Carcass morphology and meat quality from roosters slaughtered at eight months affected by genotype and finishing feeding

D. Franco¹, D. Rois², J. A. Vázquez³ and J. M. Lorenzo¹*

¹ Centro Tecnológico de la Carne de Galicia. Rúa Galicia, 4. Parque Tecnológico de Galicia.
San Cibrán das Viñas. 32900 Ourense, Spain
² Federación de Razas Autóctonas de Galicia (BOAGA). Fontefiz. 32152 Coles (Ourense), Spain
³ Grupo de Reciclado e Valorización de Materiais Residuais (REVAL). Instituto de Investigaciones Marinas (CSIC).
C/ Eduardo Cabello 6. 36208 Vigo, Spain

Abstract

The aim of this study was to describe the carcass characteristics and the meat quality of the roosters from the autochthonous Mos breed slaughtered at 8 months. With comparative purpose roosters from hybrid line Sasso T44 were used in this study. Birds were reared on their typical production system (extensive indoor or barns and finishing diet whit corn). Both live and carcass weight were higher for commercial breed ($p < 0.001$). Drumstick, thigh and wing percentages were greater in Mos breed than in Sasso T-44, while breast was similar for both genotypes. Only significant differences in cholesterol and $\alpha$-tocopherol content between genotypes have been found, whereas finishing feeding treatment had effect on moisture, intramuscular fat content, cholesterol, tocopherol isomers and meat yellowness. Unsaturated fatty acids constituted the main contribution to total amount of fatty acid (FA), where monounsaturated oleic acid was the major compound, and found higher concentrations in commercial breed. Mos breed showed higher amounts of polyunsaturated fatty acids (PUFA) and lower amounts of monounsaturated fatty acids (MUFA) than Sasso T-44. The relation PUFA/SFA was above 0.68 for Mos breed and was slightly lower for the other genotype. In conclusion, the carcass morphology and meat quality was influenced by breed and finishing feeding with corn.

Additional key words: autochthonous breed; poultry production; sensory properties.

Introduction

In ancient times, the authochthonous Mos chicken breed was very used in Galicia (NW Spain) for the production of meat and eggs (Rois et al., 2009). From the sixties decade, due to the arrival of new genetic varieties more adapted to the industrial production, Mos breed was falling into disuse raising the extinction. Clearly, this breed could not compete neither in terms of growth potential nor economic yield with commercial strains, which has been genetically selected to obtain the maximum profit in intensive production (Rivero et al., 2007) and this constituted the main reason of the diminution in Mos chickens’ population. However, natural growth rate offers a very real significant advantage that can only be obtained with age: different texture and flavour.

Nowadays, consumers are concerned about meat quality and demand meat products linked to natural feeding and breeding. Several studies have observed that consumers have grown somewhat tired of broiler meat, because of their scarce taste and texture (Wattanachant et al., 2004; Miguel et al., 2008). Certainly, today the chicken meat is quite different from what our grandparents ate. Traditional roaster age range was from 6 to 9 months and carcass weight from 1.8 to 3.6 kg. In the case of Mos breed, this indigenous rooster is commercially ready when its live weight ranges 3-4.5 kg and heavier animals (12 months and caponized) are only traditionally consumed on

Abbreviations used: CL (cooking loss); CW (carcass weight); DP (drip loss); FA (fatty acid); FAME (fatty acid methyl ester); LW (live weight); ME (methyl ester); MUFA (monounsaturated fatty acids); PUFA (polyunsaturated fatty acids); SFA (saturated fatty acids); WB (Warner-Bratzler); WHC (water holding capacity).
Christmas Day after having been cooked for a long (> 3 hours) period of time.

Previous research about this breed has been focused on chemical composition and physico-chemical properties of meat from castrated and entire roosters (Sánchez et al., 2005; Díaz et al., 2010; Franco et al., 2012a,b) and on fatty acid profile of intramuscular fat of breast and drumstick (Rodríguez, 2010; Franco et al., 2012a,b). It has been established that the caponization cause important differences in fat deposits —intramuscular, subcutaneous and abdominal (Cason et al., 1988; Tor et al., 2002)—, which have consequences in consumer acceptance.

Nowadays in Galicia, for the production of roosters and capons the use of local breed as Mos is of great importance, although commercial hybrids of slow and medium growth are widely used (Sasso T -44 or X-44). In order to complete the information previously published the aim of this study was to describe the quality of the carcass and meat reared on their typical production system (extensive indoor or barns and finishing diet whit corn) and compared with those corresponding to Sasso T-44 animals slaughtered at 32 weeks.

Material and methods

Experimental design, animal management and sample collection

A total of 80 roosters (n = 40 of Sasso T-44 line and n = 40 of Mos breed) reared in the Centro de Recursos Zoogeneticos de Galicia, Fontefiz (Ourense) were used. Birds were housed under extensive indoor (barn reared) conditions according to describe by Commission Regulation 543/2008 (OJ, 2008). At birth the chicks were housed in a pen provided with a central hallway, several departments and natural ventilation with a density of 12 birds m–2. At the 4th week of life, birds were sexed and accommodated in departments of second age with a density of 8 birds m–2. As heat source heaters of 250 W at the ratio of 1 per 40 chicks were used. Heaters were partially removed at 4 weeks and completely after 6 weeks. From the 8th week of life until the slaughtered the chicks were moved to the definitive installation. The poultry house had a density of 1 animal m–2.

In the last month prior to slaughter, half of birds of each genotype were separated into two groups to study the finishing diet with corn. Birds were fed “ad libitum” with a starter fodder (21% protein and 3000 kcal kg⁻¹ ME) up to six weeks and later for the rest of the study with a growth standard fodder provided by Piensos Biona Lalin, Spain (19% protein and 2900 kcal kg⁻¹ ME; for more details see Table 1). Table 1 shows the chemical composition and fatty acid profile of commercial fodder and corn.

Intakes of compound feed and live weight (LW) of birds in all treatment groups were recorded biweekly from 2 to 32 weeks. The animals, at 8 months, were placed in crates and transported to an accredited abattoir, a journey time of approximately 2 h. The birds were weighed, hung on shackles on a slaughter line, killed by manual exsanguination, plucked and eviscerated. The carcasses were chilled in a 4°C cool room for 24 h. The day after, the carcasses were weighed and the left side of the carcass was quartered.

Table 1. Chemical composition and fatty acid profile of commercial fodder and corn

|                | Fodder¹ | Corn² |
|----------------|---------|-------|
| **Chemical composition** |         |       |
| Crude protein   | 17.0    | ND    |
| Crude fibre     | 3.0     | ND    |
| Organic matter  | ND      | 66.5  |
| Neutral detergent fiber | ND | 5.56  |
| Ash             | 6.60    | 0.87  |
| Fat             | 4.10    | 2.53  |
| Moisture        | ND      | 32.62 |
| **Oil fatty acid composition** |         |       |
| C16:0           | 34.99   | 14.13 |
| C16:1           | 0.21    | 0.11  |
| C18:0           | 4.33    | 1.88  |
| C18:1n9c        | 31.06   | 28.52 |
| C18:2n6c        | 26.77   | 52.38 |
| C20:1           | 0.18    | 0.30  |
| C18:3n3         | 1.39    | 1.49  |
| C22:0           | ND      | 0.23  |
| SFA³            | 40.39   | 16.88 |
| MUFA⁴           | 51.45   | 29.04 |
| PUFA⁵           | 28.16   | 54.08 |

¹Fodder additives: vitamines in UI kg⁻¹ (A, 10000; D3, 2500; E, 9), Fe (60 mg kg⁻¹), Zn (50 mg kg⁻¹), Cu (5 mg kg⁻¹), Mn (60 mg kg⁻¹), Co (0.05 mg kg⁻¹), Se (0.20 mg kg⁻¹), iodine (0.40 mg kg⁻¹) and Fe (425 mg kg⁻¹), methionine (0.33%), lysine (0.85%) and P (0.59%). ²Expressed as percentage of dry matter. ND= not determined. ³SFA = saturated fatty acids (sum of C16:0, C18:0, and C22:0). ⁴MUFA = monounsaturated fatty acids (sum of C16:1, C18:1n9c and C20:1). ⁵PUFA = polyunsaturated fatty acids (total, minus SFA and MUFA).
according to the World’s Poultry Science Association recommendations (Jensen, 1983). Carcass portions were obtained as follows: the breast muscle was dissected from the carcass and weighed. The legs were disarticulated at the hip and knee joints and the drum and thigh portions were weighed. The head, neck and feet were also obtained and weighed. Carcass weight (CW) was determined as sum of head, neck, legs, drumstick, thigh, wing and breast, while dressing percentage (DP) was calculated as $DP = \frac{CW}{LW}$. The pectoralis major and peroneus longus muscles were excised from breast and drumstick for analysis. The drumstick was dissected into skin, muscle and bone and the parts of all three portions were individually weighed. Breast was used to measure pH, colour parameters, water holding capacity and textural traits, whereas drumstick was minced and used for chemical composition determinations and sensorial analysis.

Analytical methods

Colour, pH, heme-iron content and chemical composition

The colour, pH and chemical composition of the samples were measured according to Lorenzo et al. (2011), the amount of collagen according to AOAC official method 990.26 (AOAC, 2000), whereas heme-iron content was measured following Franco et al. (2011).

Water holding capacity and texture analysis

Breast cuts were cooked placing vacuum package bags in a water bath with automatic temperature control (JP Selecta, Precisdg, Barcelona, Spain) until they reached an internal temperature of 70°C, controlled by thermocouples type K (Comark, PK23M, UK) and connected to a data logger (Comark Diligenge EVG, N3014, UK). After cooking, samples were cooled in a circulatory water bath set at 18°C during a period of 30 min and the percentage of cooking loss was recorded. All samples were cut perpendicular to the muscle fibre direction at a crosshead speed of 3.33 mm s$^{-1}$ in a texture Analyzer (TA.XT.plus of Stable Micro Systems, Vienna Court, UK).

Four meat pieces of 1 cm height $\times$ 1 cm width $\times$ 2.5 cm length were removed parallel to the muscle fibre direction and were completely cut using a Warner-Braztlr (WB) shear blade with a triangular slot cutting edge (1 mm of thickness). Maximum shear force (Møller, 1980), shear firmness (Brady & Hunecke, 1985) and total necessary work performed to cut the sample were obtained.

The water-holding capacity (WHC) was measured by cooking loss (CL). The CL was evaluated by cooking breast (pectoralis major muscle) as described in the texture analysis. The CL was calculated by measuring the difference in weight between the cooked and raw samples as follows:

$$CL = \frac{\text{weight loss}}{\text{initial fresh meat weight}} \times 100 \quad [1]$$

Analysis of fatty acid methyl esters

Before analysis, intramuscular fat was extracted from 5 g of ground meat sample according to Folch et al. (1957). Lipid extracts were evaporated to dryness under vacuum at 35°C and stored at $-80°C$ until analysis by preparation of fatty acid methyl esters (FAMEs). Lipids were transterified with a solution of boron trifluoride (14%) in methanol, as described by Carreau & Dubaq (1978). Fifty milligrams of the extracted lipids were esterified and the FAMEs were stored at $-80°C$ until chromatographic analysis.

Separation and quantification of the FAMEs were carried out using a gas chromatograph (Agilent 6890N, Agilent Technologies Spain, S.L., Madrid) equipped with a flame ionization detector and an automatic sample injector HP 7683, and using a Supelco SPTM–2560 fused silica capillary column (100 m, 0.25 mm i.d., 0.2 μm film thickness, Supelco Inc, Bellefonte, PA, USA). The chromatographic conditions were as follows: initial column temperature 120°C maintaining this temperature for 5 min, programmed to increase at a rate of 5°C min$^{-1}$ up to 200°C maintaining this temperature for 2 min, then at 1°C min$^{-1}$ up to 240°C maintaining this temperature for 5 min. The injector and detector were maintained at 260°C and 280°C respectively. Helium was used as carrier gas at a constant flow-rate of 1.1 mL min$^{-1}$, with the column head pressure set at 35.56 psi. The split ratio was 1:50, and 1 μL of solution was injected. Nonanoic acid methyl ester (C9:0 ME) at 0.3 mg mL$^{-1}$ was used as internal standard. Individual FAMEs, were
identified by comparing their retention times with those of authenticated standards. Fatty acids were expressed as percentage of the total fatty acids identified.

**Total cholesterol and tocopherols**

The saponification, extraction and simultaneous identification of cholesterol and tocopherols in meat were performed in normal phase following the procedure described by Prates et al. (2006).

**Sensory analysis**

The taste panel evaluation was conducted with eight panellists selected from the Meat Technology Centre of Galicia, San Cibrao das Viñas, Ourense. Panellists were trained according to methodology proposed by ISO regulations (ISO 8586-1:1993 and ISO 8586-2:2008) over 3 months with the attributes and the scale to be used. The samples were individually labelled with 3-digit random numbers. Seven sensory traits of drumstick fresh meat were considered: skin colour, skin transparency, colour meat, uniformity meat, hardness fat, intensity odour and liver odour while for cooked meat were taste intensity, rancidity taste, liver taste, hardness, juiciness, pastiness and fibrousness, following methodology proposed by ISO regulations (ISO 6564:1985, 3972:1991, 11036:1994 and 5496:2006). The intensity of every attribute was expressed on a structured scale from 0 (very low) to 9 (very high) in two sessions, a specific session for these samples and the evaluation session. During sensory evaluation, the panellists were situated in private cubicle illuminated with red light, according to ISO regulations (ISO 8589, 2007). The panellists were given water to clean the palate and remove residual flavours at the beginning of the session and between samples.

**Statistical analyses**

For the statistical analyses of carcass and meat quality results an analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of the SPSS package (SPSS 15.0, Chicago, IL, USA) was performed for all variables considered in the study.

Fixed effect of breed and finishing feeding were included in the model. The model used was:

\[
Y_{ij} = \mu + B_i + P_j + \varepsilon_{ij}
\]  

where \(Y_{ij}\) is the observation of dependent variables, \(\mu\) is the overall mean, \(B_i\) is the effect of breed, \(P_j\) is the effect of finishing feeding, and \(\varepsilon_{ij}\) is the residual random error associated with the observation. Interaction \(B \times P\) was included in the model, only when significance was showed. Correlations between variables \((p < 0.05)\) were determined using the Pearson’s linear correlation coefficient with SPSS 15.0 for Windows (SPSS 15.0, Chicago, IL, USA) software package.

**Results**

Carcass characteristics of Mos and Sasso T-44 roosters slaughtered at 32 weeks are depicted in Table 2. The effect of breed affected LW and CW \((p < 0.001)\) and all commercial cuts except for breast and neck \((p > 0.05)\), whereas finishing dietary affected all traits, except breast and lean/bone ratio of drumstick. As expected, the LW and CW at slaughter clearly differed \((p < 0.001)\) between genotypes at the same age, due to the lower growth rate of Mos roosters, being differences in dressing percentage not statistically different.

Drumstick \((p < 0.001)\), thigh \((p < 0.01)\) and wing \((p < 0.01)\) percentages were significantly higher for Mos animals. However, breast, which is the most highly valued piece of the chicken, was similar for both genotypes. Sasso T-44 rooster presented a higher head (including the comb) than Mos ones \((p < 0.001)\) with values of 4.08% and 2.97%, respectively. The lean:bone ratio was calculated to determine the edible fraction, and was higher for Mos breed \((p < 0.01)\).

Chemical composition of drumstick as well as colour and textural traits from breast for both types of roosters are shown in Table 3. Significant differences in pH, ashes, cholesterol and \(\alpha\)-tocopherol content between genotypes have been found, whereas finishing feeding affected moisture, fat, collagen and all tocopherol isomer family content in the chemical composition. On the other hand, the finishing feeding treatment (corn vs. fodder) had effect on yellowness index and regarding textural traits chewiness was affected. Fat content was affected by finishing feeding with an average value of 0.52 in birds finishing with corn.
The total collagen amount was significantly ($p < 0.01$) more abundant in birds that were finishing fed with fodder. A significant ($p < 0.05$) difference was observed in the cholesterol value between genotypes. Regarding colour instrumental traits, neither luminosity ($L^*$) nor redness ($a^*$) values showed significant differences among groups. However, meat from roosters fed with corn showed a significant ($p < 0.001$) higher yellowness ($b^*$) than presented in birds finishing with fodder.

On the other hand WHC, which was measured as cooking loss (CL), did not show significant differences ($p > 0.05$) between breeds. Textural traits, measured by WB test, were not significantly affected by genotype or finishing feeding treatment. Values recorded for texture profile analysis did not expose significant differences among groups for any parameter studied with the exception of chewiness that was affected by finishing feeding.

The fatty acid (FA) composition of the finishing diets is shown in Table 1. The greatest difference between treatments was found for the linoleic acid and PUFA content, two times higher in corn diet. The intramuscular FA composition (mg FA/g of fat) of breast from all groups studied is shown in Table 4. For both genotypes, the FA proportions in this study are predominated by SFA, MUFA and PUFA with mean values of 40%, 35% and 25%, respectively. Concerning SFA, palmitic acid (C16:0) and stearic acid (C18:0) were the most abundant compounds within this group. Unsaturated fatty acids constituted the main contribution to total amount of FAs due firstly to the high level of oleic acid, as monounsaturated compound, and secondly to the presence of several polyunsaturated fatty acids, such as linoleic acid (C18:2n-6), linolenic acid (C18:3n-3), eicosatrienoic acid (C20:3n-6), arachidonic acid (C20:4n-6) and docosahexanoic acid (C22:6n-3). Mos breed showed higher amount of PUFA (271 vs. 247 mg g$^{-1}$ of fat; $p < 0.01$) and lower percentage of MUFA (338 vs. 375 mg g$^{-1}$ of fat; $p < 0.001$) than Sasso T-44 chicken muscles. For C17:0, C18:2n-6, C20:1, C18:3n-3, C20:2, and C20:3n-6 there were no differences between genotypes ($p > 0.05$), whereas differences in FA profile were mostly less pronounced between the two feeding treatments and only an important FA such as oleic acid and minoritary FA (C16:1 cis-9, C17:0, C20:2, C20:3n-6 and C20:5n-3) were significantly affected by finishing corn fed.

Table 2. Effect of breed (Mos vs. Sasso T-44) and finishing feeding (corn vs. fodder) on carcass quality.

| Breed (B) | Finishing feeding (F) | Significance$^1$ | SEM$^2$ |
|-----------|----------------------|-------------------|--------|
| Mos       | Fodder               | Corn              | B      | F   | B × F |
| Live weight (kg) | 4.04 | 4.85 | 4.29 | 4.37 | *** | * | ** | 0.043 |
| Carcass weight (kg) | 3.34 | 4.02 | 3.54 | 3.63 | *** | * | * | 0.036 |
| Dressing percentage (%) | 82.67 | 82.86 | 82.38 | 83.11 | NS | NS | NS | 0.295 |

$^1$ Significance: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$), NS (not significant). $^2$ SEM is the standard error of the mean.

$^3$ D + T = Drumstick + Thigh.
Total amount of fatty acids n-3 was bigger for Mos breed and the same trend was observed for n-6 FA. These results led to similar ratios n-6/n-3 for both breeds ($p > 0.05$). Meat of Mos roosters presented similar levels of SFA ($p > 0.05$) than Sasso-T44 ones, but higher levels of PUFA ($p < 0.001$). Thus relation PUFA/SFA was higher for Mos breed.

Mean scores given by the panellists for four groups studied are shown in Table 5. Colour and transparency of skin and hardness fat were affected by genotype. A similar trend was observed when the finishing diet effect was studied. There were no significant differences ($p > 0.05$) in raw meat between Mos and Sasso T-44. However, when the meat was cooked, the

### Table 3. Effect of breed (Mos vs. Sasso T-44) and finishing feeding (corn vs. fodder) on meat quality (chemical composition of drumstick as well as colour and textural parameters from breast)

| Chemical composition                   | Breed (B) | Finishing feeding (F) | Significance$^1$ | SEM$^2$ |
|----------------------------------------|-----------|-----------------------|------------------|---------|
|                                        | Mos       | T-44      | Fodder | Corn | B | F | B × F |
| pH                                     | 5.95      | 6.02      | 5.96   | 5.98 | * | NS | NS | 0.015 |
| Water (%)                              | 74.66     | 74.06     | 74.77  | 74.21 | NS* | NS* | NS | 0.154 |
| Protein (%)                            | 21.74     | 21.68     | 21.67  | 21.75 | NS* | NS* | NS | 0.109 |
| Fat (%)                                | 0.39      | 0.48      | 0.29   | 0.52  | NS* | NS* | NS | 0.056 |
| Ashes (%)                              | 1.28      | 1.24      | 1.25   | 1.27  | ** | NS | NS | 0.006 |
| Collagen (%)                           | 0.83      | 0.74      | 0.99   | 0.67  | NS** | ** | *** | 0.037 |
| TBARS$^3$                              | 0.04      | 0.03      | 0.03   | 0.04  | NS | NS | NS | 0.045 |
| Myoglobin (mg/100 g wet meat)          | 2.82      | 2.97      | 2.80   | 2.99  | NS | NS | NS | 0.07  |
| cholesterol (mg g$^{-1}$ wet meat)     | 0.57      | 0.53      | 0.55   | 0.55  | *  | NS | NS | 0.009 |
| α-tocopherol (mg g$^{-1}$ wet meat)    | 0.53      | 0.68      | 0.55   | 0.66  | ***| ** | NS | 0.017 |
| β-tocopherol (mg g$^{-1}$ wet meat)    | 0.18      | 0.16      | 0.14   | 0.21  | NS***| NS | NS | 0.004 |
| γ-tocopherol (mg g$^{-1}$ wet meat)    | 0.22      | 0.23      | 0.25   | 0.19  | NS***| NS | NS | 0.005 |
| β-carotene (mg g$^{-1}$ wet meat)      | 0.01      | 0.01      | 0.01   | 0.02  | NS***| NS | NS | 0.000 |
| Colour parameters                      |           |           |       |      |    |    |     |
| Luminosity ($L^*$)                     | 52.67     | 50.94     | 52.32  | 51.78 | NS | NS | NS | 0.367 |
| Redness ($a^*$)                        | 1.35      | 1.47      | 1.61   | 1.26  | NS | NS | NS | 0.126 |
| Yellowness ($b^*$)                     | 3.01      | 2.88      | 1.65   | 3.80  | NS***| NS | NS | 0.215 |
| WHC$^4$                                |           |           |       |      |    |    |     |
| Cooking loss (%)                       | 12.51     | 12.32     | 12.09  | 12.60 | NS | NS | NS | 0.357 |
| Textural parameters                    |           |           |       |      |    |    |     |
| Shear force (kg cm$^{-2}$)             | 1.59      | 1.56      | 1.57   | 1.58  | NS | NS | NS | 0.039 |
| Firmness (kg cm$^{-2}$)                | 0.48      | 0.47      | 0.49   | 0.46  | NS | NS | NS | 0.017 |
| Total work (kg × s)                    | 5.23      | 5.03      | 5.51   | 4.78  | NS | NS | NS | 0.257 |
| TPA$^5$-test                           |           |           |       |      |    |    |     |
| Hardness (kg)                          | 4.15      | 3.99      | 4.40   | 3.78  | NS | NS | NS | 0.193 |
| Springiness (mm)                       | 0.45      | 0.46      | 0.47   | 0.44  | NS | NS | NS | 0.008 |
| Chewiness (kg × mm)                    | 1.20      | 1.23      | 1.34   | 1.08  | NS* | NS | NS | 0.067 |
| Gumminess (kg)                         | 2.46      | 2.46      | 2.64   | 2.27  | NS | NS | NS | 0.113 |
| Cohesiveness                           | 0.61      | 0.62      | 0.61   | 0.61  | NS | NS | NS | 0.006 |

$^1$ Significance: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$), NS (not significant).  $^2$ SEM is the standard error of the mean.  $^3$ TBARS: Thiobarbituric acid reactive substances.  $^4$ WHC: Water holding capacity.  $^5$ TPA: Textural profile analysis.
taste intensity was significantly ($p < 0.001$) higher in Mos breed. Regarding to texture attributes, hardness and juiciness were also significantly affected by genotype ($p < 0.001$). A lesser effect was found with the finishing effect. The first one showed high scores in Sasso T-44 (4.55 vs. 5.94; $p < 0.001$) and in breast samples from birds finishing with fodder (4.66 vs. 5.83; $p < 0.01$).

**Discussion**

It is well-known in chickens that the indigenous breeds show much more slowly growths than those obtained by commercial broilers (Wattanachant et al., 2004). Rodríguez (2010) studied the growth of ‘Villalba Capón’ (a typical Christmas dish of Galicia obtained from rooster) animals, that are obtained with the castrated Mos breed and Sasso T-44. This author found LW of 4.360 kg and 5.027 kg for Mos breed and Sasso T-44, at 32 weeks respectively. Other Spanish autochthonous breeds revealed inferior LW at 30 weeks than corresponding Mos growths observed in Table 2.

Regarding dressing percentage our results were similar to those reported by Sanchez et al. (2005) for both genotypes slaughtered at 8 months. The carcass yield for the Mos breed was higher than that reported for other Spanish autochthonous breeds such as Castellana Negra cock slaughtered at 29 weeks (Miguel et al., 2008) and higher than that reported for Penedeseca Negra roosters slaughtered at 28 weeks (Tor et al., 2002). In previous studies, similar dressing percentage was found for Mos breed slaughtered at 24 and 40 weeks (Franco et al., 2012a,b).

### Table 4. Effect of breed (Mos vs. Sasso T-44) and finishing feeding (corn vs. fodder) on fatty acid profile of breast (mg of fatty acid/g of intramuscular fat)

| Fatty acids | Breed (B) Fatty acid profile | Finishing feeding (F) | Significance$^1$ | SEM$^2$ |
|-------------|-----------------------------|-----------------------|-------------------|---------|
|             | Mos T-44eteor Fodder Corn    |                       |                   |         |
| C14:0       | 7.06 9.63 8.31 7.71          | ▶▶▶ NS * 0.200       |                   |         |
| C15:0       | 0.95 0.67 0.77 0.92          | ▶▶ NS NS NS 0.04     |                   |         |
| C16:0       | 270.12 300.01 286.03 276.32  | ▶▶▶ NS NS NS 3.52    |                   |         |
| C16:1cis-9  | 20.69 26.30 25.44 20.22      | ▶▶▶ * ▶▶▶ 0.69      |                   |         |
| C17:0       | 1.17 0.72 0.71 1.27          | NS NS NS 0.13        |                   |         |
| C17:1       | 0.46 0.24 0.21 0.54          | ▶▶ ▶▶ NS NS 0.03     |                   |         |
| C18:0       | 120.00 104.96 110.95 117.84  | ▶NS NS NS 2.37       |                   |         |
| C18:1cis-9  | 307.50 340.62 325.61 313.93  | ▶▶ NS NS 3.97        |                   |         |
| C18:2n-6    | 198.96 190.01 195.31 196.07  | NS NS NS 3.15        |                   |         |
| C20:1       | 0.70 0.56 0.57 0.72          | NS NS * 0.05         |                   |         |
| C18:3n-3    | 8.31 9.08 8.84 8.37          | NS NS NS 0.29        |                   |         |
| C20:2       | 1.55 1.51 1.29 1.77          | NS * NS 0.10         |                   |         |
| C20:3n-6    | 2.97 2.86 3.59 2.32          | ▶▶▶ * ▶▶▶ 0.10      |                   |         |
| C20:4n-6    | 53.14 39.08 51.91 44.43      | ▶▶▶ NS * 1.57       |                   |         |
| C20:5n-3    | 0.60 0.15 0.90 0.00          | ▶▶ ▶▶ ▶▶ 0.07       |                   |         |
| C24:1       | 9.13 7.87 9.67 7.75          | * * ▶▶▶ 0.25        |                   |         |
| C22:6n-3    | 5.66 4.45 5.61 4.87          | ▶ NS NS 0.26        |                   |         |
| SFA$^3$     | 399.32 416.00 406.81 404.06  | NS NS NS 4.64       |                   |         |
| MUFA$^4$    | 338.49 375.61 361.54 343.16  | NS NS NS 4.15       |                   |         |
| PUFA$^5$    | 271.24 247.17 267.48 257.87  | ▶ NS * 3.69         |                   |         |
| Σn-3$^6$    | 14.02 13.55 14.49 13.25      | NS NS NS 0.42       |                   |         |
| Σn-6$^7$    | 255.08 231.95 250.82 242.83  | ▶ NS * 3.60         |                   |         |
| n-6/n-3     | 19.87 18.07 18.28 20.08      | NS NS NS 0.81       |                   |         |
| PUFA/SFA    | 0.68 0.59 0.66 0.64          | NS NS NS 0.008      |                   |         |

$^1$ Significance: ▶▶▶ ($p < 0.001$), ▶▶ ($p < 0.01$), ▶ ($p < 0.05$), NS (not significant). $^2$ SEM is the standard error of the mean. $^3$ SFA: saturated fatty acids. $^4$ MUFA: monounsaturated fatty acids. $^5$ PUFA: polyunsaturated fatty acids. $^6$ n-3: omega-3 fatty acids. $^7$ n-6: omega-6 fatty acids.
In recent years, the quartering results have acquired relevance because of the trend of commercializing chickens in pieces. Thus, the most appreciate parts are breast and drumstick, and their percentages over total carcass are good markers of the animal economic value. The value of 15.07% for breast found in Mos roosters remained in the same order than values found by Quentin et al. (2003) for a commercial French ‘label’ type and by Berry et al. (2001) for a genetically selected broiler strain. Similar results were observed by Jaturashita et al. (2008), for an indigenous Thai breed, who reported values around 15.5% for breast yield. With regard to drumstick percentage, values for Mos and Sasso T-44 were 14.7 and 13.1 respectively, as observed in Table 2, higher ($p < 0.001$) for Mos breed. Mos value was similar to those obtained by Santos et al. (2005) and Castellini et al. (2002) in broilers from an autochthonous Brazilian breed (Paraiso Pedres) and in Ross breed, respectively. Besides, the dissection of the drumstick allowed estimating in a precise way, the proportion of meat, bone and skin of the whole carcass. Relation lean/bone was 3.06 for Mos rooster breed, a higher value than 2.72 found for Sasso-T44 rooster ($p < 0.05$). Also, the sum of drumstick and thigh (D + T in Table 2) provides an idea of the ratio between the weight of the edible products and the bones, which gives a good image of carcass quality as a whole (Ricard, 1972). In the present study Mos breed had a significantly higher percentage of edible product than Sasso T-44 (32.93 vs. 30.24; $p < 0.001$). In addition, this percentage decreased with the age, because in Mos birds slaughtered at 24 and 40 weeks this edible part was 34.25 (Franco et al., 2012a) and 32.28 (Franco et al., 2012b), respectively.

According to these results, it has been demonstrated that Mos breed provided similar or even higher economic interest than Sasso T-44 breed. Although full carcass weight of Mos breed was lower, the percentage for most appreciated parts, wing, thigh and drumstick, remained higher; this is an important issue from an economical and productive point of view.

### Table 5. Effect of breed (Mos vs. Sasso T-44) and finishing feeding (corn vs. fodder) on sensorial analysis.

| Breed (B) | Finishing feeding (F) | Significance$^1$ | SEM$^2$ |
|-----------|-----------------------|-----------------|--------|
| Mos       | T-44                  | Fodder | Corn  | B | F | B × F |
| Skin appearance |                      |        |       |    |    |       |
| Colour    | 3.22  | 5.27  | 3.83  | 4.66 | *** | **  | **   | 0.13 |
| Transparency | 5.83  | 3.22  | 4.55  | 4.50 | *** | NS  | NS   | 0.18 |
| Colour meat | 5.66  | 5.83  | 5.77  | 5.72 | NS  | NS  | NS   | 0.18 |
| Uniformity meat | 6.33  | 6.33  | 6.50  | 6.16 | NS  | NS  | NS   | 0.12 |
| Hardness fat | 4.50  | 6.77  | 5.33  | 5.94 | *** | *   | NS   | 0.15 |
| Odour |                      |        |       |    |    |       |
| Intensity | 3.61  | 2.88  | 3.66  | 2.83 | NS  | NS  | NS   | 0.25 |
| Liver     | 0.88  | 0.44  | 0.61  | 0.72 | NS  | NS  | NS   | 0.17 |
| Cooked meat |                      |        |       |    |    |       |
| Taste |                      |        |       |    |    |       |
| Intensity | 6.61  | 5.05  | 5.94  | 5.72 | *** | NS  | NS   | 0.17 |
| Rancid    | 0.50  | 0.55  | 0.50  | 0.55 | NS  | NS  | NS   | 0.17 |
| Liver     | 2.83  | 2.83  | 4.55  | 2.83 | NS  | NS  | NS   | 0.22 |
| Texture |                      |        |       |    |    |       |
| Hardness | 4.55  | 5.94  | 5.83  | 4.66 | *** | **  | **   | 0.16 |
| Juiciness | 5.50  | 4.16  | 4.38  | 5.27 | *** | *   | NS   | 0.16 |
| Pastiness | 1.66  | 2.05  | 1.88  | 1.83 | NS  | NS  | NS   | 0.27 |
| Fibrousnesses | 3.27  | 3.72  | 3.72  | 3.27 | NS  | NS  | NS   | 0.22 |

$^1$ Significance: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$), NS (not significant).  $^2$ SEM is the standard error of the mean.
The pH values measured in the breast muscle at 24 h post-mortem were significantly different between genotypes. This fact could be due to differences in behaviour, more aggressive and alert in indigenous strains than in hybrid lines. In a previous work with castrated animal of Mos breed and Sasso T-44 (slaughtered at 8 months), Díaz et al. (2010) found pH breast values of 5.47 and 5.67, respectively. Low pH of chickens could be due to the better welfare conditions that reduce the stress pre-slaughter and consequently the consumption of glycogen (Castellini et al., 2002). In the present study, all birds were manipulated and transported in the same conditions, thus, the lower pH observed could be consequence of a major capacity of Mos chickens to metabolize another substrate than glycogen during transport step (Musa et al., 2006). A pH similar to that presented in birds of this study was found in Castellana Negra (Miguel et al., 2008) and in other indigenous chicken breeds (Jaturasitha et al., 2008). On the contrary De Marchi et al. (2005) found lower pH values in Padovana chickens. Differences could be attributable to favourable conditions during transport and slaughter (resting period).

Mean values of moisture content in pectoralis major muscle (74.36%) were inside the range of values described by other authors (74-76%) in improved hybrids commercial breeds for meat production (Wattanachant et al., 2004) and autochthonous breeds (Wattanachant et al., 2004; De Marchi et al., 2005; Miguel et al., 2008).

Mean values of protein (21.71%) was higher than those reported in broilers (Wattanachant et al., 2004) and lower than other values described in the bibliography for autochthonous breeds (De Marchi et al., 2005; Miguel et al., 2008), broilers (Ding et al., 1999; Qiao et al., 2002) and broilers in an organic system (Castellini et al., 2002) with protein contents in the range of 22.6% to 24.7%.

Mean values of cholesterol found in drumstick in the present study (55 mg/100 g) are similar to those found by Konjufca et al. (1997) and Komprda et al. (2003). Comparison of the results between present study and literature are very difficult because the analytical method used to measure cholesterol content in various animal tissues depends strongly on the method of determination (Komprda et al., 2003). The daily intake of cholesterol currently recommended must not exceed 300 mg (www.nal.usda.gov/foodcomp/search). Therefore, the knowledge about cholesterol content in foods is important, especially in poultry meat because consumption of these foods is currently increasing based on the recommendations of healthy nutrition and price. In the light of the results, a 100-g portion of chicken drumstick meat without skin represents 19% of the upper limit of daily cholesterol intake concerning α-tocopherol; this value is lower than the one detected by Carreras et al. (2004), who found values of 2.40 mg g⁻¹ in breast. These authors explain that dietary supplementation with this vitamin results in higher amounts of vitamin E in muscle tissues (Carreras et al., 2004) and in the present study fodder formulation contains a scarce amount of vitamin E (≤ 6 mg kg⁻¹). Similar values were previously reported in older animals (Franco et al., 2012b).

Meat colour is a crucial quality attribute for consumers in order to choose poultry meat. Meat and skin colour are influenced by various factors, including genetic and feeding (Fletcher, 1999; Xiong et al., 1999) and the present study confirmed the presence of a strong feeding influence. According to Fletcher (2002) breed is a factor that affects poultry meat colour; however in our study there were not significant differences by genotype effect. Luminosity value for Mos breed was 52.7; this value was slightly higher than obtained by Castellini et al. (2002) for chickens produced in organic farming and by Quentin et al. (2003) for fast-growing selected ones. A negative correlation (r = −0.38, p < 0.01) between L* and pH was found, belonging the lowest pH and the highest L* to both genotypes. This finding is in accordance with that reported by Le Bihan-Duval et al. (2008).

Cooking loss of 12.51-12.32% for Mos and Sasso T-44, respectively, was lower when compared to the 33% and 31% reported for organic and broiler chickens (Castellini et al., 2002) and 19-23% found for the Thai indigenous chicken (Wattanachant et al., 2004; Jaturasitha et al., 2008). Results in the same range were found in Padovana breed chicken (13-14%) (De Marchi et al., 2005), while Díaz et al. (2010) observed higher values (19%) than those found in our study in Mos and Sasso T-44 slaughtered at 8 months of age.

In disagreement with our study Jaturasitha et al. (2008) found differences in breast muscle shear force in four different genotypes. The meat tenderness that increases when shear force decreases depends mainly on the post-mortem changes affecting myofibrillar proteins and on the connective tissue that represents the background toughness (Ariño et al., 2006).
Díaz et al. (2010) reported shear force values of 3.48 kg cm\(^{-2}\) for Mos breed slaughtered at 8 months and these authors did not find breed effect when comparing Sasso T-44 and Mos, which is consistent with our study. Jaturasitha et al. (2008) also found higher values in Thai breed (3.87 kg cm\(^{-2}\)). Values in the same order (2.1 kg cm\(^{-2}\)) were found by Castellini et al. (2002) for conventional broilers. In different species, it has been established that the values of shear force increased with age (Aberle et al., 2001; Fletcher, 2002). It can be confirmed, because Mos animals slaughtered at 40 weeks support this affirmation with values of 2.10 kg cm\(^{-2}\). Also, values of hardness were higher in these animals (5.64 kg) (Franco et al., 2012b). This is noticeable in the present study, as shear force levels were slightly higher than those found for broiler breast meat (Cavitt et al., 2004; Fanatico et al., 2005).

Regarding PUFA content, our results are in disagreement with those reported by other authors for breast meat (Crespo & Esteve-García, 2002; Tor et al., 2005; Rikimaru et al., 2009) since MUFA were the most abundant of fatty acids. Surprisingly, the PUFA content in the tissues did not increase, when dietary PUFA level increase (birds finishing with corn; see corn FA in Table 1) in disagreement with results found by Cortinas et al. (2004). In all cases monounsaturated oleic acid (C18:1cis9) was the major compound, according with data reported by Cortinas et al. (2004) and other authors (Crespo & Esteve García, 2002; Azcona, et al., 2008) in poultry meat. In this study, oleic acid had the lowest percentaje (\(p < 0.001\)), with values of 30% and 33% for Mos and Sasso T44 breeds, respectively, followed by palmitic acid (28%) and linoleic acid (19%) for both genotypes. This pattern was consistent with those reported by Sheu & Chen (2002), De Marchi et al. (2005) and Tor et al. (2005). However, these results are not in agreement with those reported by Jaturasitha et al. (2008) in breast raw meat of Thai chicken since palmitic was the most abundant FA, followed by linolenic acid. In contrast, other studies reported linolenic as the predominant FA in Castellana Negra cocks (Miguel et al., 2008). Mos breed had greater levels of linoleic and stearic acid than Sasso T-44 cocks, whereas palmitic and oleic acid were higher for Sasso T-44 than Mos breed. Concentrations of minority PUFA, such as C20:4n6 and C22:6n3 were higher in Mos class that suggested an upper ability of this chicken breed for the transformation of linoleic and linolenic acids in these polyunsaturated compounds.

Ratio n-6/n-3 was under 20 for Mos chickens; this value was in the same order that the one obtained by Jaturashita et al. (2008) in chickens of different autochthonous Thai breeds and was below the value obtained when another kinds of diets, enriched in C18:2n6, were used, such as sunflower oil based diets (Crespo & Esteve-García, 2001).

To assess the nutritional index of breast meat fat, the PUFA/SFA ratio (P/S) was determined. P/S ratio was higher for Mos breed remaining up to minimum recommended of 0.4 (Wood et al., 2004). In this study, breast from Mos breed showed a P/S ratio of 0.68. This P/S ratio was within the range 0.5-0.7 reported as being typical of the Mediterranean diet (Ulbricht & Southgate, 1991). The P/S ratio for Mos breed was greater than those reported for Thai indigenous broilers (0.19) and chickens (0.06) (Wattanachant et al., 2004). On the contrary, Jaturasitha et al. (2008) found P/S ratios of 0.80 and 0.85 for Thai indigenous broilers and chickens due to strong relationship between dietary fat source and adipose tissue content (Scaife et al., 1994; López Ferrer et al., 1999).

Tenderness is generally the most important attribute driving meat acceptance (Fletcher, 2002); however, meat is not a homogeneous product, as there is tenderness variation from fillet to fillet (Cavitt et al., 2004). On the other hand, juiciness (the amount of perceived juices in the meat during chewing), which is very important for the consumers because of the major meat characteristics influencing eating quality (Maltin et al., 1997; Latter-Dubois, 2000), was higher in Mos breed (5.50 vs. 4.16; \(p < 0.001\)) and in birds finished with corn (5.27 vs. 4.38; \(p < 0.05\)).

As final conclusions, there was a wide difference in carcass characteristics between the Mos breed and commercial strain Sasso T-44 breed. Corn-based finishing diet is beneficial due to the increment of intramuscular fat in the breast, decreasing in collagen content and increasing in levels of tocopherols. Textural properties for both treatments and both genotype was not affected. Furthermore, yellowness of meat was influenced by the presence of corn. On the contrary, corn had minor effect on fatty acid profile, while genotype had a major influence. A trained panel confirmed differences in external appearances, taste intensity and textural properties between genotypes.

Finally, an increase in slaughtered age (from six to eight months) provides an increase in percentage breast and a decrease in percentage thigh. Slaughtered age and hardness (from six to ten months) were negatively
correlated to intramuscular fat so that increasing in slaughtered age decreased intramuscular fat.

**Acknowledgments**

Authors are grateful to Xunta de Galicia (the Regional Government) for its financial support (PGIDIT09MRU001CT).

**References**

Aberle EJ, Forrest D, Gerrard E, Mills H, Hedric M, Judge, 2001. Principles of meat science, 4th ed. Kendall–Hunt Publ Co, IA, USA.

AOAC, 2000. AOAC official method 990.26. Hydroxyproline in meat and meat products. 39.1.27. In: Official methods of analysis, 17th ed. Association of Official Analytical Chemists, Arlington, VA, USA.

Ariño B, Hernandez P, Blasco A, 2006. Comparison of texture and biochemical characteristics of three rabbit lines selected for litter size or growth rate. Meat Sci 73: 687-692.

Azcona JO, Garcia PT, Cossu ME, Iglesias BF, Picallo A, Perez C, Gallinger CI, Schang MJ, Canet ZE, 2008. Meat quality of argentainean “camperos” chicken enhanced in omega-3 and omega-9 fatty acids. Meat Sci 79: 437-443.

Berry C, Wacrenier N, Millet N, Le Bihan-Duval E, 2001. Effect of selection for improved body composition on muscle and meat characteristics of broilers from experimental and commercial lines. Poult Sci 80: 833-838.

Brady PL, Hunecke ME, 1985. Correlations of sensory and instrumental evaluations of roast beef texture. J Food Sci 50: 300-303.

Carreau JP, Dubaccq JP, 1978. Adaptation of a macro-scale method to the micro-scale for fatty acid methyl transesterification of biological lipid extracts. J Chromatogr A 151: 384-390.

Carreras IL, Guerrero MD, Guardia E, Esteve-Garcia JA, Garcia, JA, Regueiro Sárraga C, 2004. Vitamin E levels, thiobarbituric acid test and sensory evaluation of breast muscles from broilers fed a-tocopheryl acetate and β-carotene-supplemented diets. J Anim Sci Food Agr 84: 313-317.

Cason JA, Fletcher DL, Burke WH, 1988. Research note: effects of caponization on broiler growth. Poult Sci 67: 979-981.

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

Cavitt LC, Young GW, Meullenet JF, Owens CM, Xiong R, 2004. Prediction of poultry meat tenderness using razor blade shear, Allo-Kramer shear, and sarcomere length. J Food Sci 69: 3274-3283.

Cortinas L, Villaverde C, Galobart J, Baucells MD, Codony R, Barroeta AC, 2004. Fatty acid content in chicken thigh and breast as affected by dietary polyunsaturation level. Poult Sci 83: 1155-1164.

Crespo N, Esteve-García E, 2001. Dietary fatty acid profile modifies abdominal fat deposition in broiler chickens. Poult Sci 80: 71-78.

Crespo N, Esteve-Garcia E, 2002. Nutrient and fatty acid deposition in broilers fed different dietary fatty acid profiles. Poult Sci 81: 1533-1542.

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

Diaz OL, Rodriguez A, Torres A, Cobos A, 2010. Chemical composition and physico-chemical properties of meat from capons as affected by breed and age. Span J Agric Res 8: 91-99.

Ding HR, Xu J, Chan DKO, 1999. Identification of broiler chicken meat using a visible/near-infrared spectroscopic technique. J Sci Food Agr 79: 1382-1388.

Fanatico AC, Cavitt LC, Pillai PB, Emmert JL, Owens CM, 2005. Evaluation of slower-growing broiler genotypes grown with and without outdoor access: meat quality. Poult Sci 84: 1785-1790.

Fletcher DL, 1999. Broiler breast meat color variation, pH, and texture. Poult Sci 78: 1323-1327.

Fletcher DL, 2002. Poultry meat quality. World’s Poultry Sci J 58: 131-145.

Folch J, Lees M, Sloane-Stanley GH, 1957. A simple method for the isolation and purification of total lipids from animal tissues. J Biol Chem 226: 497-509.

Franco D, Rodríguez E, Purriños L, Crespo N, Esteve-García E, 2001. Vitamin E levels, thiobarbituric acid test and sensory evaluation of breast muscles from broilers fed a-tocopheryl acetate and ß-carotene-supplemented diets. J Anim Sci Food Agr 84: 313-317.

Fletcher DL, 2002. Poultry meat quality. World’s Poultry Sci J 58: 131-145.

Folch J, Lees M, Sloane-Stanley GH, 1957. A simple method for the isolation and purification of total lipids from animal tissues. J Biol Chem 226: 497-509.

Franco D, Rodríguez E, Purriños L, Cercenes S, Bermúdez R, Lorenzo JM, 2011. Meat quality of “Galician Mountain” foals breed. Effect of sex, slaughter age and livestock production system. Meat Sci 88: 292-298.

Franco D, Rois D, Vázquez JA, Purriños L, González R, Lorenzo JM, 2012a. Breed effect between Mos rooster (Galician indigenous breed) and Sasso T-44 line and finishing feed effect of commercial fodder or corn. Poultry Sci 91: 487-498.

Franco D, Rois D, Vázquez JA, Lorenzo JM, 2012b. Comparison of growth performance, carcass components, and meat quality between Mos rooster (Galician indigenous breed) and Sasso T-44 line and finishing feed effect of commercial fodder or corn. Poultry Sci 91: 1227-1239.

ISO, 1985. Methodology. Flavour profile methods, ISO 6564:1985. International Organization for Standardization, Geneva, Switzerland.

ISO, 1991. Method of investigating sensitivity of taste, ISO 3972:1991.

ISO, 1993. General guidance for the selection, training and monitoring of assessors. Part 1: Selected assessors, ISO 8586-1:1993.

ISO, 1994. Methodology. Texture profile, ISO 11036:1994.

ISO, 2006. Methodology. Initiation and training of assessors in the detection and recognition of odours, ISO 5496:2006.

ISO, 2007. General guidance for the design of test rooms, ISO 8589:2007.

ISO, 2008. General guidance for the selection, training and monitoring of assessors. Part 2: Expert sensory assessors, ISO 8586-2:2008.
Jaturasitha S, Srikanchhai 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). Poult Sci 87: 160-169.

Jensen J, 1983. Method of dissection of broiler carcasses and description of parts. Papworth’s Pendragon Press, Cambridge, UK.

Komprda T, Zelenka J, Fajmonová E, Bakaj P, Pechova P, 2003. Cholesterol content in meat of some poultry and fish species as influenced by live weight and total lipid content. J Agric Food Chem 51: 7692-7697.

Konjufca VH, Pesti GM, Bakalli RL, 1997. Modulation of cholesterol levels in broiler meat by dietary garlic and copper. Poult Sci 76: 1264-1271.

Latter-Dubois J, 2000. Poulets fermiers: leurs qualités nutritionnelles et organoleptiques et la perception du consommateur. MS Faculté des Sciences de l’Agriculture et de l’Alimentation. Univ Laval, Quebec, Canada.

Le Bihan-Duval E, Debut M, Berri CM, Sellier N, Sante-Lhoutellier V, Jego Y, Beaumont C, 2008. Chicken meat quality: genetic variability and relationship with growth and muscle characteristics. BMC Genetics 9: 56.

López-Ferrer S, Baucells MD, Barrota AC, Grashorn MA, 1999. N-3 enrichment of chicken meat using fish oil: alternative substitution with rapeseed and linseed oils. Poult Sci 78: 356-365.

Lorenzo JM, Purrinos L, Temperan S, Bermúdez R, Tallon S, Franco D, 2011. Physicochemical and nutritional composition of dry-cured duck breast. Poult Sci 90: 931-940.

Maltin CA, Warkup CC, Matthews KR, Grant CM, Porter AD, Delday MI, 1997. Pig muscle fibre characteristics as a source of variation in eating quality. Meat Sci 47: 237-248.

Miguel JA, Asenjo B, Ciria J, Calvo JL, 2008. Effect of caponisation on growth and carcass meat characteristics in Castellana Negra native Spanish chicken. Animal 2: 305-311.

Moeller A, 1980. Analysis of Warner Bratzler shear force pattern with regard to myofibrillar and connective tissue components of tenderness. Meat Sci 5: 247-260.

Musa HH, Chen GH, Cheng JH, Shuiep ES, Bao WB, 2006. Breed and sex effect on meat quality of chicken. Int J Poult Sci 5: 566-568.

OJ, 2008. Directive 543/2008/CE of the Council of June 16. Official Journal of the European Union L 157/64/2008. pp: 68-69.

Prates JA, Gonçalves Quaresma MA, Branquinho Bessa RJ, Andrade Fontes C, Mateus Alfaia C, 2006. Simultaneous HPLC quantification of total cholesterol, tocopherols and β-carotene in Barrosã-PDO veal. Food Chem 94: 469-477.

Qiao M, Fletcher DL, Northcutt J, Smith DP, 2002. The relationship between raw broiler breast meat color and composition. Poult Sci 81: 422-427.

Quentin M, Bouvarel I, Berri C, Le Bihan-Duval E, Baeza E, Jego Y, Picard M, 2003. Growth, carcass composition and meat quality response to dietary concentrations in fast-, medium- and slow-growing commercial broilers. Anim Res 52: 65-77.

Ricard FH, 1972. Étude de la composition anatomicque du poulet. IV- Possibilités d’estimation des pourcentages de viande, d’os et de peau à partir d’une dissection simplifiée des membres. Ann Zootech 21: 49-57.

Rikimaru K, Ogawa S, Komatsu M, Isizuka J, 2009. Effects of caponization on meat quality of Hinaijidori chicken. Japan Poult Sci 46: 345-350.

Rivero CJ, Rois D, Fernández M, Justo JR, Adán S, Lama J, 2007. Study of the increase of weight and index of conversion in a population of Galina de Mos. Arch Zootec 56: 529-534.

Rodríguez L, 2010. Efectos de la raza, edad de sacrificio y alimentación en los parámetros de calidad de la canal y carne del capón de Villalba. Doctoral Thesis. Universidad de Santiago de Compostela, Spain.

Rois D, Rivero CJ, Fernandez M, Rivero G, 2009. Galína de Mos. In: Guía de Campo de las Razas Autóctonas Españolas. RAE 235 (Fernández M, Gómez M, Delgado JV, Adán S, Jiménez M, coords). Sociedad Española para los Recursos Genéticos Animales, Ministerio de Medio Ambiente y Medio Rural y Marino. Spain. pp: 638-641.

Sánchez L, Le de la Calle B, Iglesias A, Sánchez B, 2005. Use of native ancestries for the production of chicken label. Arch Zootec 206: 491-496.

Santos AL, Sakomura NK, Freitas ER, Fortes CL, Carrilho EM, Fernandes JB, 2005. Growth, performance, carcass yield and meat quality of three broiler chickens strains. Rev Bras Ciencia Avicola 34: 1589-1598.

Scalfé JR, Moyo J, Galbraith H, Michie W, Campbell V, 1994. Effect of different dietary supplemental fats and oils on the tissue fatty acid composition and growth of female broilers. Brit Poult Sci 35: 107-118.

Sheu KS, Chen TC, 2002. Yield and quality characteristics of edible broiler skin fat obtained from five rendering methods. J Food Eng 55: 263-269.

Tor M, Estany J, Villalba D, Molina E, Cubiño D, 2002. Comparison of carcass composition by parts and tissues between cocks and capons. Anim Res 51: 421-431.

Tor M, Estany J, Franches D, Cubiño D, 2005. Comparison of fatty acid profiles of edible meat, adipose tissues and muscles between cocks and capons. Anim Res 54: 413-424.

Ulbricht TLV, Southgate DAT, 1991. Coronary heart disease: Seven dietary factors. Lancet 338: 985-992.

Wattanachant S, Benjakul S, Ledward DA, 2004. Composition, color, and texture of Thai indigenous and broiler chicken muscles. Poult Sci 83: 123-128.

Wood JD, Nute GR, Richardson RI, Whittington FM, Southwood O, Plastow G, Mansbridge R, Da Costa N, Chang KC, 2004. Effects of breed, diet and muscle on fat deposition and eating quality in pigs. Meat Sci 67: 651-667.

Xiong YL, Ho CT, Shahidi F, 1999. Quality characteristic of muscle food. In: Quality attributes of muscle foods (Xiong YL, Ho CT, Shahidi F, eds). Kluwer Acad/Plenum Publ, NY. pp: 309-318.

Carcass morphology and meat quality of meat from roosters