Growth performance, carcass morphology and meat quality of meat from roosters slaughtered at eight months affected by genotype and finishing feeding

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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 rooster from hybrid line Sasso T44 was used in this study. Birds were reared on their typical production system (extensive indoor or barns and finishing diet whit corn). Both live weight 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 α-tocopherol content between genotypes have been found, whereas finishing feeding treatment had effect on moisture, intramuscular fat content, cholesterol, tocopherol isomers and in 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 acid (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: poultry production, autochthonous breed, sensory properties

Resumen

Efecto del genotipo y acabado en el crecimiento, morfología de la canal y calidad de la carne de gallos sacrificados a los ocho meses

El objetivo de este estudio consistió en describir las características de la canal y de la calidad de la carne de gallos de la raza autóctona Mos sacrificados a los 8 meses de edad. Con fines comparativos se realizó el trabajo también con gallos de la línea Sasso T-44. Estos fueron criados en un sistema de producción tradicional (sistema extensivo con acabado con maíz). Tanto el peso vivo como el peso canal fueron mayores en el genotipo comercial (p<0,001). Los porcentajes de contramuslo, muslo y ala fueron superiores en la raza Mos, mientras que la pechuga fue similar en ambos genotipos. Se encontraron diferencias en el contenido en colesterol y en α-tocopherol por efecto del genotipo, mientras que el acabado afectó al contenido en agua, grasa intramuscular, colesterol, isómeros del tocoferol e índice de amarillo de la carne. Los ácidos grasos insaturados fueron mayoritarios dentro del perfil de ácidos grasos, siendo el ácido oleico el principal, encontrándose en mayor proporción en los gallos comerciales. La carne de la raza Mos presentó altas cantidades de ácidos grasos poliinsaturados (PUFA) y menores de monoinsaturados (MUFA) que Sasso T-44. La relación PUFA/MUFA fue superior a 0,68 para Mos y ligeramente inferior para Sasso T-44. En conclusión, la morfología de la canal y calidad de la carne de los gallos estuvo influenciada por la raza y el acabado con maíz.

Palabras clave adicionales: producción avícola, razas autóctonas, propiedades sensoriales

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 acid); PUFA (polyunsaturated fatty acid); SFA (saturated fatty acid); WB (Warner-Bratzler); WHC (water holding capacity)

Introduction

In ancient times, the authochtonous 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, in terms neither 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 rooster, this indigenous rooster is commercially ready when its live weight ranges 3-4.5 kg and heavier animals (12 months and caponizated) are only traditionally consumed on 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 roosters (Sanchez *et al.,* 2005; Diaz *et al.,* 2010; Franco *et al.,* 2012a; Franco *et al.,* 2012b) and on fatty acid profile of intramuscular fat of breast and drumstick (Rodriguez, 2010; Franco *et al.,* 2012a; Franco *et al.,* 2012b). 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 4^{th} 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 8^{th} 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, a killed by manual exsanguination, plucked and eviscerated. The carcasses were chilled in a 4ºC cool room for 24 h. The day after, the carcasses were weighed and the left side of the carcass was quartered according to the World´s Poultry Science Association recommendations (Jensen, 1983). Carcass portions were obtained as follows: the breast muscle were 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=CW/LW. The *pectoralis major* and *peroneous 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

Analytical methods

pH, colour, heme-iron content and chemical composition

The pH, colour 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 70ºC, controlled by thermocouples type K (Comark, PK23M, UK) and connected to a data logger (Comark Dilligence EVG, N3014, UK). After cooking, samples were cooled in a circulatory water bath set at 18ºC 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 × 1 cm width × 2.5 cm length were removed parallel to the muscle fibre direction and were completely cut using a Warner-Braztler (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:

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

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 35ºC and stored at -80°C until analysis by preparation of fatty acid methyl esters (FAMEs). Lipids were transesterified with a solution of boron trifluoride (14%) in methanol, as described by Carreau & Dubacq (1978). Fifty milligrams of the extracted lipids were esterified and the FAMEs were stored at -80ºC 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 120ºC maintaining this temperature for 5 min, programmed to increase at a rate of 5ºC 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 and 280ºC 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. Ten sensory traits of drumstick fresh meat were considered: skin colour, skin transparency, darkness lean, fat firmness, intensity odour, rancidity odour and liver odour, while for cooked meat were taste intensity, rancidity taste,

liver taste, hardness, juiciness, pastosity and fibrousness, following methodology proposed by ISO regulations (ISO 6564:1985, ISO 3972:1991, ISO 11036:1994 and ISO 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 this 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 analysis

For the statistical analyses of the results of carcass and meat quality 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 production system was included in the model. The model used was:

$$Y_{ij} = \mu + B_i + P_j + \varepsilon_{ij} \quad [2]$$

where Y_{ij} is the observation of dependent variables, μ is the overall mean, B_i is the effect of breed, P_j is the effect of production system, and ε_{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 significant higher for Mos animals. However, breast, that 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) growth ($p<0.001$) than Mos ones 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 α-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 bird 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 genotype (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 (C16:1cis-9, C17:0, C20:2, C20:3n-6 and C20:5n-3) were significantly affected by finishing corn fed. 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 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). Rodriguez (2010) worked with the castrated Mos breed and Sasso T-44 to obtain "Villalba Capón" (a typical Christmas dish of Galicia obtained from rooster) studied the growth of animals. 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 Penedesenca 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; Franco *et al.,* 2012b)

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.

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), Diaz *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 this case, all animals belonging 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 (Jaturashita 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 to 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/fnic/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. This value is lower than the one detected by Carreras *et al.* (2004), who found values of 2.40 $\mu g\ g^{-1}$ in breast. These authors explain that dietary supplementation with this antioxidant results in higher amounts of vitamin E in muscle tissues (Carreras *et al.*, 2004) and in the present study fodder formulation contain 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).

CL 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 (Jaturasitha *et al.*, 2008; Wattanachant *et al.*, 2004). Results in the same range were found in Padovana breed chicken (13-14%) (De Marchi *et al.*, 2005), while Diaz *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 decrease depends mainly on the *post-mortem* changes affecting myofibrillar proteins and on the connective tissue that represents the background toughness (Ariño *et al.*, 2006).

Diaz *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 theses 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, lowest percentage for oleic acid corresponded to Mos rooster (p<0.001), found values were 30 and 33% for Mos and Sasso T44 breeds, respectively, followed by palmitic acid (28%) and linoleic acid (19%). 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 predominat 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 24.5 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) were 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 (Ulbrich & 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 ratio 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; Lopez 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 was lower, yield for most appreciated parts, breast and drumstick, remained higher, which is an important issue from an economical and productive point of view. The finishing dietary with corn 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 presences of corn. On the contrary the corn had minor effect on fatty acid profile, while genotype had a major influence. Finally, a trained panel confirmed differences in external appearances, taste intensity and textural properties between genotypes.

Further studies are necessary to evaluate growth performance and confirm the results of this work under other rearing conditions in order to promote this breed.

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

Chemical composition	**Fodder**[1]	**Corn**[2]
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
SFA[3]	40.39	16.88
MUFA[4]	51.45	29.04
PUFA[5]	28.16	54.08

[1]Fodder additives vitamine A (UI kg^{-1}) 10000, vitamine D3 (UI kg^{-1}) 2500, vitamine E (UI kg^{-1}) 9, Fe (60 ppm), Zn (50 ppm), Cu (5 ppm), Mn (60 ppm), Co (0.05 ppm), Se (0.20 ppm), Iodine (0.40 ppm) and Fe (425 ppm), methionine (0.33%), lisyne (0.85%) and *p* (0.59%)

[2] expressed as percentage of dry matter

ND= not determined

[3]SFA = saturated fatty acids (sum of C16:0, C18:0, and C22:0)

[4]MUFA = monounsaturated fatty acids (sum of C16:1, C18:1n9c and C20:1)

[5]PUFA = polyunsaturated fatty acids (total, minus SFA and MUFA)

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

Carcass quality	Breed (B)		Finishing feeding (F)		Significance[1]			SEM[2]
	Mos	T-44	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
Commercial cuts (% respect to carcass)								
$Weight_{drumstick}$	14.68	13.06	14.54	13.63	***	***	NS	0.114
$Skin_{drumstick}$	1.05	1.23	1.17	1.06	**	*	*	0.026
$Lean_{drumstick}$	10.30	8.60	9.88	9.48	***	**	NS	0.085
$Bone_{drumstick}$	3.40	3.20	3.42	3.22	*	*	NS	0.044
$Lean_{drumstick}/Bone_{drumstick}$	3.06	2.72	2.92	2.95	***	NS	NS	0.048
Thigh	18.24	17.17	18.44	17.25	**	***	NS	0.167
Wing	9.28	8.51	9.31	8.69	**	**	NS	0.111
Breast	15.07	14.82	15.18	14.78	NS	NS	NS	0.193
Head	2.97	4.08	3.52	3.20	***	*	NS	0.071
Neck	6.33	6.47	6.59	6.16	NS	*	NS	0.097
Legs	4.45	4.19	4.48	4.23	*	*	NS	0.060
D+T[3]	32.93	30.24	32.99	30.88	***	***	NS	0.243

[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

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).

	Breed (B)		Finishing feeding (F)		Significance[1]			SEM[2]
	Mos	**T-44**	**Fodder**	**Corn**	**B**	**F**	**B × F**	
Chemical composition								
pH	5.95	6.02	5.96	5.98	*	NS	NS	0.015
Water (%)	74.66	74.06	74.77	74.21	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	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 (μg g^{-1} wet meat)	0.53	0.68	0.55	0.66	***	**	NS	0.017
β-tocopherol (μg g^{-1} wet meat)	0.18	0.16	0.14	0.21	NS	***	NS	0.004
γ-tocopherol (μg g^{-1} wet meat)	0.22	0.23	0.25	0.19	NS	***	NS	0.005
γ-tocopherol (μg g^{-1} wet meat)	0.01	0.01	0.01	0.02	NS	***	NS	0.000
β-carotene (μg g^{-1} wet meat)	0.01	0.01	0.01	0.01	NS	NS	NS	0.002
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	0.215
WHC								
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-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	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

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)		Finishing feeding (F)		Significance[1]			SEM[2]
	Mos	T-44	Fodder	Corn	B	F	B×F	
C14:0	7.06	9.63	8.31	7.71	***	NS	*	0.20
C15:0	0.95	0.67	0.77	0.92	**	NS	NS	0.04
C16:0	270.12	300.01	286.03	276.32	***	NS	NS	3.52
C16:1*cis*-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	0.03
C18:0	120.00	104.96	110.95	117.84	**	NS	NS	2.37
C18:1*cis*-9	307.50	340.62	325.61	313.93	***	*	NS	3.97
C18:2*n*-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
C18:3*n*-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
C20:3*n*-6	2.97	2.86	3.59	2.32	NS	***	**	0.10
C20:4*n*-6	53.14	39.08	51.91	44.43	***	NS	*	1.57
C20:5*n*-3	0.60	0.15	0.90	0.00	**	***	**	0.07
C24:1	9.13	7.87	9.67	7.75	*	*	***	0.25
C22:6*n*-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	4.15
PUFA[5]	271.24	247.17	267.48	257.87	**	NS	*	3.69
Σ*n*-3[6]	14.02	13.55	14.49	13.25	NS	NS	NS	0.42
Σ*n*-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 acid
[4]MUFA: monounsaturated fatty acid
[5]PUFA: polyunsaturated fatty acid
[6]n-3: omega-3 fatty acid
[7]n-6: omega-6 fatty acid

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

	Breed		Finishing feeding		Significance[1]			SEM[2]
	Mos	**T-44**	**Fodder**	**Corn**	**B**	**F**	**B × F**	
Fresh meat								
Skin appearance								
Colour skin	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
Textural								
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