |      |     |     |      | ns      |
| a*                        | 175| -2.67| 0.68| 0.08| 0.68 | ns      |
|                            |    |      |     |     |      | ns      |
| b*                        | 176| 3.98 | 4.17| 0.34| 3.51 | ns      |
|                            |    |      |     |     |      | ns      |
| Breast muscle              | 177| 44.45| 2.66| 0.20| 2.47 | ***     |
|                            |    |      |     |     |      | ns      |
|                            |    |      |     |     |      | ns      |
|                            | 178| 2.11 | 0.58| 0.27| 0.52 | ***     |
|                            |    |      |     |     |      | **      |
|                            | 177| 2.22 | 2.79| 0.56| 1.93 | ns      |
|                            |    |      |     |     |      | ns      |
|                            | 174| 5.84 | 0.14| 0.38| 0.11 | ***     |
|                            |    |      |     |     |      | ns      |
|                            | 176| 4.98 | 2.33| 0.44| 0.02 | *       |
|                            |    |      |     |     |      | ***     |
|                            | 175| 19.87| 3.66| 0.44| 0.02 | ***     |
|                            |    |      |     |     |      | ***     |
|                            | 175| 15.35| 3.33| 0.14| 3.22 | ns      |
|                            |    |      |     |     |      | ns      |

SD, standard deviation; R², coefficient of determination; RMSE, root mean square error; G, genotype; S, sex; A, age; L*, lightness; a*, redness; b*, yellowness. Dressing percentage is calculated as carcass weight/live weight*100; breast incidence is calculated as breast weight/carcass weight*100. *P<0.05; **P<0.01; ***P<0.001; ns, not significant.
Fatty acid composition

Total fat measured on breast muscle was 2.11 ± 0.86% (Table 4). Major FA (% of total fat) ranged from 8.24 ± 1.11% for C18:0 to 29.04 ± 3.10% for C18:1 cis-9, minor FA (% of total fat) from 0.11 ± 0.03% for C20:0 to 2.22 ± 1.28% for C20:4 n-6, and groups of FA (% of total fat) were 33.73 ± 3.60, 30.92 ± 4.42, and 31.81 ± 2.16% for MUFA, PUFA, and SFA, respectively. Finally, o-3 and o-6 averaged 1.64 ± 0.37 and 29.00 ± 4.05%, respectively. The coefficients of determination ranged from 0.05 to 0.65. Age at slaughter affected significantly (P<0.01) almost all FA composition of breast muscle, except for C14:1, C15:0, C17:1, and C20:1 n-9. Sex effect was important (P<0.01) for major FA and less for minor and groups of FA. Finally, breed effect and interactions between main factors affected significantly only few FA (Table 4).

Contrast estimates for FA profile of breast muscle (% of total fat) are shown in Table 5. Breast muscle of PC exhibited lower C16:0 content (-0.86%; P<0.001) and significantly greater (P<0.05) content of minor FA than BG, except for C18:3 n-6. Breast muscle of cross-bred chickens exhibited greater (P<0.05) C18:3 n-6 and C20:4 n-6 content than the average of BG and PC. Fatty acid composition of PC meat had similar composition to that reported by Zanetti et al. (2010) who estimated significant differences of FA profile studying three Italian local breeds and De Marchi et al. (2012) who investigated the feasibility of using near infrared spectroscopy to assess the FA composition of breast meat. Bearing in mind that all birds of the present trial were fed the same diet, differences in FA composition among genotypes were not expected. However, further investigation is needed to gain more knowledge on this aspect.

Table 2. Contrast estimates and standard error for weights, dressing percentage, breast incidence, and quality traits.

| Trait                                  | Male                                                        | Female                                                   | Slaughtering age, d |
|----------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|---------------------|
|                                        | PC vs BG                                                    | BG vs PC vs (BG+PC)                                      |                     |
| Live weight, g                         | -1038.66±43.19***                                          | 20.05±38.02***                                           |                     |
| Carcass weight, g                      | -776.18±33.93***                                           | 40.02±35.16***                                           |                     |
| Breast weight, g                       | -156.02±57.22***                                           | 22.81±5.71***                                            |                     |
| Dressing percentage, %                | 1.50±0.02***                                               | 1.38±0.55***                                             |                    |
| Breast incidence, %                   | -1.14±0.40**                                               | 0.99±0.36**                                              |                    |
| Breast skin                            | -0.59±0.82**                                               | 1.74±0.73**                                              |                    |
| Breast muscle                          | -2.65±0.45***                                              | -0.13±0.40**                                             |                    |
| pH                                     | 0.48±0.03***                                               | -0.08±0.06**                                             |                    |
| Thawing losses, %                      | -0.04±0.35**                                               | 0.64±0.31**                                              |                    |
| Cooking losses, %                      | 2.28±0.44***                                              | -0.39±0.39**                                              |                    |
| Shear force, N                         | -0.33±0.59**                                              | 0.18±0.53**                                              |                    |

Est. estimates; PC, Padovana Camocciata; BG, Berlanda-Gaina; BG vs PC (BG+PC), contrast between crossbred genotype and the average of BG and PC genotypes; L*, lightness; a*, redness; b*, yellowness. Dressing percentage is calculated as carcass weight/live weight*100; breast incidence is calculated as breast weight/carcass weight*100. *P<0.05; **P<0.01; ***P<0.001, ns, not significant.

Table 3. Least squares means for weights, dressing percentage, breast incidence, and quality traits for sex and slaughtering age.

| Trait                                  | Male       | Female     | 131        | 180        | 201        |
|----------------------------------------|------------|------------|------------|------------|------------|
| Live weight, g                         | 2818*      | 2035*      | 1992*      | 2571*      | 2717*      |
| Carcass weight, g                      | 2278*      | 1487*      | 1559*      | 1997*      | 2092*      |
| Breast weight, g                       | 405.2*     | 308.4*     | 306.3*     | 373.6*     | 390.5*     |
| Dressing percentage, %                | 80.13*     | 73.63*     | 77.28*     | 77.43*     | 75.93*     |
| Breast incidence, %                   | 17.69*     | 20.49*     | 19.78*     | 18.74*     | 19.06*     |
| Breast skin                            | 61.82      | 61.13      | 60.05*     | 61.82*     | 62.56*     |
| a*                                     | -2.76      | -2.59      | -2.64      | -2.72      | -2.66      |
| b*                                     | 3.62       | 4.32       | 2.26*      | 4.52*      | 5.12*      |
| Breast muscle                          | 44.44      | 44.42      | 44.06      | 44.48      | 44.75      |
| pH                                     | -1.99*     | -2.22*     | -2.26*     | -2.05*     | -2.00*     |
| Thawing losses, %                      | 0.30*      | 4.20*      | 2.52       | 2.37       | 1.86       |
| Cooking losses, %                      | 5.88*      | 5.80*      | 5.84       | 5.83       | 5.85       |
| Shear force, N                         | 4.04*      | 5.88*      | 6.39*      | 3.74*      | 4.74*      |

L*, lightness; a*, redness; b*, yellowness. *Least squares means of sex or slaughtering age effects within a row with no common superscripts are significantly different (P<0.05).
Table 4. Descriptive statistics and results from analysis of variance for total fat and fatty acid composition of breast meat (n=171).

| Trait                     | Mean   | SD    | R²   | RMSE | G      | S      | A      | GxS    | GxA    | SxA    | P value |
|---------------------------|--------|-------|------|------|--------|--------|--------|--------|--------|--------|---------|
| Total fat, %               | 2.11   | 0.86  | 0.15 | 0.82 | ns     | **     | *      | ns     | ns     | ns     | ns      |
| Major FA, % on total fat   |        |       |      |      |        |        |        |        |        |        |         |
| C16:0                     | 21.85  | 1.61  | 0.43 | 1.26 | **     | **     | ***    | ns     | ns     | ns     | ns      |
| C18:0                     | 8.24   | 1.11  | 0.38 | 0.91 | ns     | ***    | ***    | ns     | ns     | **     | ns      |
| C18:1 cis n-9             | 29.04  | 3.10  | 0.61 | 2.02 | ns     | ***    | ***    | ns     | ns     | **     | ns      |
| C18:2 cis n-6             | 26.36  | 3.24  | 0.34 | 2.74 | ns     | ***    | ***    | ns     | ns     | ns     | ns      |
| Minor FA, % on total fat   |        |       |      |      |        |        |        |        |        |        |         |
| C6:0                      | 0.14   | 0.08  | 0.23 | 0.07 | ns     | ns     | ***    | ns     | ns     | ns     | ns      |
| C14:0                     | 0.73   | 0.17  | 0.38 | 0.14 | ns     | ns     | ***    | ns     | ns     | ns     | ns      |
| C14:1                     | 0.12   | 0.26  | 0.11 | 0.26 | ns     | ns     | ns     | ns     | ns     | ns     | ns      |
| C15:0                     | 0.25   | 0.12  | 0.13 | 0.12 | ns     | ns     | ns     | ns     | ns     | ns     | ns      |
| C15:1                     | 0.12   | 0.09  | 0.24 | 0.08 | ns     | ns     | ns     | ns     | ns     | ns     | ns      |
| C16:1                     | 2.06   | 0.57  | 0.52 | 0.48 | ns     | ***    | ***    | ns     | ***    | ***    | ns      |
| C17:0                     | 0.31   | 0.06  | 0.21 | 0.05 | *      | *      | **     | ns     | ns     | ns     | ns      |
| C17:1                     | 0.16   | 0.12  | 0.05 | 0.12 | ns     | ns     | ns     | ns     | ns     | ns     | ns      |
| C18:1 cis (n-11)          | 1.86   | 0.18  | 0.34 | 0.15 | ***    | ***    | ***    | ns     | ns     | ns     | ns      |
| C18:3 n-3                 | 1.34   | 0.26  | 0.24 | 0.24 | ns     | ns     | ***    | ns     | ns     | ns     | ns      |
| C18:3 n-6                 | 0.18   | 0.06  | 0.17 | 0.06 | *      | ns     | **     | ns     | ns     | ns     | ns      |
| C20:0                     | 0.11   | 0.03  | 0.27 | 0.03 | **     | ns     | ***    | ns     | *      | ns     | ns      |
| C20:1 n-9                 | 0.35   | 0.08  | 0.08 | 0.08 | ns     | ns     | ns     | ns     | ns     | ns     | ns      |
| C20:2                     | 0.25   | 0.09  | 0.65 | 0.06 | ***    | ***    | ***    | **     | ns     | ns     | ns      |
| C20:3 n-6                 | 0.24   | 0.08  | 0.15 | 0.08 | ns     | ns     | ns     | ns     | ns     | ns     | ns      |
| C20:4 n-6                 | 2.22   | 1.28  | 0.54 | 0.90 | ***    | ***    | ***    | **     | ns     | ns     | ns      |
| C22:6 n3                  | 0.23   | 0.13  | 0.30 | 0.12 | ns     | ns     | ***    | ***    | ns     | *      | ns      |
| Group of FA, % on total fat|        |       |      |      |        |        |        |        |        |        |         |
| MUFA                      | 33.73  | 3.60  | 0.61 | 2.34 | ns     | ***    | ***    | ns     | ***    | ***    | ns      |
| PUFA                      | 30.92  | 4.42  | 0.47 | 3.35 | ns     | ***    | ***    | ns     | ***    | ***    | ns      |
| SFA                       | 31.81  | 2.16  | 0.18 | 2.03 | ns     | ns     | ***    | ns     | ***    | ***    | ns      |

(continued)

Table 5. Contrast estimates+standard error for fatty acid composition of breast meat (n=171).

| Trait                     | Contrast Est±SE |
|---------------------------|-----------------|
|                           | PC vs BG        | BGxPC vs (BG+PC) |
| Major FA, % on total fat  |                 |                 |
| C16:0                     | -0.86±0.23***   | -0.18±0.21**    |
| Minor FA, % on total fat  |                 |                 |
| C17:0                     | 0.02±0.01*      | 0.01±0.01*      |
| C18:1 trans (n-11)        | 0.15±0.03***    | 0.04±0.02**     |
| C18:3 n-3                 | 0.01±0.01*      | 0.02±0.01*      |
| C20:0                     | 0.02±0.01**     | 0.01±0.01*      |
| C20:4 n-6                 | 0.04±0.01***    | 0.00±0.01*      |
| C22:6 n3                  | 0.74±0.17***    | 0.34±0.15*      |

(continued)

References

ASPA, 1996. Metodiche per la determinazione delle caratteristiche qualitative della carne. Università degli Studi di Perugia ed., Perugia, Italy.

Castellini, C., Dal Bosco, A., Mugnai, C., Pedrazzoli, M., 2006. Comparison of two chicken genotypes organically reared: oxidative stability and other qualitative traits of the meat. Ital. J. Anim. Sci. 5:29-42.

Castellini, C., Mugnai, C., Dal Bosco, A., 2002. Effect of organic production system on broiler carcass and meat quality. Meat Sci. 60:219-225.

Commission Internationale de l’Eclairage, 1978. International commision on illumination recommendations on uniform color

Conclusions

Significant differences among genotypes were detected for production traits, colour recorded on breast skin and meat, and technological features. The local breed was lighter than the slow-growing line, showed greater pH 48 h post mortem, thawing and cooking losses, and confirmed the peculiar characteristics of skin and meat colour. Crossbred animals performed better than the average of parental genotypes for breast weight, dressing percentage, and cooking losses. Findings of the present study confirmed the specificity of meat from the local breed and showed the potential benefit of crossbreeding to improve production traits of the local chickens without compromising the peculiar quality of its meat.
spaces, color-difference equations, psychometric color terms. Commission Internationale de l’Eclairage, Paris, France.

De Marchi, M., Cassandro, M., Lunardi, E., Baldan, G., Siegel, P.B., 2005. Carcass characteristics and qualitative meat traits of the Padovana breed of chicken. Int. J. Poul. Sci. 4:233-238.

De Marchi, M., Dalvit, C., Targhetta, C., Cassandro, M., 2006. Assessing genetic diversity in indigenous Veneto chicken breeds using AFLP markers. Anim. Genet. 37:101-105.

De Marchi, M., Penasa, M., Battagin, M., Zanetti, E., Pulici, C., Cassandro, M., 2011. Feasibility of the direct application of near-infrared reflectance spectroscopy on intact chicken breasts to predict meat color and physical traits. Poultry Sci. 90:1594-1599.

De Marchi, M., Riovanto, R., Penasa, M., Cassandro, M., 2012. At-line prediction of fatty acid profile in chicken breast using near infrared reflectance spectroscopy. Meat Sci. 90:653-657.

Fanatico, A.C., Cavitt, L.C., Pillai, P.B., Emmert, J.L., Owens, C.M., 2005. Evaluation of slower-growing broiler genotypes grown with and without outdoor access: meat quality. Poultry Sci. 84:1785-1790.

FAO, 2007. The state of the world’s animal genetic resources for food and agriculture. Food and Agriculture Organization ed., Rome, Italy.

Hoffmann, I., 2009. The global plan of action for animal genetic resources and the conservation of poultry genetic resources. World. Poultry Sci. J. 65:286-297.

Jaturasitha, S., Khiaosaard, R., Pongpaew, A., Leawtharakul, A., Saitong, S., Apichatsarangkul, T., Leaungwunta, V., 2004. Carcass and indirect meat quality of native and Kai Baan Thai chickens with different sex and slaughter weight. pp 116-126 in Proc. 42nd Ann. Conf. Kasetsart University, Bangkok, Thailand.

Jaturasitha, S., Srikanchai, T., Kreuzer, M., Wicke, M., 2008. Differences in carcass and meat characteristics between chicken indigenous to Northern Thailand (Black-boned and Thai native) and imported extensive breeds (Bresse and Rhode Island Red). Poultry Sci. 87:160-169.

Joseph, R.L., 1979. Recommended method for assessment of tenderness. In: J.C. Bowman and P. Susmel (eds.) The future of beef production in the European Community. Martinus Nijhoff ed., The Hague, the Netherlands, pp 596-606.

Klaus, S., 1998. Accelerated solvent extraction of lipids for determining the fatty acid composition of biological material. Anal. Chim. Acta 358:69-77.

Rizzi, C., Baruchello, M., Chiericato, G.M., 2009. Slaughter performance and meat quality of three Italian chicken breeds. Ital. J. Anim. Sci. 8(Suppl.3):228-230.

Rizzi, C., Contiero, B., Cassandro, M., 2013. Growth patterns of Italian local chicken populations. Poultry Sci. 92:2226-2235.

Rizzi, C., Marangon, A., Chiericato, G.M., 2007. Effect of genotype on slaughtering performance and meat physical and sensory characteristics of organic laying hens. Poultry Sci. 86:128-135.

Ruane, J., 1999. Selecting breeds for conservation. In: J.K. Oldenbroek (ed.) Gene banks and the conservation of farm animal genetic resources. Institute for Animal Science and Health, Lelystad, The Netherlands, pp 59-73.

Verdiglione, R., Cassandro, M., 2013. Characterization of muscle fiber type in the pectoralis major muscle of slow-growing local and commercial chicken strains. Poultry Sci. 92:2433-2437.

Zanetti, E., De Marchi, M., Dalvit, C., Molette, C., Remignon, H., Cassandro, M., 2010. Carcase characteristics and qualitative meat traits of three Italian local chicken breeds. Brit. Poultry Sci. 51:629-634.