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Evaluation of Growth Performances and Meat Quality of Tunisian Local Poultry Raised in Outdoor Access

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Abstract: Local and indigenous poultry in Tunisia represent very diversified and heterogeneous populations which remain largely unknown and understudied in spite of the real economic assets that they seemed to represent mainly in rural areas. The present study was envisaged in the objective of conservation, valorization and development of this rustic and well adapted genetic substrate. In this respect growth parameters were measured and meat quality measurements on pH and color (L*: luminance, a*: yellowness b*: redness) were operated. Results showed that a mean Body Weight (BW) of 632 g was reached at week 8, 923 g at week 12 and 1249 g at week 16, with mean Daily Weight Gain (DWG) of 16.72, 11.26 and 10.89 g/d respectively. Males were found to be more ($p < 0.05$) performing than females both in BW and DWG at all ages. The ultimate meat pH value after 24 h of slaughtering was relatively high (6.1) and color parameters in the main muscles were particularly intense. Feed Conversion Ratio (FCR) was relatively low (3.97) and remained far lower than several other local populations studied in some European and African countries. It was concluded that Tunisian local poultry presented potentially interesting growth parameters and meat quality characteristics. In addition to the high potential of selection and crosses possibilities, they could represent a strong argument of development of local production systems for rural populations. Thereby, an urgent program of screening, evaluation and conservation of these populations is to be conceived and applied.

Key words: Local poultry, performances, meat quality, alfalfa

INTRODUCTION

In Tunisia, traditional breeding based on local poultry population is widely spread in the rural areas and around agglomerations. This activity provides about 9% of the produced poultry meat and quite 7% of eggs consumed by Tunisians (GIPAC, 2010). In addition, traditional poultry plays very important social roles. In deed, products from this sector represent further sources of income for poor or modest rural families, are sometimes presented as gifts to important guests (Bergaoui, 1990; Bessadok *et al.*, 2003) and could be used as a mean of barter in some local markets or between neighbor's peasants.

However, the indigenous chicken seems to have low performances comparatively with exotic or hybrid or selected poultries. In this respect, most of the studies carried out in African and Middle Eastern countries on local poultries had shown that they have low size of eggs and chicks (Fotsa *et al.*, 2007; Moula *et al.*, 2009a,b; Kingori *et al.*, 2010) and low parameters relative to meat and eggs performances, comparatively to usual norms in industrial poultry. This may be attributed, in addition to genetic limits, to the extensive systems breeding

generally practiced by farmers and which are marked by unbalanced feeding, inadequate housing and inappropriate veterinary cares and treatments (Bergaoui, 1990; Fotsa *et al.*, 2007). In rural regions, local poultry feeding is based mainly on worms, mollusks, insects, stones, grasses and the various wastes mixed with the ground. The farmers provide some other supplements such as some cereal wastes, wet or dried bread, domestic wastes (Bessadok *et al.*, 2003). Unfortunately, except the study carried out by Bessadok *et al.* (2003), scientific investigations on Tunisian local poultry performances are quite in existent. The cited authors found that the studied Tunisian poultry population was of low performances both for meat and eggs comparatively with selected breeds and that in spite of the genetic erosion, these populations had conserved a sufficiently important variability allowing not only to guarantee a minimum level of production of eggs and meat, but also to safeguard a rich reserve of different genes (color, form, rusticity...).

Indigenous chickens seems to have the advantage of being well adapted to the local stressful conditions in the rural areas such as high temperature, serious

disease problems, poor farming hygiene and unbalanced diets (Bessadok *et al.*, 2003; Fotsa *et al.*, 2007; Kingori *et al.*, 2010). Another merit of the indigenous chickens is the typically appreciated taste and flavor of products, more and more claimed by the consumers (Fanatico *et al.*, 2005b; Moula *et al.*, 2009b; Kingori *et al.*, 2010). Consequently, a real demand of special products from heritage chicken breeds is currently requested in spite of their relatively high prices (Bessadok *et al.*, 2003; Kingori *et al.*, 2010). The consumers believe that rural egg is more delicious with its deeper yellow yolk than intensively produced eggs and that the meat of rural chicken is also tasteful (Bergaoui, 1990; Ekue *et al.*, 2000; Fanatico *et al.*, 2005b). A serious interest is given to valorize local poultry breeds especially for the positive impact that this activity could induce in rural poverty alleviation strategies. Based on the above considerations, the current experiment was initiated to characterize growth performances and meat of the Tunisian rural chickens in improved conditions including grazing on legumes pastures.

MATERIALS AND METHODS

Animals, housing and prophylaxis: A total of 160 chicks of local Tunisian poultry were individually identified, weighed at day one and followed during 16 weeks from June to September 2009 at the "Centre de Formation Professionnelle Agricole dans le Secteur de l'Aviculture à Sidi Thabet". They were bred on a fresh wood shavings litter in a small building divided into 4 indoor pens containing 40 birds each (18 birds/m²). Every pen was connected, through a bird exit, to an enclosed outdoor area (28 m²: 1.5 bird/ m²) in which birds had free access to grazing on cultivated alfalfa. All chicks were vaccinated against Newcastle, Infectious Bronchitis and Gomboro diseases.

Feeding: Animals were fed *ad libitum* a starter during 4 weeks and then passed to a growing concentrate *ad libitum* during 12 weeks until slaughter. A transition period from the day 28 to the day 35 was respected and both concentrates were mixed. During the growing period, birds have free access to outdoor alfalfa pasture during the daylight until the end of the experimental period. The alfalfa was irrigated during the summer (June-September). The ingredient composition and nutrient content of the commercial diet used in these experiments are presented in Table 1. Samples of alfalfa were collected from 1 m² paddocks, by cutting it at 3 cm above the ground, for chemical analysis (Table 2). Water was available continuously throughout the experiment.

Table 1: Ingredient composition and calculated analysis of the cereal-based feed

Ingredients (%)	Starter (0-4 w)	Grower (5-16 w)
Corn	64.0	69.00
Soybean meal 48	32.0	27.00
Mineral and vitamin premix ¹	4.0	4.00
Calculated nutrient content		
Energy (kcal ME/kg)	2895.0	2930.00
Crude protein (%)	19.9	17.90
Fat (%)	2.5	3.10
Crude fiber (%)	2.3	4.70
Ash (%)	7.6	8.40
Methionine (%)	0.5	0.45

¹Mineral-vitamin premix provided the following per kilogram of diet: vitamin A, 10 000 IU; vitamin D3, 2 500 IU; vitamin E, 20 mg; nicotinic acid, 30 mg; vitamin B12, 0.12 mg; calcium pantothenate, 11 mg; vitamin K3, 2 mg; thiamin, 1 mg; riboflavin, 4.2 mg; vitamin B6, 1.7 mg; folic acid, 0.5 mg; biotin, 0.5 mg; Fe, 172 mg; Cu, 20 mg; Mn, 110 mg; Zn, 125 mg; Co, 0.3 mg; I, 2.4 mg; Se, 0.5 mg

Table 2: Chemical composition of alfalfa (% DM)

	Dry matter	Crude protein	Fat	Ash	NDF	ADF	ADL
Alfalfa	24.9	19.1	1.6	10.2	44.8	35.2	7.1

Measurements

Performances: Weekly, feed consumption and individual body weights were recorded. Feed conversion ratio for concentrate feed was calculated by dividing the weight of feed consumed by the weight gain per pen, including the weight gain of any dead birds. Bird mortality was recorded daily. At the end of the experiment, at day 112, one bird per pen was slaughtered and the crop content was collected. Forage particles were separated from cereal-based feed particles. The DM weights of the forage and concentrate fractions found in crop were measured. This allowed the estimation of pasture consumption by considering the intake of concentrate and the DM content of the pasture and the concentrate (Ponte *et al.*, 2008a).

Carcass characteristics and meat quality: At the end of the experimental period, on day 112, a sample of 20 birds (5 birds x 4 floor pens) was slaughtered. Feed was withheld for 8 h before slaughter and birds were weighed individually. The carcasses obtained after defeathering, eviscerating and removing the head, neck and extremities, were refrigerated at 4°C for 24 h and weighed.

The pH was measured at different time postmortem (15 mn; 1 h; 2 h; 3 h; 4 h; 5 h; 6 h; 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.

The Color of skin and meat (breast and thigh) were determined at 24 h postmortem using a Minolta chromameter CR-300 (Osaka, Japan). The readings were taken on equivalent positions. The tip of the chromameter measuring head was placed flat against the surface of the skin or of the meat for breast and thigh. For each reading, 3 measurements were performed and the average of these readings was considered as the final value. Skin and meat color were expressed in the CIELAB dimensions of lightness (L), redness (a) and yellowness (b).

Statistical analysis: Descriptive statistical analysis (arithmetic mean, maximum and minimum values, standard error) was achieved for all the determined parameters. Effect of sex on growth parameters was assessed through an analysis of variance, using the SAS software (General Linear Model, Statistical Analysis Software, 1999).

Growth curve parameters were estimated, according to the Gompertz equation:

$$Y = Ae^{-Be^{-kt}}$$

Where, Y = Live body weight at age t, A = Asymptotic final body weight, B = Integration constant and K = Represents the growth rate. Additional parameters (Mignon-Grasteau and Beaumont, 2000) describing growth curves such as: Ti = Age at the inflexion point, Yi = Body weight at inflexion point, Ui = Maximum weight gain at the inflexion point. Curves were fit for 16 weekly. Fitting quality was assessed via the coefficient of determination ($R^2 = 1 - (\text{error sum of squares}/\text{total sum of squares})$) and the mean absolute error. These parameters were estimated by non-linear regression using the NLIN procedure of SAS (1999), taking into account all available weights from birth to slaughter.

RESULTS AND DISCUSSION

Lives weight variation of local poultry: Registered live weight evolution of local poultry is presented in Table 3. Mean weight at hatching was 37.8 g. This value is close to that recorded by N'dri (2006) for the Gouloise (33-39 g) and Saadey *et al.* (2008) for Egyptian Fayoumi and Sinai breeds (respectively 36 and 38 g), but was higher than which recorded for poultry local breed in Cameroun (23-28 g: Fotsa *et al.*, 2007), Dandarawy local breed in Egypt (29 g: Abdellatif, 1989) and the ardennaise in Belgium (30 g: Moula *et al.*, 2009a).

Global mortality was 9.4% (15 animals). This value is equivalent to which recorded in Fayoumi (9.8%) by Azharul *et al.* (2005) but is largely higher than the value reported by Moula *et al.* (2009a,b,c) for Ardennaise (4.38%) and by Sauveur (1997) for the *Label Rouge* (2.5%) and the standard chicken (5.1%). These differences may be related to hygiene conditions and some health care that may be or not practiced in some of these breeding.

Table 3: Body weight for local poultry (g)

	Male	Female	SE	Mean values
BW0	37.94	37.79	0.29	37.84
BW1*	66.21a	62.35b	0.86	63.57
BW2*	113.33a	103.70b	1.62	106.68
BW3*	176.69a	159.20b	2.26	164.64
BW4*	282.48a	255.61b	3.40	264.18
BW5	373.68a	325.03b	4.06	340.71
BW6*	467.55a	405.66b	5.03	425.49
BW7*	561.77a	493.62b	6.31	515.74
BW8*	690.91a	604.61b	7.43	632.22
BW9*	745.02a	650.85b	7.88	681.24
BW10*	857.11a	738.07b	8.57	776.42
BW11*	935.66a	800.21b	9.26	844.12
BW12*	1038.19a	868.23b	10.49	923.54
BW13*	1108.17a	933.34b	11.39	990.40
BW14*	1187.32a	998.43b	12.31	1060.08
BW15*	1331.91a	1103.80b	14.54	1178.26
BW16*	1419.30a	1166.05b	15.78	1248.71

a,b: Values with different letters in the same line are statistically different. *p<0.05. SE: Standard Error of the Mean

For all ages, the registered live weight were significantly (p<0.05) higher in males than in females. This result confirmed several observations in poultry (Mignon-Grasteau and Beaumont, 2000; Pedersen *et al.*, 2003; Moula *et al.*, 2009a,b).

For the medium age of 8 weeks, our results confirmed the earlier records of Bessadok *et al.* (2003) for the same local Tunisian poultry population both for males and females. For females, our recorded live weight (604 g) was slightly higher than which observed in Fayoumi (469 g) local breed (Merat and Bordas, 1982) and higher than which noted in the local ecotype from Cameroun (479 g) at equal age (Fotsa, 2008). In the same trend, at the age of 16 weeks, the mean live weight (1249 g: 1166 g for the females and 1419 g for the males) was comparable to the values found by Bessadok *et al.* (2003) for the Tunisian local population at the same age (1010 g for the females and 1303 g for the males) and close to local Thailand chicken (1280 g: Jaturasitha *et al.*, 2008) but lower than the Ardennaise (1335-1671 g: Moula *et al.*, 2009a), the Chinese local breed Gushi (1419 g: Dou *et al.*, 2009), the Fayoumi and the Sinai (respectively 1331.65 and 1316.38 g: Saadey *et al.*, 2008) and the Gauloise Noire (1485 g) at 17 weeks of age (N'dri, 2006).

It's worthy to note that in all the presented results, considering the age and the sex of birds, the observed values are clearly lower than those observed in industrial poultry, for both genetic and management reasons. The variability of results in local breeds observed in all over the world may be related to genetic, management, feeding and hygiene level variations. Also, some differences between recorded values could be related to the fact that performances measured in research stations, compared with those usually met in province, were probably higher, because of a more regular quantitative and qualitative feeding supply and probably further health cares and control.

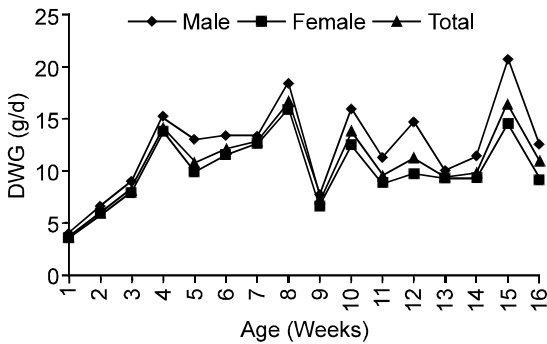


Fig. 1: Daily weight gain (g/d)

Daily weight gain: Daily Weight Gain (DWG) evolution is illustrated in Fig. 1. It started at 3.65 g/d during the first week and increases to reach a maximum of 16.7 g/d at the 8th week. It decreased then to 6.9 g/d at week 9 but increased again to 10 g/d at week 10 until week 14. At week 15, the DWG increased to 16 g/d and decreased to 10.89 g/d at week 16. An important decrease was finally observed between the 9th and the 14th week. This trend of evolution of DWG is classical (Pedersen *et al.*, 2003). As for live weights, a difference is observed ($p < 0.05$) between males and females in the period between the 5th and the 16th week. Values became similar in both sexes at the 9th week.

Average daily weight gain showed a gradual increase from one day old to 8 weeks of age. After the 8th week, the weight gain and the rate of growth declined. This trend was maintained until 16 weeks of age. In our results, the 8th week could therefore, be regarded as the point of inflection of growth in the studied local chicken. The observed great fluctuations of DWG are probably related to the heat strokes recorded during August and September (Temperature varied between 30°C and 40°C). The global DWG for all the period of breeding was 10.81 g/d. This value is relatively close to those found by Moula *et al.* (2009a) for the Ardennaise (12.04 g/d) for 12 weeks of breeding and for the varieties “bleue dorée” (11.24 g/d) for a period of 16 weeks breeding but was lower than that found by Iraqi *et al.* (2002) for Mandarrah breed (16.14 g/d) measured during a period of 16 weeks.

Feed Conversion Ratio (FCR): The overall value found for the FCR during the measurement period (FCR = 3.97) was lower than which found by Dou *et al.* (2009) for the Chinese local breed Cushi (4.41) and the value found by Fotsa *et al.* (2007) for different local populations in Cameroun (4.34-5.34) at the same age.

For the period until 12 weeks, FCR (3.11) was close to the result (3.37) found by Fanatico *et al.* (2005a) but lower than the value (5.09) reported by Lariviere *et al.* (2009). Lower values ranging between 2.17 and 2.24 were associated to the French Label Rouge (Sauveur,

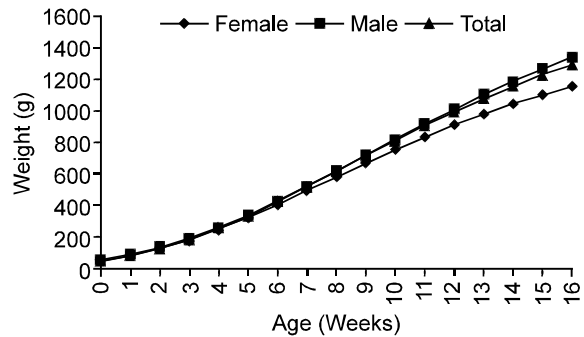


Fig. 2: Local broiler growth curve from week 1- week 6.
 Female: $Y = 1502.31 \cdot \text{EXP}(-3.41 \cdot \text{EXP}(-0.16 \cdot t))$;
 Male: $Y = 1947.37 \cdot \text{EXP}(-3.51 \cdot \text{EXP}(-0.14 \cdot t))$;
 Total: $Y = 1778.86 \cdot \text{EXP}(-3.52 \cdot \text{EXP}(-0.15 \cdot t))$

Table 4: Growth curve parameters of local breed

	Yi (g)	A (g)	B	K (/w)	T (w)	U (g)	R ²
Male	716.4	1947.37	3.51	0.145	8.7	103.8	0.978
Female	552.7	1502.31	3.41	0.156	7.8	86.5	0.979
Total	654.4	1778.86	3.52	0.150	8.5	95.8	0.998

1997). It's worth noting that local poultry breeds presented generally low efficiency of feed utilization (Momoh *et al.*, 2010). However, the Tunisian studied population seemed to be enough interesting, since FCR remained far lower than several other local population such as the Gasconne (6.58) and the Bresses (4.59) in France (Tixier-Boichard *et al.*, 2006), the Fayoumi (4.61 at 9-14 weeks of age) in Egypt (Azharul *et al.*, 2005) and a Nigerian local poultry (from 5.06-6.8 at 12-16 weeks, Momoh *et al.*, 2010).

Gompertz curve parameters: The local broiler growth curve from week 1 to week 16 is illustrated in Fig. 2. Parameters calculated for the growth curve are presented in Table 4. These values were different between males and females. Such differences are in concordance with the results recorded by Mignon-Grasteau and Beaumont (2000), Pedersen *et al.* (2003) and Gous *et al.* (1999) in commercial broiler. Indeed, Barbato and Vasilatos-Younken (1991) showed sex to explain 5-10% of whole variability of growth. Our results are in line with the report stipulating that in all species for which males are heavier than females, as in poultry, asymptotic weight (A) are expected to be lower and maturation speed (K) higher in females (Mignon-Grasteau and Beaumont, 2000). However a contradictory result was found by Moula *et al.* (2009c). These authors found that maturation speed was higher in male than in female when characterizing a Belgium poultry breed (the Fammenoise). They explained this finding by selection on growth trade which could result in an increase of this parameters more efficiency in males than in females. The speed of maturation (K = 0.15/week) was lower than that found for the varieties of the Ardennaise

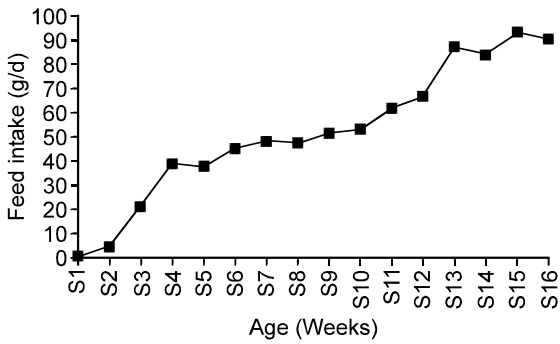


Fig. 3: Feed intake (g/d)

($K = 0.0259$ to $0.0289/d$, Moula *et al.*, 2009a) and for Algerian local poultry ($K = 0.026/d$, Moula *et al.*, 2009b). Associated to dairy weight gain, this parameter may explain the relatively low live weight registered even at 15 week of age and could be considered as a selection criterion in an eventual selecting program.

Intake: The intake of concentrate per week of local poultry is illustrated by Fig. 3. The total concentrate intake for 16 weeks was 4847 g. The value is much lower than that found by Fanatico *et al.* (2005a) for 12 weeks (7568 g) in slower-growing birds with outdoor access. Nielsen *et al.* (2003); Ponte *et al.* (2004) and Fanatico *et al.* (2005a) reported that slower-growing broilers used the outdoor area more than faster-growing broilers. In the current study, the local birds were observed to be more active and appeared to forage more than the industrial breed Arbor Acres (unpublished).

The legume pasture was estimated by weighting digestive tract gut content. At 16th week of age, alfalfa DM intake varied between 9.4 and 22.3% (averaged 14.4%) of the total intake. Our results are close to those found by Ponte *et al.* (2008b) in the case of dehydrated forage (11.1% of the total intake) offered *ad libitum* to broiler chicks from day 1-28. However, our values are very higher than those found in slow growing birds by Ponte *et al.* (2008a) at the 8th week. In this study, legume intake varied between 2.5 and 4.5% on DM basis of total feed intake. In the same connection, Fanatico (2006) suggested that pasture could replace 5-10% of the total diet.

Pasture intake of birds has rarely been measured and results are difficult to be explained since bird behaviour in pasture is not well known and differences between observations could be related by one hand to the nature, the physical form and the height of the forage and by another hand to the format of the birds themselves. In addition, intake measurements in pasture represent an estimation of pasture consumption at a specific moment

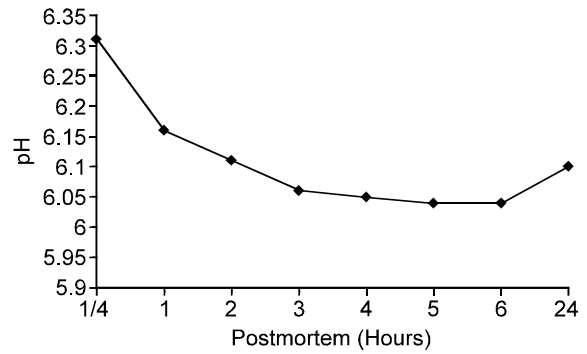


Fig. 4: Evolution of postmortem pH

of the growth period and forage consumption may vary during the experiment (Ponte *et al.*, 2008a). Consequently, intake values of birds on forage grazing, even very interesting to be examined, should always be relativised.

Meat quality

pH: The variation of post mortem pH values in breast of local poultry is illustrated by Fig. 4. The ultimate pH value reached at 24 h was 6.1. This value is higher than the values relative to the Thai native (5.77) at the same age (Jaturasitha *et al.*, 2008), the Label (5.73) as reported by El Rammouz *et al.* (2004) and slow growing broiler (5.66) cited by Jehl *et al.* (2003). Our finding is likely surprising because several studies have indicated decreases in meat pH values in outdoor-reared chicken, reflecting better welfare conditions, reduced preslaughter stress and thus reduced consumption of glycogen (Castellini *et al.*, 2002).

However, the relatively high value of pH in our experiment are in line with the finding of Husak *et al.* (2008), who found that breast meat from organic broilers had a higher pH ($p < 0.05$) than conventional broilers. Moreover, Alvarado *et al.* (2005) reported that free-range raising system resulted in high pH of meat. In addition our value could be related to the late age of slaughtered birds (16 weeks), since meat from old age birds had consistently high pH values (Ponte *et al.*, 2008a). According to Husak *et al.* (2008), the rate and the extent of pH decline have a large influence on meat quality characteristics and variation in muscle pH is likely to influence color and the ability of meat to hold water. Higher meat pH is more effective for retaining desirable color and moisture absorption properties (Husak *et al.*, 2008).

Color: Results relative to color characteristics of local poultry meet are presented in Table 5. There was no difference in Luminance (L^*) and redness (a^*) values between thigh and breast (62.54-66.42 and 12.54-12.64 respectively). Breasts of local poultry are characterized

Table 5: Color characteristics (L*, a* and b* value) of thigh, breast and skin breast of local broiler (mean value \pm standard deviation, n = 20)

	L*	a*	b*
Thigh	62.57 \pm 4.28	12.54 \pm 2.05	7.53 \pm 2.28
Breast	66.42 \pm 3.50	12.64 \pm 1.66	15.44 \pm 2.64
Skin breast	68.20 \pm 4.07	10.17 \pm 1.28	13.79 \pm 3.08

L*: Luminance, a*: Redness, b*: Yellowness

by a clearer appearance than the thigh (66.42 vs 62.57) and the intensity of the yellow color was much lower in thigh than in breast (7.53 vs 15.44).

The breast presents a higher L* value than that found in Label (55.36) by Ponte *et al.* (2008a). The redness color (a*) in the breast of the studied population was more intense than which in the label poultry (-1.059) and the yellowness was higher in the breast of the local population (15.44) than that (9.42) in the Label (Ponte *et al.*, 2008a).

Our values CIE lab for breast are higher than those found by Lonergan *et al.* (2003) for Fayoumi breed at the age of 8 weeks (L* = 40.31, a* = 6.08, b* = 12.52). On the other hand the values of the yellowness (b*) for breast and the thigh were similar to those found by Jaturasitha *et al.* (2008) in local chicken Thai native at the same age (13.6 and 7.8 respectively).

Colour is generally influenced by animal related factors, mainly the genotype (Fletcher, 1995) and the age of animals (Fanatico *et al.*, 2005b). However, it could be influenced by other management factors such as feeds and feeding systems (Fanatico *et al.*, 2005b; Ponte *et al.*, 2008a). This effect could vary between different muscles. In deed, Ponte *et al.* (2008c) found that in Red Bro poultry, pasture improved breast skin pigmentation ($p < 0.001$), so influenced breast skin yellowness but not skin Luminance and redness. In addition, Grashorn and Serini (2006) found that skin showed lower redness but higher yellowness in organic poultry carcasses. The same tendency was observed in the colour of breast meat. Fanatico *et al.* (2007) reported that birds with outdoor access, which had green forage available for consumption, displayed more deeply pigmented skin. In our study, the relatively high values of yellowness of skin and breast meat, comparatively with different observations reported in literature may be due to the access of outdoor and the natural pigments present in the legume-based pasture (Ponte *et al.*, 2004; Ponte *et al.*, 2008c; Fanatico *et al.*, 2005b; Grashorn and Serini, 2006; Mourao *et al.*, 2008). Indeed, Alfalfa and grass are widely known as natural sources of xanthophylls for poultry diets (Ponte *et al.*, 2004).

Conclusion: In the light of the found results, it was concluded that comparatively with other local poultry breeds in several countries; Tunisian local population presented potentially interesting growth parameters and meat quality characteristics. In addition to the high

potential of selection and crosses possibilities, they could represent a strong argument to develop local production systems for rural populations. Thereby, an urgent program of screening, evaluation and conservation of these populations is to be conceived and applied.

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