Effect of Genotype on Slaughtering Performance and Meat Physical and Sensory Characteristics of Organic Laying Hens

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ABSTRACT Slaughtering yields and some meat physical and sensorial parameters of laying hens reared under organic system production were studied. The hens belonged to both Italian dual-purpose breeds [Ermellinata di Rovigo (ER; brown eggshell) and Robusta Maculata (RM; brown eggshell)] as well as hybrid genotypes [Hy Line White 36 (white eggshell) and Hy Line Brown (brown eggshell)]. The birds were reared under organic farming system production from 24 to 44 wk of age, when they were slaughtered. They were reared throughout summer and autumn, and the temperature ranged from about 28 to 3°C. Local breeds presented higher ($P < 0.01$) live BW and dressing percentage compared with hybrids. The RM and ER carcasses had ($P < 0.01$) the highest breast and leg (thigh and drumstick) percentage, respectively. The muscle-bone ratio of the Hy Line White 36 drumstick was lower ($P < 0.05$) than the RM ratio, whereas the other groups were intermediate. The ER breast presented the highest ($P < 0.01$) lightness value and the lowest ($P < 0.01$) final pH value compared with the other 3 groups. The breast meat significantly differed according to genotype for almost all the studied sensorial parameters (adhesivity, fibrousness, chewiness, solubility, juiciness, tenderness, shear resistance), with the exception of aroma and odor intensity. In the thigh, genotype significantly affected aroma, adhesivity, fibrousness, solubility, tenderness, and shear resistance.

Key words: organic laying hen, genotype, slaughtering performance, meat quality, sensory evaluation

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INTRODUCTION

During the last 10 yr, opportunities to improve the welfare of laying hens have included alternative housing systems where hens are able to express normal behaviors. Free-range birds or organic birds with shelters are able to express behaviors such as freedom of movement, running, flying, and soil scratching as well as having the opportunity to be exposed to a wide variety of environmental stimuli (Appleby and Hughes, 1991). Organic farming system suggests the rearing of local genotypes, which should be less susceptible to environmental variations and inclement weather conditions (Koelkebeck and Cain, 1984).

Furthermore, the consumers' preference for colored-feather and slow-growing meat-type chickens is growing in certain regions of the world. Growing interest regards the appearance (plumage, skin, combs, etc.), meat flavor, and meat texture because these are the main attributes that attract customers to purchase chicken meat (Yang and Jiang, 2005).

There are few indications on the productive performance and quality of the products of local genotypes, and, generally, they refer to chicken (Lewis et al., 1997; Castellini et al., 2002a). Many local breeds are dual-purpose, being able to provide both eggs and meat.

In a previous research study, the productive performance and the quality of eggs of hybrid and Italian-breed laying hens were compared during the first phase of the productive cycle following organic rearing procedures (Rizzi et al., 2002), but no information is currently available on the slaughtering performance, quality, and sensory evaluation of the meat of these genotypes.

MATERIALS AND METHODS

Birds and Rearing Conditions

Seventy laying hens belonging to 2 Italian dual-purpose breeds, Ermellinata di Rovigo (**ER**) and Robusta Maculata (**RM**), and 2 hybrid strains, Hy-Line White 36 (white eggshell, **HLW**; Hy-Line Int., Des Moines, IA) and Hy-Line Brown (brown eggshell, **HLB**), were reared under organic farming production (European Union, 1999).

These local genotypes were created in Veneto, Italy during the 1950s from Sussex and Rhode Island (ER) and Orpington Fulva and White America (RM) purebreds. The color of their eggshell is of brown tonality.

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Table 1. Diet composition (as-fed basis)

Item	%
Ingredients	
Corn meal	58.0
Toasted soybean	13.0
Wheat bran	11.0
Sunflower	10.0
Calcium carbonate	7.50
Dicalcium phosphate	0.50
Chemical analysis	
DM	89.8
CP	18.7
Ether extract	7.0
Crude fiber	4.0
Ash	11.0

The hens were reared from 24 until 44 wk of age throughout summer and autumn from the months of July to December. The birds were kept under the same prophylaxis procedures, rearing conditions, and feeding treatments from time of hatching until the start of the trial and until the end of the experimental period. Throughout the trial, the photoperiod was 16L:8D, and the environmental temperature (30 to 5°C) and RH (68 to 82%) levels ranged widely from summer to autumn. The birds of each genotype were reared in spaces divided by netting: The outdoor space was 4 m^2/bird, and the indoor space was 0.20 m^2/bird. Nests (8 birds/nest) and perches (22 cm/bird) were allocated in the indoor space (European Union, 1999). The birds were fed an organic feed ad libitum (Table 1) having been analyzed for nutrient content (Association of Official Analytical Chemists, 2000).

Slaughtering Procedures

At 44 wk of age, 12 birds per genotype were weighed and brought to the slaughterhouse. Feed was withdrawn 12 h before slaughter; the birds, previously weighed were electronically stunned, killed by exsanguination, plucked, and eviscerated (intestines; perivisceral, perineal, and abdominal fat; gall bladder; esophagus; full crop; proventriculus; and spleen). Warm and cold (after 24 h at +4°C) carcass weights were recorded. From the refrigerated carcasses the head, neck, feet, and edible viscera (heart, liver, and gizzard) were removed to obtain the ready-to-cook carcass. Successively, the breast muscles, thighs, drumsticks, and wings were weighed. Finally, the feet, head, and neck were weighed.

pH and Physical Parameters of Breast Meat

On the right breast muscle, superficialis major, at 36 h postmortem, the ultimate pH [by a Delta Ohm HI-8314 pH meter (Delta Ohm, Padova, Italy) and Crison electrode (Crison, Barcelona, Spain)], and color [by a Minolta Chroma Meter CR-300 tristimulus analyzer (Minolta Corp., Ramsey, NJ); CIELAB color space model (Commission International de l'Eclairage, 1976)] were recorded. The CIELAB color space model was chosen to numerically describe the color parameters. Lightness (**L***) is the amount of incident light that a surface reflects; –a* values represent green and +a* values represent red color; –b* values represent blue and +b* values represent yellow color.

The skinless breasts were weighed and frozen at –20°C until cooking. They were removed from the freezer, placed on trays, and thawed in a commercial refrigerator at 3 to 4°C for 24 h. The breast muscles were cooked in water at 70°C for 45 min inside sealed bags. After 15 min of cooling under running water, the fillets were dried.

The shear force was measured by an Instrom equipped with a Warner-Bratzler shear apparatus (Texture Technologies Corp., Scarsdale, NY) on cores with cross-sectional areas of 1.25 cm^2 obtained from the breast. The samples were cut perpendicular to the fiber direction.

The breasts were weighed before and after thawing and cooking to evaluate thawing and cooking loss.

Sensory Evaluation of Meat

Left skinless breast and thighs were analyzed following the sensory profile procedure (International Standards Organization, 2003).

Breasts and thighs were cooked in a prewarmed 200°C oven to a final temperature of 75°C. Internal temperatures were monitored with a handheld thermometer. Thigh cooking required 20 min more than the breast. Samples were removed from the oven and tempered 15 min in the pan before preparation for the sensory analysis.

Samples were prepared by cutting a 2-cm-wide strip parallel to the fibers. This strip was then cut into 2 or 3 cubes of 2 cm. Samples were placed in prewarmed glass custard dishes that were nested in coded Styrofoam cups to maintain the serving temperature (50°C). Sample containers were coded with 3-digit numbers and presented to panelists in individual sensory workstations equipped with computers for data collection using FIZZ Network software (FIZZ version 2.10, Biosystems, Couternon, France). Panelists used 1 cube for odor and flavor and 1 cube for texture to evaluate the intensity of the sample attributes and mark the responses on 10-point scales (Table 2).

A trained descriptive analysis panel (n = 10) was used in this study. Panelists were trained on the specific matrix; during orientation sessions for this study, the lexicon and panel performance were validated through sampling, discussions, and reference materials. During training, the most adequate preparing and cooking procedures were defined to make the evaluation objective and to highlight the characteristics of the product.

The sensory attributes and definitions used by the descriptive panel to evaluate cooked breast and thigh meat are detailed in Table 2. Odor, flavor, and texture terms represented different phases of evaluation. The lexicon of odor, aroma, and texture terms was developed previously by the trained descriptive sensory panel.

The sample cooking and presentation to panelists followed a monadic sequence at 20-min intervals to allow for fatigue recovery between samples. Sensory evaluations

Table 2. Sensory attributes, definitions, and evaluation method used to profile breast and thigh muscles

Attribute	Definition	Evaluation method	Score
Odor sensations			
Odor intensity	Stimulation strength experienced over the sample when it is near the nose.	Smell the sample immediately and evaluate the strength of the stimulation.	1 to 10
Flavor sensations			
Aroma intensity	Strength of total stimulation at level of odor bulb. This stimulation is due to the aromatic compounds produced during chewing that are directed into the nose by respiration.	Chew the sample until aromatic compounds are tasted.	1 to 10
Texture sensations[1]			
Tenderness	Force required to compress the sample with molars.	Put the sample between molars and compress uniformly, evaluating the force.	10 to 1
Juiciness	Sensation produced by release of juice from the sample during chewing.	Evaluate the total quantity of liquid deriving from the sample in the mouth during the first 2 bites.	1 to 10
Fibrousness	Perception of the form and orientation of the fibers.	Chew the sample and note the presence of parallel fibers.	1 to 10
Adhesivity	Sensation due to rapid disgregation of the sample into the saliva.	Chew the sample, and after 2 to 3 chews, evaluate the force required to open the mouth.	1 to 10
Chewiness	Number of chews required to chew the sample to point of swallow.	Put the sample between teeth and chew with constant speed (1 bite/sec with constant force); evaluate the number of bites until swallow.	1 to 10
Solubility	Sensation felt when the sample mixed with saliva during chewing.	Put the sample into the mouth and chew 2 to 4 times with molars. Then evaluate how quickly the pieces dissolve in the saliva.	1 to 10
Meat texture evaluated by fingers and knife			
Shear resistance	Resistance of the sample to the shear of the knife.	Evaluate the force requested to cut the sample with a knife positioned perpendicular to the direction of fiber.	1 to 10

[1]Texture attributes were evaluated from first bite to swallow.

Table 3. Hen slaughtering performance

Item	Genotype[1] ER	RM	HLW	HLB	MSE
Live BW (g)	2,609^{b,B}	3,147^{a,A}	1,726^{d,D}	2,088^{c,C}	17,028
Dressing out[2] (%)	64.37^{b,A}	66.29^{a,A}	55.89^{d,B}	57.65^{c,B}	4.0501
Breasts (g)	279^{b,B}	401^{a,A}	173^{d,D}	201^{c,C}	605
Wings (g)	17.21^{b,B}	21.03^{a,A}	9.92^{d,D}	13.05^{c,C}	11.1087
Thighs and drumsticks (g)	569^{b,B}	677^{a,A}	302^{d,D}	379^{c,C}	1,796
Incidence[3] (%)					
Breast	16.59^{c,C}	19.25^{a,A}	17.93^{c,B}	16.75^{c,BC}	1.4857
Wing	10.22^{b,B}	10.09^{b,B}	10.28^{b,B}	10.80^{a,A}	0.1939
Thigh and drumstick	33.84^{a,A}	32.47^{b,AB}	31.27^{c,B}	31.45^{bc,B}	2.0843
Incidence[4] (%)					
Head and neck	6.67^{c,B}	5.97^{d,C}	8.00^{a,A}	7.48^{b,A}	0.3092
Feet	3.66^{a,A}	3.26^{b,B}	3.44^{ab,AB}	3.44^{ab,AB}	0.0834
Muscle:bone[5]					
Thigh	4.05	3.97	3.83	3.89	0.7160
Drumstick	7.03^{ab}	7.41^{a}	6.39^{b}	6.87^{ab}	1.0385

$^{a–d}$Means within same rows followed by a different superscript are significantly different ($P \leq 0.05$).

$^{A–D}$Means within same rows followed by a different superscript are significantly different ($P \leq 0.01$).

[1]ER = Ermellinata di Rovigo; RM = Robusta Maculata; HLW = Hy-Line White; HLB = Hy-Line Brown; MSE = mean square error (52 df).

[2]Ready-to-cook carcass/BW.

[3]Carcass without head and neck, feet.

[4]Caracas with head and neck, feet.

[5]df = 36.

were replicated 4 times. Sample order presentations to panelists were randomized across sessions.

Statistical Analysis

All data on slaughtering performance and chemical and physical properties of meat were subjected to 1-way ANOVA as a completely randomized design, with genotype as main effect, using the GLM procedure of SAS (SAS Institute, 2000).

Significant differences among the means were determined using Duncan's multiple range test (SAS Institute, 2000).

Data on sensory evaluation were analyzed using the FIZZ Statistical Calculation and SYSTAT 10 (Biosystems) for sensory data. This multivariate analysis procedure is used in sensory profiling to analyze genotype effect, panelist effect, and attribute performance. Genotype means are subsequently plotted in a 2-dimensional space to visualize their relationships according to a reduced set of factors derived from the attributes.

RESULTS AND DISCUSSION

Given the relevant differences in productive yields of these genotypes, it is opportune to consider the parameters throughout the different phases of the productive cycle before discussing the results. Therefore, this work presents the slaughtering performance and the meat quality of the laying hens during the first phase of production.

Slaughtering Performance

In Table 3, the live BW and slaughtering performance of the hens are reported.

At 44 wk of age, local breeds were heavier ($P < 0.01$) than the hybrid hens; the HLB and RM hens presented higher ($P < 0.01$) BW compared with the HLW and ER hens, respectively.

Dressing percentage was higher in the local breeds ($P < 0.01$) than in the hybrids, as their carcass conformation and body dimensions recall those of genotypes with characteristics for meat production. Within the hybrid and local groups, the RM and HLB values were significantly ($P < 0.05$) higher than ER and HLW, respectively.

The breast weight significantly ($P < 0.01$) differed among the 4 genotypes as well as the thighs, drumsticks, and wings: The RM hens showed the highest values, followed by the ER ($P < 0.01$) and HLB ($P < 0.01$), whereas the HLW showed the lowest weight ($P < 0.01$).

The breast percentage was higher ($P < 0.01$) in RM than in HLB, HLW, and ER carcasses. The thigh and drumstick incidence was higher ($P < 0.01$) in purebred carcasses than in the hybrids and, within local genotypes, in the ER hens rather than ($P < 0.05$) in the RM. The wing percentage was higher ($P < 0.01$) in the HLB carcasses compared with the other groups.

The muscle-bone ratio of the thigh did not differ among the groups, whereas in the drumstick, it was higher ($P < 0.05$) in the RM group and lower ($P < 0.05$) in the HLW hens. The ER and HLB samples were intermediate.

As far as the slaughtering wastes are concerned, the incidence of the head and neck was lower ($P < 0.01$) in the purebreds than in the hybrids. Furthermore, HLB ($P < 0.05$) and RM ($P < 0.01$) hens presented lower values than HLW and ER, respectively.

The feet incidence was higher ($P < 0.01$) in the ER carcasses and lower ($P < 0.01$) in the RM; the hybrids were intermediate.

The different response in terms of live BW and slaughtering performance observed among the 4 genotypes is related to their genetic assessment.

All of the birds exhibited poor weight gains (Rizzi et al., 2002) throughout the trial, having reached sexual maturity and on laying activity. However, the Italian breeds showed higher body increments and lower laying activity (Rizzi et al., 2002) compared with the hybrids, because they are dual-purpose genotypes simultaneously exhibiting a discrete egg production and meat growth.

Genetic improvements carried out during these years on the hybrid strains of hens have focused on egg production and, therefore, although this has allowed the obtaining of higher egg yields, muscle growth is limited. The impossibility of concurrently improving these 2 characters due to the negative correlations between them is well established (Bell, 2002).

Although the egg yield was substantially similar between hybrids (85%, Rizzi et al., 2002), some differences in slaughtering performance were observed. These differences are the expression of a different genetic assessment given that the genetic origin of these 2 strains is different. The white eggshell strain originates from White Leghorn and presents high egg-laying capability and low body mass and feed consumption.

Otherwise, the meat of spent hens met a part of the entire poultry meat production, and the carcass should present a satisfactory level of meatiness. Therefore, in the brown eggshell hybrid strains, geneticists also utilize lines or breeds with carcass characteristics useful for meat production, such as the dual-purpose breeds Barred Plymouth Rock, Rhode Island Red, Rhode Island White, Australorp, New Hampshire, and others (Scott and Silversides, 2000).

In addition, the 2 Italian breeds, with different genetic origins from European, American, or both purebreds, presented differences on some productive (Rizzi et al., 2002) and carcass characteristics.

pH and Physical Characteristics of Breast Meat

In Table 4, the breast pH and some physical parameters are reported.

The final pH was lower ($P < 0.01$) in the ER breasts compared with the other groups. The genetic origin of hens also influenced some physical parameters of the breast muscles. Significant differences were found in L* value, which was higher ($P < 0.01$) in ER muscles than in the others. Additionally, the a* and b* values did not differ among the genotypes.

The meat color could be affected by the movement of the birds and thus by a more or less intense muscular activity. In these experimental conditions, the hens were allowed to move outdoors and indoors over the 24 h, and they showed similar motorial activity. Therefore, it is not possible to attribute the differences found among the genotypes to exercise.

Genotype could modify muscle color, as observed by Le Bihan-Duval et al. (1999) in breast muscles of broilers of different genetic lines. Color differences may also be due to myoglobine content in the muscle and to the final pH (Berri et al., 2001).

Our results agree with those of other authors (Le Bihan-Duval et al., 1999), who found a negative correlation between the final pH of the muscle and the L value.

Higher ($P < 0.01$) thawing losses were observed in local and HLW genotypes. The HLW breast presented higher ($P < 0.01$) cooking losses when compared with the other groups. Within the local breeds, the RM samples exhibited lower ($P < 0.01$) losses than the ER breasts. Higher total weight losses were observed in ER and HLW breasts, indicating that final pH and other factors such as breast muscle growth characteristics may influence them. Our results agree with those of Kok et al. (2005), who found a significant relationship between the weight of the fillets and the cooking loss, which is higher in smaller fillets.

The shear force (Table 4) was similar in the 4 groups. The absence of significant differences among the genotypes could be due to the type of sample used. In fact, in our trial the shear force was tested on cooked breast meat after thawing. In organic farming production, it might be necessary to slaughter the birds only during certain periods of the year and not in cold seasons (to avoid extreme environmental cold temperature and an excessive increase of feed consumption), and, therefore, the meat has to be frozen. However, in the intensive production system, which is carried out only indoors, the production is extended throughout the year.

Freezing and thawing procedures could have altered some physical properties of the meat, and in these conditions, small variations of meat tenderness of genotypes could not be perceived by instruments.

Sensory Profile of Breast and Thigh Meat

The meat odor and flavor properties and texture characteristics are presented in Table 5.

Given the influence of diet (fatty acid composition), particularly on some sensorial parameters of products (Lopez-Ferrer et al., 1999; Gonzalez-Esquerra and Leeson, 2000), it is worth noting that, in our trial, the diet of the birds in the 2 mo previous to slaughter was mainly based on commercial feed (Table 1) instead of grass, which grew very little during the hot summer and grew in very limited areas during the autumn.

The odor intensity did not differ among the genotypes for either the breast or thigh. The values for the thigh are higher than those of the breast; such differences could be due to muscle composition, because the thigh had a higher lipid content than the breast, in addition to being chemically different (C. Rizzi, unpublished data). In fact, the lipid content of the meat and its chemical composition may imply relevant differences in the scores between breast and thigh meat; flavor was higher in the thighs than in the breasts, particularly when fish oil was added to the diet instead of vegetable oil (Lopez-Ferrer et al., 1999).

Table 4. pH and physical properties of breast meat

	Genotype[1]				
Item	ER	RM	HLW	HLB	MSE
pH	$5.61^{b,B}$	$5.75^{a,A}$	$5.82^{a,A}$	$5.76^{a,A}$	0.0057
Lightness (L*)	$57.27^{a,A}$	$53.78^{b,B}$	$54.25^{b,B}$	$52.83^{b,B}$	5.9843
Redness (a*)	–0.72	–1.08	–1.00	–0.57	0.9815
Yellowness (b*)	4.94	4.03	5.24	4.12	3.4528
Thawing loss[2] (%)	$6.21^{a,A}$	$6.13^{a,A}$	$5.85^{a,AB}$	$3.43^{b,B}$	4.1926
Cooking loss[3] (%)	$16.54^{b,B}$	$14.44^{c,C}$	$19.90^{a,A}$	$15.67^{b,BC}$	1.6952
Shear force (kg/cm^2)	2.17	2.26	2.30	2.20	0.1014

$^{a–c}$Means within same rows followed by a different superscript are significantly different ($P \leq 0.05$).

$^{A–C}$Means within same rows followed by a different superscript are significantly different ($P \leq 0.01$).

[1]ER = Ermellinata di Rovigo; RM = Robusta Maculata; HLW = Hy-Line White; HLB = Hy-Line Brown; MSE = mean square error (36 df).

[2]Thawing loss was calculated as weight difference between raw breast fillet and thawed breast fillet/weight of raw breast fillet × 100.

[3]Cooking loss was calculated as weight difference between uncooked breast fillet and cooked breast fillet/weight of uncooked breast fillet × 100.

Aroma intensity was similar among the groups in the breast but not in the thigh, which presented higher values ($P < 0.05$) in the hybrids. The variability of this parameter between breast and thigh meat seems to be related to the genotype. Chemical reactions during cooking release many substances, such as volatile compounds, that give aroma and flavor to the meat (Aliani and Farmer, 2005).

It is worth noting that these attributes may be particularly affected by the concentrations of lipids and other compounds of raw meat, such as reduced and phosphorylated sugars, amino acids, and thiamine (Aliani and Farmer, 2005). The natural components have little aroma until they interact during cooking; the reactions include lipid oxidation, the thermal degradation of thiamine, and the Maillard reaction between an amino compound (amine, amino acid, peptide, or protein) and a carbonyl compound (Aliani and Farmer, 2005).

Table 5 presents the shear resistance of the breast meat; it was higher ($P < 0.01$) in the ER and HLW samples compared with the HLB and RM as well as in the thigh ($P < 0.01$).

Table 6 summarizes some texture attributes of the breast and thigh.

The breast adhesivity in RM and ER samples was higher ($P < 0.01$) than in the HLB and HLW; significant differences were found between the Italian breeds, being higher ($P < 0.01$) in the RM samples compared with the ER.

The opposite was observed in the thigh; the RM samples showed significantly ($P < 0.05$) lower adhesivity than ER. More relevant differences were observed between the muscles of ER and RM hens compared with the hybrids.

Breast fibrousness was significantly higher ($P < 0.05$) in RM and ER samples compared with HLB ($P < 0.05$). Thigh meat presented higher ($P < 0.05$) values in ER and HLW when compared with RM; HLB was intermediate. Thigh meat presented higher fibrousness than breast meat, probably due to higher muscular activity, as previously stated by Castellini et al. (2002b).

Chewiness was lower ($P < 0.01$) in HLW compared with RM breast; the other genotypes were intermediate. No differences were observed in thigh meat.

Table 5. Odor and flavor properties and shear resistance of breast and thigh meat

	Genotype[1]				
Item	ER	RM	HLW	HLB	MSE
Odor sensations					
Odor intensity					
Breast	5.60	6.73	5.99	6.21	1.3934
Thigh	7.86	7.07	7.51	6.87	1.2572
Flavor sensations					
Aroma intensity					
Breast	6.34	5.66	6.44	5.94	1.6423
Thigh	6.30^{ab}	5.20^{b}	6.91^{a}	7.21^{a}	1.8576
Shear resistance					
Breast	$9.03^{a,A}$	$7.24^{b,B}$	$9.01^{a,A}$	$7.34^{b,B}$	1.3490
Thigh	$6.90^{a,A}$	$5.46^{b,B}$	$8.03^{a,A}$	$5.20^{b,B}$	1.4507

^{a,b}Means within same rows followed by a different superscript are significantly different ($P \leq 0.05$).

^{A,B}Means within same rows followed by a different superscript are significantly different ($P \leq 0.01$).

[1]ER = Ermellinata di Rovigo; RM = Robusta Maculata; HLW = Hy-Line White; HLB = Hy-Line Brown; MSE = mean square error (24 df).

Table 6. Texture properties of breast and thigh meat

	Genotype[1]				
Texture sensations	ER	RM	HLW	HLB	MSE
Adhesivity					
Breast	$5.16^{b,B}$	$6.41^{a,A}$	$2.80^{c,C}$	$3.50^{bc,BC}$	2.5089
Thigh	4.14^{a}	1.34^{b}	2.61^{ab}	3.44^{a}	4.6598
Fibrousness					
Breast	6.07^{a}	7.26^{a}	5.10^{ab}	3.89^{b}	5.9603
Thigh	9.00^{a}	7.81^{b}	8.93^{a}	8.31^{ab}	0.7532
Chewiness					
Breast	1.23^{ab}	2.64^{a}	0.74^{b}	2.01^{ab}	1.6923
Thigh	0.59	1.29	1.16	0.53	0.9606
Solubility					
Breast	$1.70^{b,B}$	$2.17^{b,B}$	$2.27^{b,B}$	$3.91^{a,A}$	1.1330
Thigh	1.59^{b}	3.14^{a}	1.47^{b}	2.70^{ab}	1.7569
Juiciness					
Breast	$0.90^{b,B}$	$1.96^{b,B}$	$1.50^{b,B}$	$3.90^{a,A}$	1.5482
Thigh	4.30	5.39	4.13	4.99	3.2801
Tenderness					
Breast	$1.39^{bc,BC}$	$2.36^{ab,AB}$	$0.91^{c,C}$	$3.33^{a,A}$	1.0442
Thigh	$1.96^{b,B}$	$1.51^{b,B}$	$5.09^{a,A}$	$4.56^{a,A}$	1.7245

[a–c]Means within same rows followed by a different superscript are significantly different ($P \le 0.05$).

[A–C]Means within same rows followed by a different superscript are significantly different ($P \le 0.01$).

[1]ER = Ermellinata di Rovigo; RM = Robusta Maculata; HLW = Hy-Line White; HLB = Hy-Line Brown; MSE = mean square error (24 df).

Breast solubility was higher ($P < 0.01$) in HLB compared with the other groups. Thigh solubility was higher ($P < 0.05$) in RM than in both ER and HLW. Generally, these 2 last parameters presented lower values in thigh muscles than in breast muscles.

The same trend of breast solubility was observed in breast juiciness, with higher values ($P < 0.01$) in the HLB hens. The thigh juiciness was similar among the groups. In the present trial, the notable differences in juiciness were observed between hybrids only in the breast, but not in the thigh. Different scores were given by panelists to the thighs and breasts; the score difference was minimal only for HLB.

These results could indicate the positive effects of the genetic improvement carried out in recent years on the brown eggshell genotypes to obtain carcass meat with acceptable quality; higher juiciness in HLB is partly attributable to the higher fat content (Lawrie, 1991) of muscles (C. Rizzi, unpublished data).

Furthermore, in our trial, the juiciness reflects the trend of water loss data, according to Kok et al. (2005), as meat with higher scores presented the lowest total losses (thawing and cooking).

Different ($P < 0.01$) breast tenderness was observed among the 4 groups: HLW presented the lowest ($P < 0.01$) tenderness, followed by ER ($P < 0.01$) and RM ($P < 0.01$), whereas the HLB showed the highest ($P < 0.01$). In the thighs, significantly higher ($P < 0.01$) values were found in hybrid samples respect to local genotypes. Local breeds presented similar tenderness both for breast and thigh, whereas the hybrids showed similar values only in the thigh.

Variations of meat texture, particularly juiciness and hardness, could be related to the structure and to the acidic composition of the lipid fraction of the muscles, and many factors are able to influence them (Farmer et al., 1997; Castellini et al., 2002b; Lyon et al., 2004).

Recently, Jahan et al. (2005) pointed out that the primary difference among chicken breasts from differing production regimens (organic, free-range, corn-fed, and conventional) was mainly by appearance and texture, and less by aroma and flavor.

The effect of age on meat tenderness caused by the changing of muscle structure, in particular by increasing collagen content, is well established (Touraille et al., 1991; Castellini et al., 2002b). The increasing of the saturated fraction, with a consequent increase of melting point, or the increasing of protein content could result in drier and firmer meat (Du and Ahn, 2002).

In the present trial, differences in breast tenderness could be due to protein and lipid content, because breasts with higher lipid and lower protein content (C. Rizzi, unpublished data) showed higher tenderness. The saturated fatty acid content of the thighs, which tended to be higher in the local breeds, may be one of the factors that influenced meat tenderness.

In any case, it is worth noting that for breast samples only 1 muscle and i.m. lipids were considered, whereas for thigh samples more than 1 muscle and both i.m. and intermuscular fats were included.

Furthermore, according to Girolami et al. (2003), the differences in meat tenderness were detected by the sensory panel, whereas instrumental measures were not able to detect any difference. It is worth stating that the Warner-Bratzler method gives the maximum force needed to shear a core of meat, whereas information on perception of meat tenderness may be detected during biting and chewing. Similar responses were observed between shear resistance to the knife and the tenderness data for the breast, but not the thigh, probably because thigh samples were comprehensive of more muscles and were thus less homogeneous with respect to the breast.

The results give some indications on meat production of the 4 studied genotypes of laying hens reared under organic conditions in the first phase of the productive cycle. The local breeds demonstrated good capability in terms of meat production performance, presenting carcasses with heavier commercial cuts and higher fleshiness.

The panel test results point out that none of the genotypes presented a global sensorial profile better than another. The major effect of genotype involved the texture parameters rather than those concerning odor and flavor characteristics. The RM and HLB hens presented breast muscles with more tenderness and juiciness. Generally, the sensorial results observed on the breast do not agree with those of the thigh.

Further research is needed to determine meat yields and meat quality of hens of these genotypes reared under environmental and dietary conditions different from those studied in this trial and in a different phase of the laying cycle.

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