

Chemical composition and physico-chemical properties of meat from capons as affected by breed and age

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Abstract

The influence of the breed [Mos (Spanish indigenous breed), Sasso T-44 and X-44 (commercial strains)] and the age (5, 6, 7 and 8 months) of capons (castrated male cockerels) on some qualitative traits of breast and drumstick meat were studied. The chemical composition (dry matter, protein, lipid and ash contents), pH, water holding capacity, drip loss, cooking loss, colour and texture (compression test and shear force) were measured. In breast meat, the Mos capon showed lower water holding capacity, higher drip loss and was lighter than the other breeds. In drumstick meat, the Mos capon showed lower lipid content, lower water holding capacity and was lighter and less red than the other breeds. Chemical composition, pH, water holding capacity, drip loss, colour and texture of the meat were significantly influenced by the age of the capons. The meat of the youngest animals showed higher ash content, higher pH, lower water holding capacity, higher drip loss, higher lightness and lower shear test values, than that of the older ones. In conclusion, the capon meat quality is influenced by breed and age of the capons.

Additional key words: castrated male cockerel, meat quality.

Resumen

Influencia de la raza y edad en la composición química y las propiedades físico-químicas de la carne de capones

Se ha estudiado la influencia de la raza [Mos (raza española autóctona), Sasso T-44 y X-44 (estirpes comerciales)] y de la edad (5, 6, 7 y 8 meses) de los capones (gallos castrados) en algunos parámetros de calidad de la carne de la pechuga y del muslo. Se determinaron la composición química (contenidos de materia seca, proteína, lípidos y cenizas), el pH, la capacidad de retención de agua, las pérdidas por goteo y cocinado, el color y la textura (test de compresión y fuerza de cizalla). En la pechuga, la carne de los capones de raza Mos presentó menor capacidad de retención de agua, mayores pérdidas por goteo y fue más luminosa que la carne de las otras razas. En el muslo, la carne de los capones de raza Mos presentó menor contenido lipídico, menor capacidad de retención de agua y fue más luminosa y menos roja que la carne de las otras razas. La edad de los capones influyó significativamente en la composición química, pH, capacidad de retención de agua, pérdidas por goteo, color y textura de la carne. La carne de los animales más jóvenes mostró mayor pH, mayor contenido de cenizas, menor capacidad de retención de agua, mayores pérdidas por goteo, mayor luminosidad y menores valores en el test de cizalla que la de los animales de mayor edad. En conclusión, la raza y edad de sacrificio influye en la calidad de la carne de capón.

Palabras clave adicionales: calidad de la carne, gallos castrados.

Introduction

Nowadays, the consumer demand for specialty, high quality poultry meat products is growing. One of these

products is the capon (castrated male cockerel). Caponization increases the abdominal, subcutaneous and intramuscular fat deposition; hence, it enhances flavour, texture and meat juiciness and makes the meat more

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Abbreviations used: PSD (pooled standard deviation), WHC (water holding capacity).

tender and appreciated by consumers than that of roosters of the same age (Mast *et al.*, 1981; Tor *et al.*, 2005).

This product has traditionally been available in several European countries, such as France, Hungary and Spain. In Northwestern Spain (Galicia), castrated cockerels are grown until they are 8 months old. Nowadays, the production in Galicia is very scarce, only 2,000 capons by year (Asociación de Criadores de Capón de Vilalba, 2005). Commercial strains and Mos breed (Galician indigenous breed) are used. They spend most of that time in free range conditions. These capons reach high prices due to their well-known meat quality (€200-300 for a pair of capons), and they are consumed on Christmas day after having been cooked for four hours or more. This extremely seasonal, artisan production of very heavy animals (eviscerated carcasses weight around 4-4.5 kg) makes the commercialization of this product very difficult during the rest of the year in conventional shops at lower prices. In this sense, it would be interesting to obtain capons of lower weight since they would cost less and could also be prepared in less time. The way to decrease the weight of capons is to slaughter at an earlier age. However, this change might also modify the quality parameters of the meat. No information about the changes in meat quality parameters and chemical composition among capons of different breeds and ages was found.

The objective of this study was to determine the influence of the breed [Mos (Galician indigenous breed), Sasso T-44 and X-44 (commercial strains)] and the age (5, 6, 7 and 8 months) of capons on the chemical composition and the physico-chemical properties (pH, water holding capacity, colour and texture) of the breast and drumstick meat.

Material and methods

Animals and diet

One hundred and fifty 1-day-old male chicks were used in the experiments, 50 were the Mos slow-growing breed (Avimos, Ourense, Spain), 50 were the Sasso T-44 slow growing strain and the other 50 were the Sasso X-44 medium growing strain (Sasso, Sabres, France). They were housed separately in three indoor pens (24 m² each one) with access to grass paddocks (333 m² each one) in free range conditions. Caponization was performed at 48 days of age for the T-44 and X-44

strains and at 60 days of age for the Mos chickens. These ages were the most adequate ones for castration according to the *Asociación de Criadores de Capón de Vilalba* (Association of Capon Growers in Vilalba). All birds were caponised bilaterally using the surgical method described by López-Beceiro *et al.* (1992) and in accordance with EU regulations. The absence of testicular regeneration was determined by visual assessment in live animals and also after slaughtering.

The castrated cockerels were fed *ad libitum* the same commercial diet. This diet was mainly composed of corn, soybean meal and wheat dried distillers grains with solubles and contained 200 g kg⁻¹ crude protein, 40 g kg⁻¹ cellulose fiber, 42 g kg⁻¹ crude fat and 60 g kg⁻¹ ash. When the animals reached the predetermined age for sampling (at 5, 6, 7 and 8 months), five animals of each breed were randomly selected and they were stunned, killed by manual exsanguination, plucked, completely eviscerated (obtaining the ready-to-cook carcass) and weighed. Then, they were refrigerated at 4°C for 24 hours until analyses. A total of 60 animals (20 of each breed) were analysed.

Sampling and qualitative meat traits determinations

The left breast and drumstick of each carcass were excised for analyses. The samples were immediately analysed for physico-chemical properties, and part of the meat was vacuum packed and kept at -20°C until the later chemical analyses were carried out.

For chemical analyses, the meat samples were finely minced in a blender (Polytron PT 10-35). AOAC methods (1995) were used for the dry matter, protein and ash determinations. Lipids were extracted and purified from the former homogenate with a chloroform:methanol mixture (1:1 v/v) according to the method of Hanson and Olley (1963). The total lipids were gravimetrically determined. All analyses were made in duplicate.

The pH of the meat was determined introducing a penetration pH electrode in the sample and the measurement was carried out in triplicate with a pH meter GLP 21 (Crison Instruments, S.A., Barcelona, Spain). Water holding capacity, determined as expressible juice, was studied using a modification of the filter paper press method (Hamm, 1960). A piece of 300 ± 5 mg of intact meat was placed between two pieces of Whatman filter paper No. 1 (11 cm diameter), previously

desiccated and weighed, and was placed between two plexiglass plates and pressed by a weight of 2 kg for 5 min. The outline areas of the expressible juice and the meat film were traced, and the sizes of the two areas were measured (in cm²) after digital acquisition with a scanner using the UTHSCSA Image Tool program (version 2.0, University of Texas Health Science Center, San Antonio, Texas). Water-holding capacity (WHC) was expressed as percentage of the meat area related to the juice area.

The drip loss was measured in accordance with Honikel and Hamm (1994). A slice of breast meat was cut parallel to the fiber direction, 30 g weight, was suspended inside a polyethylene bag and sealed under atmospheric pressure. The sample was held at 2°C for 72 h and then reweighed. The drip loss was expressed as a percentage of the initial sample weight.

Cooking loss was evaluated according to Boccard *et al.* (1981). A slice of breast meat weighing approximately 70 g was placed in a plastic pouch and sealed under moderate vacuum. The pouch was introduced into water at 70°C for 50 min and then placed in cold water for 20 min. After that the meat sample was taken from the bag, mopped dry and weighed. Cooking loss was expressed as the ratio ($\times 100$) of the difference in weight between the cooked and the raw meat relative to the weight of the raw meat. Water-holding capacity, drip loss and cooking loss determinations were made in duplicate.

Colour measurements were taken on the transverse cut of the *pectoralis major* and *peroneus longus* muscles and were made in triplicate. Colour was recorded using a Spectro-Color Dr. Lange chromameter (Dr. Bruno Lange GmbH & Co., Düsseldorf, Germany). All measurements were made in the CIE L*a*b* colour space (CIE, 1976) using the D65 illuminant and the 10° standard observer. The instrument was standardized with the white and black tiles provided by the manufacturer before sample measurements. The colour values were expressed as L* (lightness), a* (redness/greenness) and b* (yellowness/blueness). From these values, chroma and hue angle were calculated as follows (Hunt, 1991):

$$C^* = (a^{*2} + b^{*2})^{1/2}$$

$$H^* = \tan^{-1} (b^*/a^*)$$

Texture analyses were done on breast meat samples cooked as described above, using a Hounsfield Material Testing Machine (Model H10KM, Hounsfield Test Equipment Limited, UK). A compression test was

carried out on small pieces of 1 × 1 cm and 2 cm along the fiber axis, using a cylindrical 10 mm diameter probe. The sample was placed under the probe (with muscular fibers almost parallel to the force direction) that moved downwards at a constant speed of 180 mm min⁻¹ (pre-test) and 60 mm min⁻¹ (test). The thickness of the sample was recorded when the probe first came in contact with it. The probe continued downwards to a pre-fixed percentage (75%) of the sample thickness. The results were expressed in N cm⁻².

Warner-Bratzler shear tests of cooked meat were made on samples of rectangular cross section, 1 × 2 cm and 2 cm along the fiber axis. The samples were sheared at a right angle to the fiber axis using a Warner-Bratzler shear blade, which moved down with a constant speed of 60 mm min⁻¹. The razor blade shear force (N cm⁻²) was calculated. The determinations of texture analyses were made in triplicate.

Statistical analyses

Data were evaluated statistically using the SPSS version 12.0 for Windows (2004) program. A two-way ANOVA was used to analyze the effects of the breed, age and their interaction on the parameters determined. These analyses were carried out using the GLM procedure. When breed × age interactions were not detected, the means of each breed or age group were compared using the Tukey *F*-test with significance at $p < 0.05$. When breed × age interactions were detected, a one-way ANOVA was used and the means of each breed within each month or the means of each age within each breed were compared using the Tukey *F*-test with significance at $p < 0.05$.

Results

The carcass weights of the different types of capons are shown in Table 1. The weight increased with age in all breeds. The carcass weight was also influenced by the breed and significant differences among the three breeds were found: the highest values were those for X-44 strain birds and the lowest values were those for Mos capons.

The chemical compositions of breast and drumstick meat are also shown in Table 1. The chemical composition of breast meat was not influenced by the breed. However, some age effects and breed × age interactions

Table 1. Effect of breed and age of capons in the carcass weight and chemical composition of breast meat and drumstick meat

Trait	Breed			Age (months)				PSD	Analysis of variance		
	Mos	T-44	X-44	5	6	7	8		Breed	Age	Inter-action
Carcass weight (g)	3,038.0 ^a	3,967.0 ^b	4,394.0 ^c	3,408.1 ^a	3,765.5 ^b	3,987.8 ^{bc}	4,294.6 ^c	360.23	***	***	NS
<i>Breast meat (g kg⁻¹)</i>											
Dry matter											
Mos				x265.18 ^a	283.34 ^b	279.90 ^{ab}	x276.86 ^{ab}	2.37	NS	*	**
T-44				y278.20	273.58	272.44	xy266.78				
X-44				y277.25 ^a	274.02 ^{ab}	277.44 ^a	y261.54 ^b				
Protein	213.8	213.5	215.6	218.9 ^a	215.5 ^{ab}	214.4 ^{ab}	207.0 ^b	10.67	NS	*	NS
Lipids											
Mos				36.06 ^a	53.92 ^b	51.64 ^b	x65.70 ^b	10.39	NS	NS	*
T-44				50.43	45.14	49.40	y43.16				
X-44				40.15	49.38	47.80	y43.80				
Ash											
Mos				x11.10	11.18	11.30	x11.26	0.46	NS	***	**
T-44				y11.80 ^a	11.00 ^{ab}	11.78 ^a	xy10.54 ^b				
X-44				xy11.66 ^a	11.09 ^a	11.76 ^a	y9.96 ^b				
<i>Drumstick meat (g kg⁻¹)</i>											
Dry matter	261.94	260.85	264.79	263.53 ^a	270.72 ^a	261.17 ^{ab}	253.48 ^b	10.21	NS	**	NS
Protein	187.03 ^a	169.48 ^b	166.27 ^b	186.07 ^a	185.86 ^a	161.93 ^b	156.72 ^b	15.26	**	***	NS
Lipids	62.93 ^a	79.77 ^b	83.55 ^b	65.51 ^a	73.09 ^{ab}	82.04 ^{bc}	86.07 ^c	12.34	***	***	NS
Ash											
Mos				10.68	x11.18	11.24	x10.70	0.47	***	***	**
T-44				11.21 ^a	y10.62 ^a	10.90 ^a	y9.54 ^b				
X-44				10.90 ^a	y10.50 ^a	10.16 ^a	y9.22 ^b				

PSD: pooled standard deviation. ^{a,b,c}: means within a row and effect (breed or age) followed by different letters differ significantly ($p < 0.05$). x,y,z: means within a column and trait preceded by different letters differ significantly ($p < 0.05$). NS: not significant ($P > 0.05$). * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$.

were observed for some parameters. Dry matter decreased with age in X-44 animals and ash contents decreased with age in T-44 and X-44 animals, while no changes were observed in Mos capons. Lipid content was not affected by breed and age, but a significant interaction was observed. The lipid content only increased with age in Mos birds. In drumstick meat, the lipid content increased with age in all breeds. The Mos breed showed lower lipid content as compared to Sasso strains. The protein content of drumstick meat decreased with the age of the capons. Mos breed meat showed higher protein content than commercial strains. The ash content was higher in the Mos breed in 6 and 8 months animals and it was not influenced by the age of the capons, while the values decreased in T-44 and X-44 8 months birds.

The results of quality parameters of breast meat and drumstick meat are shown in Tables 2 and 3, respectively. No significant effects of breed were observed in the pH values of the breast meat, and only in the Mos breed did they decrease with age. In drumsticks, the Mos breed showed higher pH values than the other strains. The pH decreased with the age of the birds.

The water holding capacity (WHC) of breast meat (Table 2), determined by the filter paper press method, was significantly lower in the Mos breed when compared to the other strains. Moreover, when the age of the animals was taken into account, the youngest animals (5 months for the Mos breed and 5-6 months for the X-44 strain) showed lower WHC values than the older ones, except for the T-44 strain, in which this parameter did not change with the age of the animals. The WHC

Table 2. Effect of breed and age of capons on the quality parameters of breast meat

Trait	Breed			Age (months)				PSD	Analysis of variance		
	Mos	T-44	X-44	5	6	7	8		Breed	Age	Inter-action
pH											
Mos				6.00 ^a	5.73 ^b	5.74 ^b	x5.47 ^c	0.12	NS	***	***
T-44				5.77	5.86	5.75	y5.67				
X-44				5.77	5.81	5.63	y5.79				
WHC (%)											
Mos				x18.6 ^a	x23.8 ^b	x21.8 ^b	x22.9 ^b	1.25	**	***	***
T-44				y23.0	xy23.6	xy23.1	x22.9				
X-44				y21.9 ^{ab}	y21.3 ^a	y24.8 ^c	y24.0 ^{bc}				
Drip loss (%)	2.48 ^a	2.14 ^{ab}	2.06 ^b	2.97 ^a	2.27 ^b	1.90 ^{bc}	1.54 ^c	0.48	NS	***	NS
Cooking loss (%)	18.3	18.5	18.8	18.5	18.1	18.7	19.0	0.99	NS	NS	NS
L*	53.6 ^a	43.7 ^b	45.0 ^b	55.4 ^a	46.5 ^b	44.9 ^{bc}	39.6 ^c	7.06	***	***	NS
a*	0.58	0.70	0.67	0.59	0.58	0.53	0.96	0.58	NS	NS	0.58
b*											
Mos				x10.5 ^a	8.52 ^a	4.47 ^b	10.3 ^a	2.60	NS	NS	*
T-44				y5.82	6.79	5.75	7.50				
X-44				y5.55	7.35	7.38	6.56				
C*											
Mos				x10.5 ^a	8.53 ^a	4.60 ^b	10.3 ^a	2.59	NS	NS	*
T-44				y5.88	6.86	5.76	7.58				
X-44				y5.58	7.46	7.46	6.61				
H*	84.7	83.1	83.5	84.2	85.6	81.7	83.1	6.88	NS	NS	NS
Compression (Ncm ⁻²)	70.9	68.6	68.8	67.8	68.9	70.1	71.0	3.40	NS	NS	NS
Shear force (N cm ⁻²)	34.2	33.2	34.6	31.7 ^a	34.4 ^b	35.4 ^b	34.8 ^b	2.84	NS	**	NS

PSD: pooled standard deviation. ^{a,b,c}: means within a row and effect (breed or age) followed by different letters differ significantly ($p < 0.05$). x,y,z: means within a column and trait preceded by different letters differ significantly ($p < 0.05$). NS: not significant ($P > 0.05$). * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$. WHC: water holding capacity.

of drumstick meat (Table 3) showed the same pattern as the WHC of breast meat when the variables breed and age were considered.

The drip loss of breast meat (Table 2) was influenced by the age of the capons in all breeds; the meat of the older birds lost less water by dripping than that of the younger ones. Significant differences between breeds were not found using two-way ANOVA ($p = 0.062$); however, using the Tukey F -test with significance at $p < 0.05$, differences were found between Mos and X-44 animals.

No significant effects of breed or age were observed in the cooking loss of the breast meat (Table 2).

As far as colour parameters are concerned (Table 2), lightness (L*) of breast meat was influenced by the breed of the capons. The Mos breed showed significantly lighter meat than the other strains. L* was also influenced

by the age of the capons; in all genotypes, L* decreased with the age. In drumstick meat (Table 3), L* values were also influenced by the breed and age of the capons; as in breast meat, the Mos breed had lighter meat than the other strains and, in all genotypes, L* decreased with age.

The breed influenced the redness values (a*) of the drumstick meat (Table 3); the values for the Mos breed were lower than in the other strains. No significant effects of the breed and age on other colour parameters of the drumstick meat were found, except for the hue angle (H*), which was higher in the Mos breed than in the others due to the lower a* values reached by these birds.

In relation to the texture of the breast meat (Table 2), no significant effects of the breed and age on the compression test values were observed. In the shear test, no significant differences were found among

Table 3. Effect of breed and age of capons on the quality parameters of drumstick meat

Trait	Breed			Age (months)				PSD	Analysis of variance		
	Mos	T-44	X-44	5	6	7	8		Breed	Age	Inter-action
pH											
Mos				x6.40 ^a	6.08 ^b	x6.15 ^{ab}	5.94 ^b	0.14	*	***	**
T-44				y6.02 ^{ab}	6.19 ^a	xy6.00 ^{ab}	5.90 ^b				
X-44				xy6.15 ^a	6.18 ^a	y5.90 ^b	5.90 ^b				
WHC (%)											
Mos				x20.0 ^a	24.2 ^b	x22.2 ^{ab}	22.9 ^b	1.26	***	*	***
T-44				y25.4	24.1	xy24.4	25.1				
X-44				y23.6 ^a	23.1 ^a	y25.4 ^b	25.2 ^b				
L*	46.9 ^a	40.2 ^b	43.3 ^{ab}	48.3 ^a	43.4 ^{ab}	42.0 ^b	38.2 ^b	6.11	*	***	NS
a*	2.36 ^a	4.59 ^b	3.66 ^{ab}	2.67	3.57	3.81	4.57	1.88	**	NS	NS
b*	7.63	7.47	7.28	7.46	7.21	7.12	8.11	2.46	NS	NS	NS
C*	8.12	8.96	8.34	8.12	8.26	8.23	9.53	2.60	NS	NS	NS
H*	71.3 ^a	58.2 ^b	63.0 ^{ab}	68.3	63.5	61.8	60.7	12.1	**	NS	NS

PSD: pooled standard deviation. ^{a,b,c}: means within a row and effect (breed or age) followed by different letters differ significantly ($p < 0.05$). x,y,z: means within a column and trait preceded by different letters differ significantly ($p < 0.05$). NS: not significant ($P > 0.05$). * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$. WHC: water holding capacity.

breeds. The values of the shear test were significantly higher in the 6th month than in the 5th month.

Discussion

T-44 and X-44 animals grew quicker than the Mos birds. Although T-44 birds are slow growing, they belong to a commercial strain genetically selected for meat production, so the animals grew quicker than the Mos breed ones, even though it is an indigenous and non-selected breed. There are no studies about the effect of the breed on the growth of capons; in chickens, the indigenous breeds are also shown to grow much more slowly than commercial broilers (Culioli *et al.*, 1990; Wattanachant *et al.*, 2004).

In drumstick meat, the Mos breed showed lower lipid content as compared to Sasso strains. Differences in meat fat content between genotypes of broiler chickens have also been found and have been attributed to differences in the degree of animal maturity (Fanatico *et al.*, 2005). The protein content of drumstick meat decreased with the age of the capons and correlated with an increase in fat; capons probably stopped protein deposition before the 5th month. There are no studies about the effects of the breed or the age on the chemical composition of capon meat. In chickens, Thai

indigenous breed meat contained higher protein content and lower fat and ash contents when compared to broiler meat (Wattanachant *et al.*, 2004).

The drumstick meat showed higher lipid content than breast meat. This result might be related to the differences in muscle type between them. Chicken breast muscle is mainly composed of white fibers while drumstick meat is composed of several muscles with fibers having different metabolic types: slow and oxidative, fast oxidative glycolytic and fast glycolytic (Smith and Fletcher, 1988; Iwamoto *et al.*, 1993). Thus, they have an important proportion of red fibers which have a high amount of oxidative enzymes, lower glycogen and higher lipid content than white fibers (Cassens and Cooper, 1971).

The lipid content of the breast and drumstick meat of capons was higher than that of broilers and organic chickens as reported by other authors (Castellini *et al.*, 2002, 2006; Qiao *et al.*, 2002; Lonergan *et al.*, 2003; Wattanachant *et al.*, 2004; De Marchi *et al.*, 2005). This fact could be attributed to caponization effects on the metabolism of the animals (their fat deposition is increased) (Mast *et al.*, 1981), and because the capons are older. However, dry matter and ash contents of breast meat were similar to those described in broilers or indigenous chickens (Wattanachant *et al.*, 2004; De Marchi *et al.*, 2005).

Some relation between palatability of meat and intramuscular fat content has been established. When fat content is lower than 3%, palatability declines below an acceptable level. However, excessively high fat content (over 7.3%) is related to a perception of low quality since this is associated with several diseases (coronary heart disease, obesity, some forms of cancer) by consumers (Miller, 1994). The preferences of consumers are mostly focused on the meat they consume habitually and do not affect specialty products consumed only on special occasions like traditional capons. However, if there were an opening in the market for a smaller size capon (like French Red Label chickens)—one that could be consumed at any time during the year—this notion of palatability should be considered.

In drumstick meat, the pH values were higher than the breast meat ones; this result coincided with those previously reported in chicken meat (Castellini *et al.*, 2002; De Marchi *et al.*, 2005), and is probably due to the different type of muscles that predominate in the drumstick (oxidative muscles *vs.* glycolytic muscles in the breast). In drumsticks, the Mos breed showed higher pH values than the other strains. In breasts and drumsticks, the pH decreased with the age of the birds. In general, meat of older animals exhibit lower pH values than that of younger animals, which is attributed to a greater muscle glycogen content in the former due to changes in the proportion of the muscle fibers that are responsible for different patterns of muscle metabolism (Kannan *et al.*, 2003; Kadim *et al.*, 2006).

The effect of age on the WHC of meat is not clear. In other species, some authors observed an increase associated with higher age (Mayoral *et al.*, 1999; Hernández *et al.*, 2004; Kadim *et al.*, 2006) whereas other researchers did not find any effect (Leach *et al.*, 1996). The values were higher in drumstick than in breast; this fact could also be attributed to the different pH values of the muscles of these anatomic portions which other authors have described in chickens (Castellini *et al.*, 2002).

The values of drip loss were higher than those reported by other authors (Fanatico *et al.*, 2005). Differences between Mos and X-44 breeds were found; other authors (Debut *et al.*, 2003; Fanatico *et al.*, 2005) have described significantly higher drip losses in slow-growing broilers than in fast-growing animals.

The cooking loss of the breast meat of capons was different than that of indigenous chickens and broilers; some authors reported lower values (Lonergan *et al.*, 2003; De Marchi *et al.*, 2005), while other researchers

(Castellini *et al.*, 2002; Wattanachant *et al.*, 2004; Fanatico *et al.*, 2005) observed higher values than those found in our study.

It has been reported that the breed is a factor that affects poultry meat colour (Fletcher, 2002). In our experiment, the Mos breed showed lighter meat than the other strains. The L* values of the younger animals were higher while the values at 8 months of age were lower than those reported by other authors in broilers and indigenous breed chickens (De Marchi *et al.*, 2005; Fanatico *et al.*, 2005).

According to the L* values reported in the literature on the quality classification of chicken meat as light, normal or dark (Fletcher, 2002; Qiao *et al.*, 2002), the meat of the 5-6 month old capons should be considered as «lighter-than-normal», while the older animals should be classified as «darker-than-normal». In red meats, it is well known that low pH values produce the shrinkage of the contractile proteins and reduce the WHC of meat, and that this increases the light scattering in the surface and the lightness of the product (Dutson, 1983); these correlations have also been observed in poultry breast meat (Qiao *et al.*, 2001; Fletcher, 2002). However, in our results no pH-WHC-lightness relationship was found; thus the classification of meat quality according to the L* values cited in previous literature is not useful for capons. Caponization might cause an increase in lightness in normal meat as can be observed in young capons of both commercial strains, even though there does not seem to be any relation for pH and WHC.

Although Wattanachant *et al.* (2004) have reported an increase in a* values in an indigenous breed chicken as compared with younger broilers of a similar weight, it is necessary to take into account that the myoglobin content increases with the age of the animals (Miller, 1994) and this determines the redness of the meat. In our work, the comparisons were made among animals of the same age and, at least with regard to the Mos breed, drumstick meat appeared to be less red than in the commercial strains. The differences in poultry meat redness among genotypes have been attributed to differences in muscle fiber type (Lonergan *et al.*, 2003).

The values of the shear test increased with age probably due to an increase in the hardness of the connective tissue. Collagen cross-linking increases with the age and is often associated with increased toughness (Fletcher, 2002). The shear force values of capon meat were higher than those found in previous literature for broiler breast meat (Detienne *et al.*, 2000; Cavitt *et al.*, 2004; Fanatico *et al.*, 2005);

this was probably due to the age differences of the animals.

In conclusion, the Mos capon meat showed lower lipid content in drumsticks, lower water holding capacity, higher drip loss and was lighter and less red than the meat from the other breeds. Chemical composition, pH, water holding capacity, drip loss, colour and texture of the meat were significantly influenced by the age of the capons. The meat of the youngest animals showed higher ash content, higher pH, lower water holding capacity, higher drip loss, higher lightness and lower shear test values, than that of the older ones.

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