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Meat characteristics of chickens from an F1 cross of two improved Spanish breeds depending on slaughter age

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Abstract

The present study analysed the meat characteristics of i) improved Castellana Negra chickens slaughtered at 18 weeks (CN-18) and ii) F1 crossbred chickens from improved Castellana Negra hens and improved Penedesenca Negra cocks (CNPN) slaughtered at 12 weeks and 18 weeks of age (young and adult animals, respectively). Purebred and crossbred specimens were compared at similar weights (CN-18 and CNPN-12) and ages (CN-18 and CNPN-18). The protein content of the meat was similar for the three types of animals; heavier animals (CNPN-18) had more fat than those slaughtered at lower weights (CNPN-12 and CN-18). Adults had a higher saturated fatty acid content and the young CNPN chickens had more monounsaturated fatty acids than CN chickens. In the CNPN adults, less water was lost during cooking, which is directly related to the juiciness of the meat. With regard to sensory analysis, a darker colour was observed in the meat as much as the internal fat of adult animals, in addition to greater colour uniformity. The meat of young CNPN birds was juicier, whereas that of the CN chickens was more fibrous. Therefore, we conclude that meat from CNPN chickens presents chemical, physical, and sensorial characteristics that make these animals a genetic base for alternative poultry production.

Additional key words: alternative animal production; autochthonous breeds; Castellana Negra; fat; fatty acids; Penedesenca Negra.

Resumen

Características de la carne de pollos del cruce F1 de dos razas españolas mejoradas en función de la edad de sacrificio

En este trabajo se estudiaron las características de la carne de pollos mejorados de raza Castellana Negra sacrificados a las 18 semanas (CN-18) y de pollos del cruce F1 de gallinas mejoradas de raza Castellana Negra y gallos mejorados de la raza Penedesenca Negra (tipo CNPN), sacrificados a las 12 y 18 semanas de vida (CNPN-12 y 18, animales jóvenes y adultos, respectivamente), con el fin de comparar la raza pura y el cruce sacrificados con peso similar (CN-18 y CNPN-12) y con la misma edad (CN-18 y CNPN-18). El contenido en proteína de la carne fue similar para los tres tipos de animales, y en grasa, los animales de mayor peso (CNPN-18) presentaron mayores contenidos que los sacrificados con pesos inferiores (CNPN-12 y CN-18). Los adultos presentaron mayor contenido en ácidos grasos saturados y el tipo CNPN joven mayor en monoinsaturados que el CN. En los tipo CNPN adultos se observaron unas menores pérdidas de agua por cocción, variable relacionada directamente con la jugosidad de la carne. Respecto al análisis sensorial, se observó un color más oscuro, tanto de la carne como de la grasa interna, en los animales adultos, así como una uniformidad mayor de ese color. La carne de los CNPN-12 resultó más jugosa, mientras que la de los CN-18 fue la más fibrosa. Así pues, podemos concluir que la carne de los pollos CNPN presenta unas características químicas, físicas y sensoriales, que hacen de estos animales una base genética adecuada para la producción avícola alternativa.

Palabras clave adicionales: ácidos grasos; Castellana Negra; grasa; Penedesenca Negra; producciones animales alternativas; razas autóctonas.

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Introduction

After a period of intensification in raising fowl to achieve greater production at lower cost and encountering problems from an environmental standpoint, as well as in terms of genetic sustainability, breeders and consumers have once again come to appreciate traditional systems of exploitation that are more in harmony with the environment of these autochthonous breeds (Lleonart and Castello, 1984; García-Martín, 1995). Similarly, society demands the conservation of autochthonous breeds as a differentiating cultural patrimony, which unites society directly with its own history. The European Union increasingly supports these practices, and the market pays better prices for quality products, which simultaneously help conserve the environment. Alternative production supposes a real possibility of economic self-sufficiency for autochthonous breeds that survive the bad times when much more productive foreign genetic types are introduced (Luque and Cardelino, 2007).

The use of slower growing animals, as opposed to the fast-growing industrial broiler, results in less fat accumulation, especially in the abdominal region, even at advanced ages (Ricard, 1984; Brackenbury and Willianson, 1989; Ricard *et al.,* 1993). According to Groom (1990), the main factors that influence meat characteristics for chickens can be divided into those linked to the animal (age at slaughter, genotype, and sex) and others that are extrinsic to the animal (feeding and management during breeding, transport, and slaughter). According to different authors, not all of these factors play the same role; thus, to Touraille and Ricard (1981), the duration of the wait is the most important aspect in regards to the taste of the meat (seems to be related to the proximity to sexual maturity). The optimum slaughter age was determined to be 12-14 weeks for label chickens, which is similar for broilers (Cepero *et al.,* 1989).

For the past several years, in the area of animal production from «E.U. de Ingenierías Agrarias de Soria (Valladolid University)», a study on genetic improvement and the characterization of products in a population of Castellana Negra chickens has been carried out that, due to its quality, can suppose an important genetic base for alternative exploitations (Miguel *et al*., 2006, 2007, 2008). Penedesenca Negra is an autochthonous breed studied and used in alternative poultry production in Spain, especially Catalonia (Francesch *et al.,* 1997, 1999; Escoda, 2004).

The objective of this paper is to contrast the characteristics of meat from improved Castellana Negra chickens slaughtered at 18 weeks (CN-18) and F1 crossbred chickens from improved Castellana Negra hens and improved Penedesenca Negra cocks (CNPN) slaughtered at 12 weeks and 18 weeks of age (young and adult animals, respectively). Thus, purebred and crossbred specimens were compared at similar weights and ages.

Material and methods

Animal and management

Improved Castellana Negra hens (Miguel *et al.,* 2006) were crossbred with improved Penedesenca Negra cocks (Francesch *et al.*, 1997), resulting in the CNPN type. For each chicken type, four pens were used as replicates. The animals (all males) were raised in captivity until the age of 4 weeks (7 animals m^{-2}), at which time they were given access to outdoor pens (4 animals m^{-2}) until slaughter. The animals had *ad libitum* access to two different diets depending on age (Table 1, 0-6 weeks; Table 2, 7-18 weeks). From birth until 4 weeks of age, the animals were weighed individually every 2 days in order to adjust the growth curve, and from 4 to 18 weeks individual weight was controlled every 2 weeks.

The following numbers of animals were slaughtered the same day, all of them chosen at random from the population in which they were included: 30 CN cocks at 18 weeks of age (CN-18), 30 CNPN cocks at 12 weeks of age (CNPN-12), and 30 CNPN cocks at 18 weeks of age (CNPN-18). The body weight of CNPN-18 (2,539 ± 57 g) was significantly higher than that of CNPN-12 (2,064 ± 55 g) and CN-18 (1,954 ± 42 g).

Slaughtering and deboning

Ten chickens were chosen at random to study carcass traits. The animals were slaughtered in a commercial

Abbreviations used: CN (Castellana Negra breed), CNPN (F1 crossbred chickens from improved Castellana Negra hens and improved Penedesenca Negra cocks), MUFA (monounsaturated fatty acids), PUFA (polyunsaturated fatty acids), SFA (saturated fatty acids), UFA (unsaturated fatty acids).

Table 1. Ingredients and chemical composition of the chicken diets fed according to age during the trial

Ingredients	0-6 weeks	7-18 weeks
Wheat, %	10.00	—
Corn, %	47.40	63.90
Gluten 60, %	11.90	8.80
Extruded soybeans, %	15.00	20.00
Soybean meal, %	11.20	3.30
Dicalcium carbonate, %	1.40	1.20
Dicalcium phosphate, %	2.00	1.60
Salt, %	0.36	0.36
DL-methionine, %	0.002	—
L-lysine HCl, %	0.31	0.35
Choline chloride 50, %	0.05	—
Mineral mix, %	0.20	0.20
Vitamin mix, %	0.40	0.40
Nicarbazine, mg kg^{-1}	55.00	55.00
Chemical composition		
Crude protein, g kg^{-1}	225.20	181.70
Crude fibre, g kg^{-1}	33.70	27.90
Crude lipid, g kg^{-1}	52.10	57.40
Ash, g kg^{-1}	57.70	44.90
Metabolisable energy, kcal kg^{-1}	3,181	3,292

Table 2. Fatty acid composition of the chicken diets fed according to age during the trial

Fatty acid (% of total fatty acids)	0-6 weeks	7-18 weeks
C 14:0	0.14	0.15
C 15:0	0.11	0.11
C 16:0	10.50	10.44
C 18:0	3.04	3.02
C 20:0	0.38	0.37
C 24:0	0.29	0.29
C 18:1 (ω9)	20.88	20.77
C 20:1 (ω9)	0.23	0.22
C 18:2 (ω6)	57.45	57.81
C 18:3 (ω3)	6.19	6.23
C 20:2 (ω6)	0.09	0.00
C 20:3 (ω6)	0.25	0.23
C 22:4 (ω6)	0.45	0.36
SFA[1]	14.46	14.38
MUFA[2]	21.11	20.99
PUFA[3]	64.43	64.63
UFA[4]/SFA	5.91	5.95
Total ω6/total ω3	9.41	9.39

[1] SFA: saturated fatty acids. [2] MUFA: monounsaturated fatty acids. [3] PUFA: polyunsaturated fatty acids. [4] UFA: unsaturated fatty acids (MUFA + PUFA).

slaughterhouse after fasting for 16 h. The chickens were bled and plucked but left whole, with their heads and shanks remaining and not eviscerated. Carcasses were deboned according to the method described by Working Group 5 of WPSA (1984) in order to obtain the main commercial parts: thighs and drumsticks, wings, and breasts. These parts and the remaining carcass were weighed.

Chemical analysis

Dry matter, ash, total nitrogen, and fat content (after removal of the intermuscular and subcutaneous fat) were determined according to the Official Methods of Analysis (AOAC, 1990). For fatty acid analysis, total lipids were extracted using a chloroform/methanol mixture (Hanson and Olley, 1963). Fatty acid methyl esters were obtained using a solution of 20% boron trifluoride in methanol (Rule, 1997). Fatty acid methyl esters were analysed by gas chromatography with a SP2330 capillary column and flame ionisation detector with helium as the carrier gas. The oven temperature program increased from 150°C to 225°C at 7°C min^{-1}. Injector and detector temperatures were both 250°C. Quantification was carried out through area normalisation with an external standard mixture of fatty acid methyl esters. Fatty acid composition was calculated as a percentage of total fatty acids.

Physical analysis

A Crison 507 portable pH meter fitted with a 6 mm Crison penetration electrode and temperature probe was used to measure pH. A buffer solution of pH 4.00 and 7.02 was used for calibration. For colour analysis, a Model 200 Minolta spectrophotometer was used. Coordinates were calculated for lightness (L*), red component (a*), and yellow component (b*) (CIE, 1986). The pH24 (measured 24 h postmortem) and colour measurements were performed for the *Pectoralis major* and *Biceps femoralis.* Cooking losses were expressed as the percentage of liquid lost during cooking; the samples were weighed and cooked at 70°C for 45 minutes before weighing again.

Sensorial analysis

The cooking preparations and sensory test arrangements were carried out as recommended by Working

Group 5 (Poultry Meat Quality) of the European Federation of WPSA (1987). Sensory tests were conducted by a panel of eight judges in three sessions over 2 days. Different attributes (see Tables 6 and 7) were judged using raw thighs and drumsticks or cooked breast meat. Each variable was scored on a scale ranging from 1 to 10.

Statistical analysis

The following model was used to analyse meat quality variables:

$$y_{ijk} = m + ChT_i + P_j + (ChT \times P)_{ij} + e_{ijk}$$

where y_{ijk} is the observation (meat quality variable), m is the minimum quadratic mean, ChT_i is the chicken type-determined fixed effect (i = 1, CN-18; i = 2, CNPN-18; i = 3, CNPN-12), P_j is the part-determined fixed effect (j = 1, thigh+drumstick; j = 2, breast), $(ChT \times P)_{ij}$ is the interaction between chicken type and part, and e_{ijk} is the random residual effect.

All analyses were performed using the SPSS (1999) general linear model (GLM) procedure. The analyses provided estimates of treatment contrasts. Significant differences were determined using the t-test.

Results

Chemical analysis

In all cases, the breast contained more protein than the drumstick (Table 3), with no differences noted in terms of age at slaughter or chicken type. The fat content of the breast and drumstick was greater in the CNPN-18 chickens compared to CNPN-12 and CN-18 chickens. The fatty acid composition of the drumstick and breast in the three groups is provided in Table 4. The very high palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), and linolenic acid (C18:2) content stands out, as they comprise more than 80% of the total fatty acids. Differences in palmitic acid (C16:0) content were not observed. Stearic acid content (C18:0) was significantly less important in the drumsticks of CNPN-12 chickens compared to CNPN-18, and it was less than the content measured in the drumsticks of CN-18 chickens, which were slaughtered at a similar weight. No differences were observed in the fatty acid content of the breast among the three groups. A greater oleic acid (C18:1) content was found in the drumstick compared to the breast for all three groups with no detectable differences according to age or weight at the time of slaughter. Linolenic acid (C18:3), though present in small quantities, was present to a greater extent in CNPN-12 chickens compared to CNPN-18, and in CN-18 compared to the similar weight CNPN-12 chickens. On the other hand, the animals slaughtered at similar weights presented similar values in the breast, and CNPN-18 chickens had lower C18:3 content.

For the three groups, fatty acids more than 18C (C20:4, C22:4, C22:5, C22:6) were found in higher concentrations in the breast compared to the thigh and drumstick. However, no differences were found between the groups for docosatetraenoic acid (C22:4) and docosapentaenoic acid (C22:5), though arachidonic acid (C20:4) and docosahexaenoic acid (DHA, C22:6) content was significantly higher in the breast and thighs and drumsticks of CN-18 chickens compared to CNPN-12.

Table 5 shows the composition and relationships between saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) in the drumstick and breast fat. Unsaturated

Table 3. Least-squares mean (± SE) for the protein, fat, ash, and dry matter content in the thighs+drumsticks and breast of Castellana Negra (CN) and F1 crossbred (CNPN) chickens

	CN 18 weeks		CNPN 18 weeks		CNPN 12 weeks		Significance[+]		
	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Chicken type	Part	ChT × P
Protein (%)	$20.77^{1} \pm 0.28$	$23.91^{2} \pm 0.12$	$21.03^{1} \pm 0.36$	$23.86^{2} \pm 0.24$	$20.38^{1} \pm 0.38$	$24.49^{2} \pm 0.15$	ns	**	ns
Fat (%)	$2.60^{b1} \pm 0.33$	$0.46^{b2} \pm 0.04$	$4.38^{a1} \pm 0.39$	$0.72^{a2} \pm 0.07$	$2.86^{b1} \pm 0.35$	$0.52^{b2} \pm 0.05$	**	**	ns
Ash (%)	$1.11^{1} \pm 0.03$	$1.09^{1} \pm 0.01$	$1.10^{1} \pm 0.01$	$1.12^{1} \pm 0.00$	$1.05^{2} \pm 0.01$	$1.20^{1} \pm 0.03$	ns	*	**
Dry matter (%)	24.82 ± 1.09	25.66 ± 0.52	26.72 ± 0.52	25.72 ± 0.61	24.94 ± 0.81	26.23 ± 0.63	ns	ns	ns

Different superscript letters in the same line indicate significant differences between animal types, $p \leq 0.05$. Different superscript numbers in the same line indicate significant differences between parts, $p \leq 0.05$. [+]ns: not significant. * $p \leq 0.05$. ** $p \leq 0.01$.

Table 4. Least-squares mean (± SE) for the fatty acid composition in select parts from Castellana Negra (CN) and F1 crossbred (CNPN) chickens (% of total fatty acids)

	CN 18 weeks		CNPN 18 weeks		CNPN 12 weeks		Significance[1]		
	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Chicken type	Part	ChT × P
C 16:0	19.69 ± 0.63	20.99 ± 0.24	20.73 ± 0.73	21.07 ± 0.27	20.81 ± 0.37	21.76 ± 0.37	ns	ns	ns
C 16:1	$1.51^{b1} \pm 0.22$	$0.89^{b1} \pm 0.35$	$1.90^{b1} \pm 0.33$	$1.21^{b1} \pm 0.22$	$3.09^{a1} \pm 0.26$	$1.32^{a2} \pm 0.07$	*	**	ns
C 18:0	$14.90^{a} \pm 0.94$	$12.05^{a} \pm 0.63$	$12.89^{a} \pm 0.79$	$12.15^{a} \pm 0.60$	$8.69^{b} \pm 0.37$	$10.79^{a} \pm 0.21$	**	ns	*
C 18:1 (ω9)	$27.07^{1} \pm 1.33$	$21.55^{2} \pm 1.06$	$28.24^{1} \pm 0.98$	$23.54^{2} \pm 0.82$	$29.89^{1} \pm 0.82$	$23.06^{2} \pm 0.41$	ns	*	ns
C 18:2 (ω6)	28.59 ± 0.98	27.78 ± 0.92	29.19 ± 1.32	27.24 ± 0.82	31.15 ± 0.90	29.26 ± 0.84	ns	ns	ns
C 18:3 (ω3)	$0.88^{b} \pm 0.07$	$1.16^{a} \pm 0.12$	$1.10^{b} \pm 0.11$	$1.09^{b} \pm 0.05$	$1.66^{a} \pm 0.09$	$1.35^{a} \pm 0.06$	**	ns	*
C 20:4 (ω6)	$2.39^{a1} \pm 0.50$	$6.36^{a2} \pm 0.75$	$1.61^{ab1} \pm 0.25$	$5.61^{ab2} \pm 0.52$	$1.19^{b1} \pm 0.13$	$4.76^{b2} \pm 0.32$	*	**	ns
C 22:4 (ω6)	$0.47^{1} \pm 0.09$	$1.05^{2} \pm 0.25$	$0.32^{1} \pm 0.11$	$0.91^{2} \pm 0.19$	$0.29^{1} \pm 0.10$	$0.68^{2} \pm 0.17$	ns	**	ns
C 22:5 (ω3)	$0.65^{1} \pm 0.13$	$2.21^{2} \pm 0.23$	$0.46^{1} \pm 0.06$	$2.12^{2} \pm 0.20$	$0.40^{1} \pm 0.04$	$1.77^{2} \pm 0.16$	ns	**	ns
C 22:6 (ω3)	$0.80^{a1} \pm 0.13$	$2.97^{a2} \pm 0.37$	$0.64^{ab1} \pm 0.07$	$2.52^{ab2} \pm 0.23$	$0.53^{b1} \pm 0.06$	$2.01^{b2} \pm 0.13$	*	**	ns

Different superscript letters in the same line indicate significant differences between animal types, $p \le 0.05$. Different superscript numbers in the same line indicate significant differences between parts, $p \le 0.05$. [1] ns: not significant. * $p \le 0.05$. ** $p \le 0.01$.

fatty acids (UFA) were notably elevated. No differences were found in the SFA content of the drumstick and breast in adult animals (CN-18 and CNPN-18), but in CNPN-12 chickens the SFA content of the drumstick was less than that of the breast. The SFA content in the thigh of CNPN-12 chickens was less than that of CNPN-18, but greater than that of CN-18 chickens, which were of similar weight. With regard to MUFA, differences were found between the CNPN-12 and CN-18 chickens, but no differences were detected between the CNPN-18 chickens and either of the other two types. However, a greater MUFA content was measured in the drumsticks of CN-18 and CNPN-18 chickens compared to the breast. The breast in all three cases contained greater PUFA content, indicating no differences with regard to breed, age, or weight at slaughter.

Physical analysis

The lightness (L*) of the drumstick and breast was not significantly different in the CNPN-12 chickens (Table 6), but the lightness of the drumstick was significantly less in CN-18 chickens. The a* index in the breast was less in CNPN-12 compared to CNPN-18, but it was not significantly different in CN-18 chickens. On the other hand, no variations were found in the drumstick in regards to age or weight. For the drum-

Table 5. Least-squares mean (± SE) for the fatty acid composition of select parts from Castellana Negra (CN) and F1 crossbred (CNPN) chickens (% of total fatty acids)

Fatty acids[1]	CN 18 weeks		CNPN 18 weeks		CNPN 12 weeks		Significance[2]		
	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Chicken type	Part	ChT × P
SFA	$36.06^{a1} \pm 0.84$	$34.26^{a1} \pm 0.64$	$35.07^{a1} \pm 0.92$	$34.28^{a1} \pm 0.78$	$30.69^{b1} \pm 0.46$	$33.64^{b2} \pm 0.45$	**	*	*
MUFA	$29.18^{b1} \pm 1.52$	$22.72^{b2} \pm 1.34$	$30.78^{ab1} \pm 1.22$	$25.03^{ab1} \pm 1.03$	$33.40^{a1} \pm 1.52$	$24.66^{a2} \pm 0.46$	*	**	ns
PUFA	$34.76^{1} \pm 1.48$	$43.02^{2} \pm 0.91$	$34.15^{1} \pm 1.62$	$40.69^{2} \pm 0.87$	$35.91^{1} \pm 1.14$	$41.70^{2} \pm 0.69$	ns	**	ns
MUFA/SFA	$0.81^{b1} \pm 0.05$	$0.66^{b1} \pm 0.05$	$0.87^{b1} \pm 0.03$	$0.73^{b1} \pm 0.04$	$1.08^{a1} \pm 0.03$	$0.73^{b2} \pm 0.00$	**	**	*
PUFA/SFA	$0.96^{1} \pm 0.05$	$1.25^{2} \pm 0.00$	$0.97^{1} \pm 0.06$	$1.18^{1} \pm 0.03$	$1.17^{1} \pm 0.04$	$1.23^{1} \pm 0.03$	ns	**	ns
UFA/SFA	$1.77^{b1} \pm 0.06$	$1.91^{b1} \pm 0.05$	$1.85^{b1} \pm 0.07$	$1.91^{b1} \pm 0.05$	$2.25^{a1} \pm 0.04$	$1.97^{b2} \pm 0.04$	**	*	*
PUFA/MUFA	$1.25^{1} \pm 0.12$	$1.96^{2} \pm 0.12$	$1.14^{1} \pm 0.09$	$1.65^{2} \pm 0.07$	$1.09^{1} \pm 0.06$	$1.69^{1} \pm 0.05$	ns	**	ns

Different superscript letters in the same line indicate significant differences between animal types, $p \le 0.05$. Different superscript numbers in the same line indicate significant differences between parts, $p \le 0.05$. [1] For abbreviations, see Table 2. [2] ns: not significant. * $p \le 0.05$. ** $p \le 0.01$.

Table 6. Least-squares mean (± SE) for the colour, pH, and cooking losses (CL) of the thighs+drumsticks and breast from Castellana Negra (CN) and F1 crossbred (CNPN) chickens

	CN 18 weeks		CNPN 18 weeks		CNPN 12 weeks		Significance[1]		
	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Thighs + drumsticks	Breast	Chicken type	Part	ChT × P
L*	$48.42^{b1} \pm 1.22$	$52.52^{b2} \pm 1.00$	$49.39^{b1} \pm 0.88$	$52.42^{b2} \pm 0.77$	$52.12^{a1} \pm 0.67$	$54.25^{a1} \pm 0.91$	*	**	ns
a*	$10.36^{a1} \pm 1.04$	$3.54^{b2} \pm 0.45$	$8.61^{a1} \pm 0.54$	$4.25^{a2} \pm 0.38$	$5.44^{a1} \pm 0.44$	$3.30^{b2} \pm 0.35$	**	**	*
b*	$-2.23^{b} \pm 0.77$	$-1.93^{b} \pm 0.51$	$-2.79^{b} \pm 0.52$	$-2.92^{b} \pm 0.62$	$-0.03^{a} \pm 0.53$	$1.58^{a} \pm 0.56$	**	ns	ns
pH24	$6.18^{1} \pm 0.03$	$5.95^{2} \pm 0.02$	$6.10^{1} \pm 0.56$	$6.03^{1} \pm 0.02$	$6.33^{1} \pm 0.01$	$5.87^{2} \pm 0.04$	ns	**	**
CL (%)	$32.06^{a1} \pm 0.87$	$28.36^{a2} \pm 0.49$	$27.60^{b1} \pm 2.05$	$27.66^{b1} \pm 0.96$	$32.20^{a1} \pm 0.38$	$28.54^{a2} \pm 0.73$	*	*	ns

Different superscript letters in the same line indicate significant differences between animal types, $p \leq 0.05$. Different superscript numbers in the same line indicate significant differences between parts, $p \leq 0.05$. [1] ns: not significant. * $p \leq 0.05$. ** $p \leq 0.01$.

sticks and breasts, the b* index was greater in CNPN-12 chickens compared to CNPN-18 and CN-18 chickens.

The pH of the breasts from CNPN-12 chickens was less than that of CNPN-18 chickens, and no variation was found with respect to CN-18 chickens. No variation was found in the drumstick when comparing CNPN-12 and CN-18 chickens.

Cooking losses were greater for the drumstick compared to the breast in CN-18 and CNPN-12 chickens, but no differences were found in CNPN-18 chickens before and after cooking. No differences were observed in terms of water loss during cooking for the drumstick or breast of the CNPN-12 chickens compared to CN-18, but we found differences with respect to CNPN-18. The capacity for water holding decreased with age in CNPN type chickens, especially in the drumstick.

Sensorial analysis

Different attributes in terms of the appearance and smell of the raw drumstick were analysed in the three groups and the results presented in Table 7. The skin was less yellowish in CN-18 compared to the crossbred birds, regardless of age at slaughter, and it was pinker compared to CNPN-18. No difference was noted relative to CNPN-12. The meat from CN-18 and CNPN-18 chickens was darker than that of CNPN-12 chickens, which coincides with results obtained in the instrumental analysis of meat colour (Table 6). The colour was more uniform and intense in the internal fat. The best drumstick conformation was observed in the CNPN-18 chickens, though this was lower that of CNPN-12, and even lower when compared to CN-18. With respect

Table 7. Least-squares means for the sensory attributes in fresh thighs + drumsticks from Castellana Negra (CN) and F1 crossbred (CNPN) chickens

	CN 18 weeks	CNPN 18 weeks	CNPN 12 weeks	SEM[1]
Visual attributes				
White/yellow colour of skin	1.9^{b}	3.0^{a}	3.3^{a}	1.21
White/pink colour of skin	3.9^{a}	2.7^{b}	4.5^{a}	1.68
Pale/dark colour of meat	6.7^{a}	6.3^{a}	3.6^{b}	1.19
Uniformity of meat colour	6.1^{a}	5.6^{a}	3.7^{b}	1.30
Colour of internal fat	6.4^{a}	5.8^{a}	4.2^{b}	1.24
Thigh conformation	2.4^{c}	4.8^{a}	3.6^{b}	1.38
Smell attributes				
Rancid	0.1	0.1	0.1	0.07
Crude meat/chicken	4.7	4.6	4.0	1.10
Blood/liver/metallic	3.5^{a}	3.6^{a}	2.1^{b}	1.43

Different superscript letters in the same line indicate significant differences between animal types, $p \leq 0.01$. [1] SEM: standard error of least squares mean.

Table 8. Least-squares means for the sensory attributes of cooked breast meat from Castellana Negra (CN) and F1 crossbred (CNPN) chickens

	CN 18 weeks	CNPN 18 weeks	CNPN 12 weeks	SEM[1]
Smell attributes				
Rancid	0.8	1.5	1.3	1.29
Pork bark	4.5	3.9	4.5	1.49
Peanut/hazelnut	1.7	1.1	1.5	1.28
Toasted	4.1	4.3	4.0	1.41
Flavour attributes				
Rancid	0.3	0.2	0.1	0.33
Metallic	3.1[a]	4.1[a]	1.7[b]	1.62
Peanut/hazelnut	0.9[ab]	0.4[b]	1.1[a]	0.74
Chicken flavour	4.2	3.4	3.9	1.34
Bark	0.6	0.3	0.3	0.60
Texture attributes				
Initial juiciness	4.1	4.8	4.8	1.47
Tendernes	4.6[b]	4.7[b]	6.2[a]	2.04
Doughiness	2.3[b]	2.4[b]	3.8[a]	1.52
Stringiness	4.3[a]	3.9[ab]	2.7[b]	1.79
Final juiciness	3.3	4.0	3.9	1.46
Adhesion	2.4	2.7	2.9	1.15

Different superscript letters in the same line indicate significant differences between animal types, $p \leq 0.01$. [1] SEM: standard error of least squares mean.

to smell, differences only appeared regarding blood/liver/metallic smell and were greater in CNPN-18 and CN-18 chickens compared to CNPN-12.

Other attributes having to do with smell, flavour, and oral texture were also studied in cooked drumsticks (Table 8). We found no differences in regards to smell. However, the flavour was more metallic in older animals (CN-18 and CNPN-18) compared to CNPN-12. The drumstick meat in the CN-18 and CNPN-18 chickens was less tender and less doughy than that of CNPN-12 chickens. The least fibrous meat was found in CNPN-12 chickens compared to CN-18, but the texture of CNPN-12 meat was not different from CNPN-18. No differences were found between CN-18 and CNPN-18 chickens.

Discussion

Chemical analysis

Our data confirmed previous results obtained by Muriel and Pascual (1999), who measured a protein content of 23.10% in the breast and 21.26% in the thigh of free range chickens. Escoda *et al*. (2001) measured a fat content of 10.66% in the drumstick and 3.45% in the breast of Penedesenca Negra chickens slaughtered at 18 weeks. The fat content of the drumstick in these chickens was greater than that of the same breed of chickens slaughtered at 14 weeks (17.74%). This data is in line with the results we found in CNPN-12 chickens. Various authors agree that animals that grow faster have increased fat content (Komprda *et al.,* 2000; Lonergan *et al.,* 2003).

Dietary composition must be taken into account when comparing the fatty acid content of the fat because diet has a decisive influence on the content (Sanz *et al.,* 2000; Bavelaar and Beynen, 2003). The linolenic acid content (C18:2) in the present study was greater than that reported by Sánchez (2001) for the Mos breed at 33 weeks (12.49% in breast and 19.60% in drumstick). The C18:2 content reported by Tor *et al.* (2005) for the Penedesenca Negra breed at 28 weeks was less (17.3% in the carcass). In broilers at 43 days (Conchello *et al*., 1995), the C18:2 content in the breast was reported to be slightly greater (31.70%) than that of other adult chicken breeds and similar to that of the young CNPN chickens, though the C18:2 content measured by Girard *et al*. (1993) in the carcass was less (20.8%).

Sánchez (2001) measured less oleic acid (C18:1) in the drumstick (15.64%) compared to the breast (20.49%), but both of these values were less than those measured in the present study. However, the C18:1 content measured by Tor *et al*. (2005) in the Penedesenca Negra breed was greater (36.7%), as was that reported by Conchello *et al*. (1995) in broilers (31.7%). Girard *et al*. (1993) reported C18:1 content in the French label chicken (28.1%) similar to that measured in the present study.

With regard to linolenic acid (C18:3), we measured content values that were slightly greater than those reported for the carcasses of Penedesenca Negra chickens slaughtered at 28 weeks (0.70%) (Tor *et al*., 2005). The C18:3 content in broilers at 42 days is greater (2.79%) according to the results reported by Conchello *et al*. (1995).

Escoda (2004) found similar arachidonic acid (C20:4) values in traditional Penedesenca Negra chickens without improvement (2.01% and 6.02% for thighs + drumsticks and breast, respectively) as those found in the present study for CN-18 chickens, and the values reported for Penedesenca Negra chickens at 18 weeks

(2.04% and 5.14% thighs + drumsticks and breast, respectively) and 12 weeks (1.30% and 4.22% thighs + drumsticks and breast, respectively) were similar to those obtained for CNPN-18 and CNPN-12 in the present study. Results for Empordanesa Roja and Prat Leonada breeds were similar. With regard to DHA (C22:6), values similar to those found in the present study were reported for the three breeds mentioned above.

The SFA content in the thighs of CNPN chickens increased with age, which are similar results as those reported by Escoda *et al*. (2001) in the three autochthonous Catalonian breeds. Differences in MUFA content were found between the CNPN chickens at 12 weeks and the CN breed at 18 weeks, but no differences were detected between the adult CNPN chickens and the other two groups or among the parts in adult CNPN chickens, as was reported by Escoda *et al*. (2001) for Penedesenca Negra at 18 weeks. However, a greater MUFA content was found in the drumstick compared to the breast in CN chickens and in the CNPN chicken at 14 weeks, which is in agreement with results reported by Escoda *et al*. (2001) for Penedesenca Negra chickens at 12 weeks and the Prat Leonada and Empordanesa Roja breeds at different ages. Sánchez (2001) measured higher values of MUFA in the breast compared to the drumstick of older Mos chickens. In all three cases, the breast demonstrated greater PUFA content with no differences based on breed, age, or weight at slaughter.

Tor *et al*. (2005) reported greater SFA (38.0%) and MUFA (42.5%) values in Penedesenca Negra chickens at 28 weeks, with lesser values for PUFA (18.6%), demonstrating a UFA/SFA proportion of 1.6 in the carcass, less than that measured in the three groups in the present study.

Physical analysis

Older animals presented with darker meat, a result observed by different researchers (Cepero *et al*., 1989; Bastiaens *et al*., 1993). The haematinic pigment content of the muscle increases with age, inducing a decrease in L*. García-Martín *et al*. (1995), studying the meat of label chickens (SASS0-451) at 14 weeks of age, also found that the breast meat was lighter in colour than the drumstick (L* value 57.88-58.86 *vs*. 53.60-54.46). Sánchez (2001), found that the breast meat of Mos chickens was lighter than the drumstick meat (L* value 45.57 *vs*. 43.24), but these values were less than those found in all cases in the present study, leading us to conclude that our chickens were lighter-meat animals. However, the Mos breed was slaughtered at a later age (33 weeks) than the chickens in our study. As expected, various authors working with broilers found lightness values higher than those obtained in this study (Qiao *et al*., 2001; Du and Ahn, 2002).

The pH results agree with those reported by Muriel *et al*. (1997) and Muriel and Pascual (1999); higher pH values were reported for drumsticks (6.28-6.37) compared to breasts (5.80-5.82). Cepero *et al*. (1994) found lower values in broilers (5.78 in drumsticks and 5.64 in breasts) and label chickens (5.97 in drumsticks and 5.60 in breasts). In addition, Sánchez (2001) found lower pH values in Mos chickens than those of the present study (5.86 in drumsticks and 5.61 in breasts).

The loss of water was along the same lines as reports from different researchers, such as Lyon *et al*. (1984) and Cepero *et al*. (1989), and can be justified by the higher pH in the drumstick and lower free water content, as well as a greater myofibrillar structure and higher fat content (Grey *et al*., 1983). Other authors studying the loss by cooking broiler and label chickens (*e.g.,* Cepero *et al*., 1994) found smaller losses in thighs (13.22% in broiler and 10.23% in label) than breasts (15.92% in label and 12.81% in broiler). When comparing the results obtained for the young and adult CNPN chickens, an improved capacity for water holding with age, especially in the drumstick, was observed, a situation that was already confirmed by Cepero *et al*. (1989), Bastiaens *et al*. (1993), and Gilles and Kyung (1993).

Sensorial analysis

In different studies concerning label chickens, this meat was found to possess a more intense aroma and flavour than broiler chickens, though its juiciness and tenderness were considered somewhat inferior. More marked differences were found in the drumstick meat compared to the breast (Dunn *et al*., 1993; Cepero *et al*., 1994; Farmer *et al*., 1997). Cepero *et al*. (1994) found that the breast in the label chickens was tougher but more aromatic than that of broilers and, in drumsticks, a greater degree of juiciness and flavour intensity was found in the label birds in addition to the other differences. García-Martín *et al*. (1995), comparing the meat from label birds raised at large or in captivity, found a more intense flavour in birds raised in captivity, though no differences were found in terms of other characteristics, such as juiciness or overall appreciation.

We can conclude that the CN breed cannot compete for meat production with other improved breeds and growing and shaping. The CNPN crossbreed, as a slow-growing chicken, allows the use of the CN breed in meat production, supposing support for their conservation.

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