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Comparison of meat quality of local poultry and Arbors acres reared in two farming systems in Tunisia

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Abstract - The aims of this study were to compare meat technological, organoleptic and nutritional qualities of both local chickens and arbors acres reared into two farming systems (industrial and traditional), and to determine the effect of storage temperatures (24°C or 4°C) on meat quality during the pattern of rigor mortis. A total of 110 chicks (n = 50 of local chickens and n = 60 of Arbor Acres) was used. Results showed that meat color parameters (L* and a*) were not affected by breeding systems, but b* parameter was significantly ($p<0.001$) affected. In fact, the pasture consumed by traditional poultry increases the value of b* compared to the industrial animals eating only commercial food. Moreover, the ultimate pH measured doesn't have any effect on color (redness and luminosity). Furthermore no significant difference in sheer force parameter was observed, despite of animals do not have the same age at slaughter. For other parameter of texture (Hardness, Cohesiveness and Chewiness), we don't reported significant difference ($p<0.05$) between breeding system. The sex and storage temperature have no influence on texture of breast meat

Keywords: meat quality, local Tunisian poultry, rearing system, temperature of storage.

1. Introduction

The use of indigenous animal genetic resources to achieve and maintain sustainable production systems able to respond to human needs is essential for food security at national and international levels. In Tunisia, traditional poultry production systems decline and the promoting of use of exotic breeds led to the dilution or loss of breeds adapted to the environmental conditions (Bergaoui, 1990; Bessadok et al., 2003). However, the genetic variability within indigenous poultry populations is a fairly important factor for their best valuation. It is very useful for the provision of quality products, well adapted to regional contexts and appreciated by consumers (Raach-Moujahed et al., 2011). In addition, traditional poultry seem to have the advantage of being well adapted to adverse and possibly stressful conditions in rural areas, such as the vagaries of climate, pathogens, lack of appropriate hygiene measures and food failures. Another merit of local poultry resides in the individual and typical taste of products, increasingly demanded by urban consumers (Bessadek et al., 2003; Fotsa et al., 2007; Moula et al., 2009b). In Tunisia; meat production was previously based primarily on levels of animal performance and animal conformation. In response to changing consumption patterns, factors influencing the quality has become a requirement (Raach- Moujahed et al., 2011). The organoleptic and technological qualities of poultry meat depend largely on biochemical and physiological reactions during the transformation phase of muscle to meat and on several ante-mortem environmental conditions. It is therefore necessary to understand and explain the heterogeneity of the quality parameters of meat chickens (Raach-Moujahed et al., 2012). Currently, informations are available regarding the importance of traditional poultry farming, the meat quality and the factors influencing the quality of the meat such as the heat treatment of carcasses after slaughter.

2. Materials and methods

2.1. Animals and Rearing Conditions

A total of 110 chicks (n = 50 of local Tunisian poultry and n = 60 of Arbor Acres) was used. Indigenous Chickens were weighed one day by week during 16 weeks from March to June 2014 in experimental unit of National Agronomic Institute of Tunisia. After hatching, the chicks were installed in the brooder for one month to ensure the start-up phase. During this period animals were fed with concentrate as start. At one month age, chicks have been installed on the pasture to move freely during three months (April, May and June). Feed was based on the vegetation of pasture (4 m2 /bird) and complemented of concentrated growth. Arbor Acres Broiler were weighed one day by week during 6 weeks from May to June 2014. At start-up phase chickens were reared in coop. During this period animals were fed with concentrate. Then, they will be subsequently housed in an enclosed building with a density of 8 birds / m2 with an artificial light of 4Watt /m2 until 42 days age. During this period animals were fed with growth concentrated. Throughout the rearing period in both systems, temperature and humidity were measured daily using a thermometer-hygrometer-digital (Hanna Instruments Inc., modèle HI99161). At the end of the experimental period, forty chickens of each production system were randomly selected to analyze technological and sensory meat quality and ten chickens of each genotype were selected to analyze physicochemical and biochemical meat quality. chickens were fasted for 12 h and weighed. Animals were slaughtered at (6 weeks of age for arbors from factory farming system and 16 weeks for local poultry from traditional breeding system). After slaughter, the eviscerated carcasses of each breeding system are divided into 2 batches and undergo two different temperature treatments (batche 1 = 20 carcass under room temperature (24 ° C) and batche 2 = 20 carcass under temperature of 4 ° C).

2.2. Measurements

Analysis of technological and sensory quality

pH and temperature measurement

The pH and temperature were measured at different time postmortem (20 min; 1 h; 2 h; 3 h; 4 h; 5 h; 6 h; 7h, 8h, 24 h) in the breast muscle at 2 cm depth. The used pH-meter (Hanna Instruments Inc., model HI99161) was equipped with an electrode calibrated at pH 4.0 and 7.0 before measuring and was coupled to a temperature control system.

Color measurement

Skin and meat (breast and thigh) color were evaluated at 24 h postmortem with a Chroma Meter (model CR-300, Minolta Chromameter CR300, Osaka, Japan) to record lightness, redness, and yellowness (L*, a*, and b*, respectively). The tip of the Chroma Meter measuring head was placed flat against the surface of the skin or the breast meat. Three measurements were taken on the ventral (top) side of the pectoralis major muscle.

Water Holding Capacity

The water-holding capacity of breast (pectoral major muscle) meat was assessed by measuring its drip cook losses according to the method of Dadgar et al. (2010). Breast cuts were placed inside vacuum bags sealed and cooked placing vacuum-package bags in a water bath with automatic temperature control until they reached an internal temperature of 70°C. After cooking, samples were cooled in circulatory water bath set at 18°C during 30 min and the percentage of cooking loss (CL) was recorded and it was reported as a percentage as follows:

% Cook Loss = [(raw weight − cooked weight)/ raw weight] × 100.

Shear Force

The maximum shear is performed by the method of Warner-Bratzler (1928 - 1932). Samples of 1 cm^2 section and 3 cm in length are taken parallel to the direction of muscle fibers (2 cores / net) and cooked on the threads are cut by a single blade located in a universal machine (MTS Synergie 200) perpendicular musculaires. Three fibers to shear measurements are made per sample, and the maximum shear force (in N / cm^2) and the mechanical work to the maximum force (in J; AUC) are retained.

Compression Test

For compression, three measurements were performed per sample. Compression defines the potential of the tenderness of meat. The sample (1 x 1 x 1 cm) was placed in a cell that holds the sample between two rigid walls, the direction of the muscle fibers is parallel to the walls of the room. Measuring compression is made perpendicularly to the fiber direction of the meat with a tool to the cylindrical end section of 1 cm2, descending at a rate of 80 mm / min. Uniaxial compression (uni axial strain) is simply set at 20% and 80% (for cooked meat) the height of a slice of meat taken in the center of the sample

2.3. Statistical Analysis

The data were subjected to ANOVA using a GLM procedure of the SPSS package (SPSS 15.0, Chicago, IL). A three-way ANOVA was used to analyze the effects of the system of breeding, sex, and storage temperature after slaughter and their interaction on the measured parameters. Two models were used in this study:

$Y_{ijk} = \mu + B_i + S_j + T_k + BT_{ik} + BS_{ij} + BTS_{ijk}\ \varepsilon_{ijk},$ [3]

Where Y_{ijk} is the observation of dependent variables, μ is the overall mean, B_i is the effect of breeding system, S_j is the sex, T_j is the storage temperature after slaughter, BS_{ijk} is the interaction between breeding system and sexual group, BT_{ijk} is the interaction between breeding system and storage temperature after slaughter, BTS_{ijk} is the effect of temperature in breeding system according to sex and ε_{ijk} is the residual random error associated with the observation.

3. Results and discussion

Kinetic of pH in carcass

The experimental data of *pH* drop over time for the 80 grown under two breeding systems and subsequently stored at two temperatures (4ºC and room temperature) are shown in figures 1.

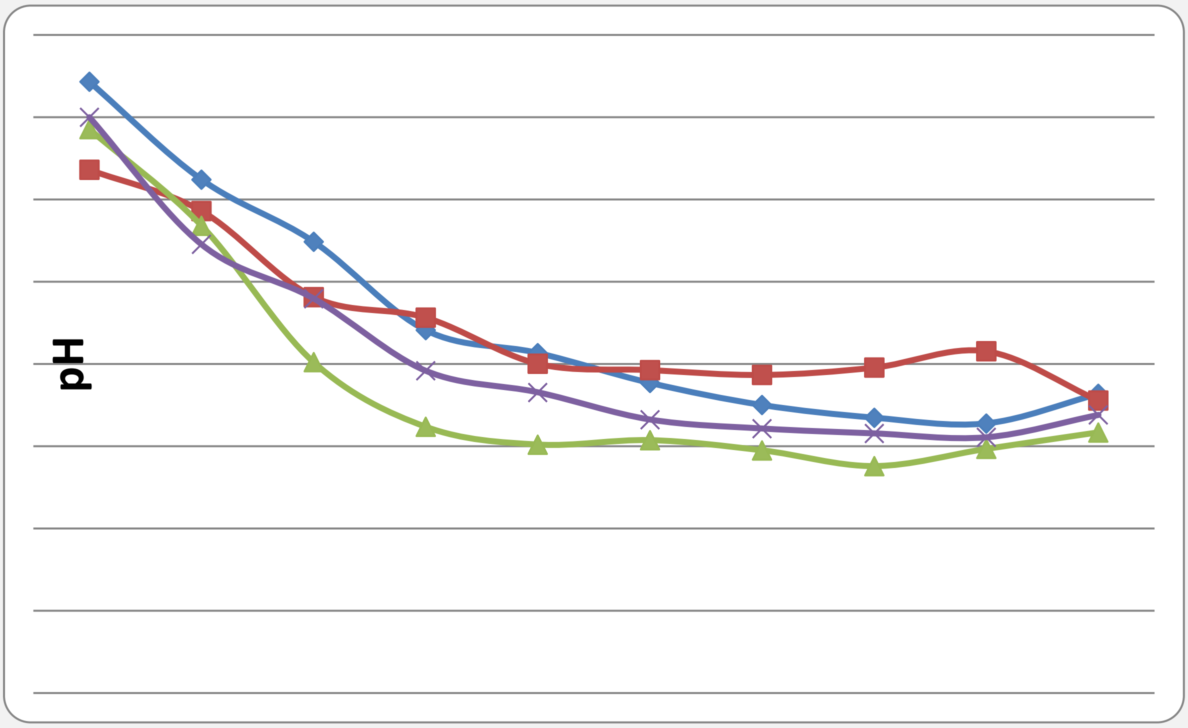

Figure 1. *pH* kinetics of two stored temperatures (24°C and 4ºC) and grown under two modalities of production: traditional and industrial.

Figure 1 showed that all pH average values recorded at different times in local poulrty are lower than those of Arbor broiler. It should also be noted that the shape of the pH decrease is faster for Arbor chicken during the first 4 hours. Although the pH value at 20 minutes post mortem is approximately 6.4 for both genotypes. Indeed, the pH value gradually decreases up to the ultimate value, respectively in local poultry (5.66) and for arbor acres (5.72) in 24 hours post mortem. These results are confirmed with those of El Rammouz et al. (2004), who stated that the falling speed of the post mortem pH is significantly influenced by genotype. They found that the pH drop is rapid during the first five hours (5.73). According to the literature, pH post mortem kinetics is characterized by its speed and amplitude. Indeed, the conditions pre slaughter and slaughter are influencing glycogen stores wich affect the speed and amplitude of the kinetics pH during post-slaughter 24h. The speed of the fall is determined primarily by the ATPase activity, while the magnitude of the fall of the post mortem pH depends mainly on muscle glycogen reserves (r = 0.77) at the time of slaughter (Bendall and Lawrie., 1962).
despite of the conservation system (4ºC and room temperature 24°C), the ultimate pH value for the local poultry is slightly less than the interval given by Santé et al. (2001) (5.7-5.9)., but similar results for the arbor. Certainly, the conditions of pre-slaughter are influencing glycogen and subsequently the kinetics of pH during the 24 hour after slaughter.. There are also other factors affecting the variation of the speed and the amplitude of the reduction in the post-mortem pH as genetic type. According to Berri et al. (2001) selection for growth and muscle development results in a slower postmortem pH drop, and an increase in the ultimate pH of muscle. Moreover, the buffer effect in the poultry meat affects the final pH value (Van Laack et al., 2001). This may explain the variation in ultimate pH between the two species. The pectoral muscle can accumulate the same amount of lactic acid with a different ultimate pH. Our data are also in agreement with the result of Owens et al. (2000) who reported that the pH kinetics is related to the age of the birds at the time of slaughter, so the older animals have the fastest speed fall with the lowest ultimate pH value. The storage temperature influences the internal temperature of the meat but it has no effect on pH kinetics. This is in agreement with Molette et al. (2003) for turkey meat at different storage temperatures (40, 20 and 4 °C for 6 hours).

Meat Quality
The results of the analysis of variance of technological, organoleptic quality from breast meat as well as color and textural parameters for the two breeding systems and storage temperatures are presented in Tables 1. In addition, Table 2 shows the effect of sex on the quality of breast meat for two systems of rearing

Ultimate pH
The pHu is 5.65 for a slow growing genotype (local chicken) and 5.72 for the fast growing genotype arbor acres. The pHu value was similar to that reported in other autochthonous breeds, such as Berri et al. (2005) and Nathalie et al. (2003) in France with pHu equal to 5.66 for 12 weeks. Concerning arbor acres broiler, our results are very close to the values found by Husak et al.(2008) (pHu = 5.75). But in this study, pHu values are lower than those reported by (Berri et al. (2007) (pHu = 5, 84). pHu is function of the nature of the pasture for a slow growth genotype (Ponte et al., 2008a). The pHu values measured in the breast muscle at 24 h postmortem were significantly different between genotypes (p= 0.01). This fact could be due to differences in behavior, more aggressive and alert in indigenous poultry than in arbors broilers. Besides, the differences pHu found for the two genotypes, could be due to the age at slaughter (6 and 16 weeks) and breeding system. Moreover, the conditions of pre-slaughter and slaughter are influencing glycogen and pH 24h after slaughter. The temperature doesn't affect pHu. This is in agreement with the results obtained by Molette and al. (2003) for turkey meat at different storage temperatures (40, 20 and 4 ° C for 6 hours).
Regarding the difference between sexes for pHu, it is not significant for both system of rearing. Regardless of the sex of the animals after slaughter, pHu for local chicken is slightly less than the interval given by Santé et al. (2001) (5.7-5.9), but it is similar for arbor broiler.

Color
Concerning meat color, luminosity is slightly high in the arbor acres (60.35) compared to local poultry (59.74). But, redness (a) and yellowness (b) are slightly higher in local poultry (11,48 vs 11,05 and 14,61

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vs 11,99, respectively). The results showed that no significant difference between the two genotypes except for the parameter of yellowness (p=0.345).
Results obtained for the two parameters (luminosity and yellowness) are in agreement with those reported by Mikulski et al (2011). moreover, breeding system does not affect meat color parameter (L* and a*) but it affects b*. This finding is in agreement with the results of Franco el al (2012b). Indeed, the pasture consumed by local chickens on the path increases the value of b *, contrarily to the industrial animals that eat only the commercial food. According to Fanatico et al, (2007); and Mourao et al, (2008), the high value of (b*) is related to physical exercise during pasture. Ponte et al. (2008b) reported that the feed intake restriction has no effect on the luminance (L*) and the red color (a*) of chicken meat (P> 0.05) but has an effect on the color yellow (b*) (P <0.001). Castellini et al. (2002b) reported that the ultimate pH influences the color of the meat. Temperature of storage has an effect on a* (p <0.05) of meat and skin. While no effect was reported in L* and b*. Our results are agreed with those of Ali et al. (2008). . The sex of chickens has a significant effect on color parameters (L * a * b *) in local poultry (p <0.0001) but no significant effect was noticed in arbor acres. Our results are in agreement with those found by Ngoka el al (1982). while the results obtained for local poultry are similar to those of Anadon (2002) and Dadgar et al (2011) who showed that the pectoralis major muscle of female chickens present lower ultimate pH and higher values of L*and b* compared to males, except a* value which is higher in males than in females. This difference observed at the color between the males and females is probably related to the difference of muscle energy.
Our study also indicates that skin color parameters (L*, a*, b*) in the Arbor Acres broiler are higher (p=0.004) than in local poultry. This is explained by the influence of several factors including genetics, age, feeding and systems of rearing. The relatively higher values of yellowing of the skin of the Arbor acres broiler is probably due to the high proportion of corn in the diet (+ 60%) (Raach-Moujahed et al 2012).

Texture
All shear force values were lower than 30 N (table 1) suggesting that samples were sufficiently tender and therefore would be highly accepted by consumers (Schilling et al., 2003 and Corzo et al., 2009). The shear force of the breast muscle of arbor acres was lower (17.83) than in local poultry (18.41) . Indeed, shear force was not significantly affected by genotype or system of rearing (p= 0.697) . These results are in agreement with results obtained by Franco et al (2013) but in disagreement with Jaturasitha et al.(2008) who found differences in breast muscle shear force in 4 different genotypes. For other parameter of texture (Hardness, Cohesiveness and Chewiness), the difference between Arbor Acres and local poultry is significant This difference is explained by the difference of collagen levels (0.7 for the arbor acres at 42 days and 0.86 for indigenous poultry at 120 days). In addition, the muscle fiber size decreases proportionally with the size of threads (Fletcher, 2002),.
The temperature has no effect on the shear force and other parameter of texture (Hardness, Cohesiveness and Chewiness .This is in disagreement with the results obtained by molette et al (2003) for turkey meat at different storage temperatures (40, 20 and 4 ° C for 24 hours) and Dadgar et al (2011) for the broiler breast meat. Similarly, no significant effect (p>0.05) was reported for sex on shear force in studied genotypes (Table 2). This is in agreement with the results obtained by Lopez et al. (2011).

Table 1. Effect of breed and storage temperature on breast meat quality

	Breed		Treatment		Pvalues	
	Arbor	**Local**	**Ambient**	**Refrigerated**	**Breed**	**Treat.**
pH$_u$	5.72	5.65	5.68	5.69	0.010	0.638
Color parameters						
L meat	60.35	59.74	60.31	59.79	0.347	0.417
a-meat	11.05	11.48	10.76	11.77	0.236	0.007
b-meat	11.99	14.61	13.64	12.95	<0.0001	0.252
L skin	68.73	63.91	66.01	66.63	0.0001	0.191
a-skin	6.47	5.68	5.64	6.50	0.008	0.004
b-skin	16.49	14.30	15.05	15.74	0.003	0.341
Textural parameters						
Shearforce (N)	17.83	18.41	18.60	17.66	0.697	0.567
Hardness	171.82	140.80	152.48	167.74	0.002	0.118
Cohesiviness	0.45	0.36	0.43	0.38	<0.0001	<0.0001
Chewiness	47.90	39.74	48.83	38.84	0.146	0.077

Table 2. Effect of sex on breast meat quality

	Arbor		Pvalue	Tunisia		Pvalue
	Male	**Female**		**Male**	**Female**	
pH$_u$	5.73	5.70	0.440	5.69	5.62	0.114
Color parameters						
L meat	60.02	60.71	0.456	57.51	61.23	<0.0001
a-meat	11.42	10.64	0.047	12.69	10.68	0.001
b-meat	11.61	12.40	0.172	12.36	16.10	<0.0001
L skin	68.87	68.56	0.608	62.64	64.76	0.004
a-skin	6.82	6.08	0.091	6.52	5.11	<0.0001
b-skin	16.59	16.39	0.830	12.73	15.35	0.020
Textural parameters						
Shearforce (N)	19.34	15.88	0.073	16.31	19.78	0.060
Hardness	173.84	169.69	0.755	126.00	149.69	0.050
Cohesiviness	0.44	0.45	0.814	0.36	0.36	0.933
Chewiness	49.27	46.29	0.764	36.01	42.23	0.330

4. Conclusion

The comparison between the two farming systems (industrial and traditional) shows an advantage in the technologic and organoleptic quality of meat for the Local poultry compared to arbors acres broiler. Our study indicated that there is not a large variability of the pH drop and ultimate pH. Concerning meat color parameter, breeding system does not affect the meat color parameter (L * and a *) but they affect the value of b *. Certainly, the pasture consumed by local poultry increases the value of b * than in the industrial animals that eat only the commercial food. Moreover, ultimate pH measured at the breast had no effect on color (the redness and luminosity) .The temperature of storage influences the value of a * ($p < 0.05$) for the meat and skin. This is related to existence of more oxidized myoglobin in the muscle of birds exposed to ambient temperature compared to breast refrigerated at 4°C. The sex of chickens of local breed has a significant effect on (L* a* b*) of meat and skin color but no significant effect was reported in arbor acres broiler.

All shear force values were lower than 30 N suggesting that samples were sufficiently tender and therefore would be highly accepted by consumers. The shear force of the breast muscle of arbor acres broiler was lower than in local poultry. Indeed, shear force was not significantly affected by genotype or system of rearing The temperature of storage has no effect on the shear force and other parameter of texture (Hardness, Cohesiveness and Chewiness)

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