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Effect of free range rearing on growth and meat quality of three different local chicken's phenotypes

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ABSTRACT. The present study was undertaken in order to evaluate the growth performances and meat quality of three indigenous chickens phenotypes reared under extensive conditions in the region of Chlef in Algeria. A week after hatching, 3 random groups of 35 chicks from each phenotype; normal plumage free-range chicken (NPFRC), crested free-range chicken (CFRC) and naked neck free-range chicken (NNFRC) were chosen and reared in free-range conditions for 18 weeks. The highest growth performance was shown by the crested free-range chicken (CFRC). In terms of meat quality, the analysis of variance (ANOVA) showed that crested phenotype (CFRC) showed the best nutritional qualities especially proteins and moisture. The discriminant analysis revealed that CFRC and NNFRC were better in terms of tenderness and overall acceptability. As consequence of these very interesting qualities, these local breeds should be considered for extensive production in order to provide a good quality meat, while assuring their preservation.

Keywords: indigenous chickens; production; extensive conditions; nutritional qualities; overall acceptability; Algeria.

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Introduction

Rural poultry production systems in Africa are mostly of subsistence type, where scavenging chickens usually receive less attention in terms of feeding, health care and housing (Akinola & Essien, 2011). Even though, indigenous chickens are known by their very desirable characteristics, such as their good adaptation to environmental conditions and resistance to various diseases (Fanatico, Cavitt Pillai, Emmert, & Owens, 2005). Local chicken production provides food security, fights against poverty and contributes to rational use of natural resources (Vincent, Yakubu, Momoh, & Oegahi, 2015). Indeed, according to Zaman, Sorensen, and Howlider (2004), it represents an important source of income especially for women in developing countries. In addition to their highly valued culinary characteristics, we are currently witnessing a growing demand for local chicken meat and eggs considered as good sources of protein (Mbaga, Sanka, Katule, & Mushi, 2014), which could be a good alternative source to satisfy the needs for animal products of a growing world population (Cullere, Schiavone, Dabbou, Gasco, & Dalle Zotte, 2019). Unfortunately, native chickens are still below their full production potential due to the extensive breeding conditions adopted by the rural communities (Faruque, Islam, Afroz, & Rahman, 2013). Despite, their slower growth rate and smaller proportion of chest muscles compared to the commercial strains, the good meat quality of the local chickens, is more valued by the modern consumers (Sokołowicz, Krawczyk, & Świątkiewicz, 2016) seeking less fat, tender and juicy meat (Walley, Parrot, Custance, Meledo-Abrahim, & Bourdin, 2015). In this context, very few studies have been conducted to investigate the growth and meat quality of the Algerian local chickens. Therefore, the present study was undertaken in order to evaluate the growth performances and meat quality of three indigenous chickens phenotypes reared under extensive conditions.

Material and method

Birds and management

This study was carried out in a local rural farm in the region of Chlef; an area located in the North western part of Algeria, in North Africa, and comprised between 35°50′33″ and 36°33′35″ of North latitude, 0°41′22″

and 1°43′15″ of East longitude . A total of 120 fertile eggs of three different chicken's phenotypes were collected from rural households. The eggs were then artificially incubated using a Petersime incubator for 18 days at 99.7°F and a humidity of 85%. The incubation period was then followed by a 3 days hatching period using a Petersime hatcher at 99.7°F and moisture of 92%. A week after hatching, 3 random samples of 35 chicks were chosen from each phenotype; normal plumage free-range chicken (NPFRC), crested free-range chicken (CFRC) and naked neck free-range chicken (NNFRC).

After being marked on their legs using a numbered metal band, the chickens were reared in free-range conditions around the farm and at night the birds were sheltered in pens. A dietary supplementation based on wheat bran, barley or wheat grains, ground or wet dry bread and kitchen scraps (couscous, pasta, rice...) was provided twice a day for 18 weeks. Fresh water was supplied *ad libitum*.

Measures and analysis

The growth assessment was performed using a weekly weighing of each bird by a high-precision balance. At the age of 126 days (slaughter age), all the chickens were slaughtered by incision of their jugular veins then eviscerated. Samples of pectoral muscles meat (Pectoralis major) were collected and stored for 24 hours at 4°C; the frozen samples were then dissected into small pieces and homogenized in a blender. Chemical analysis (moisture, protein, fat and ash) was performed according to the Association of Official Analytical Chemists (AOAC, 2000). pH was determined using a pH meter (HI 22 11 PH/ORP-instrument HANNA) equipped with an insertion glass electrode (Zidane, Ababou, Metlef, Niar, & Bouderoua, 2018).

Sensory evaluation

The sensory evaluation involved the flavor, tenderness, juiciness and overall acceptability**.** After being cooked and placed in plates, ten trained people from the department of food and nutrition were given the task to score the chest meat quality of the three phenotypes using a five degree scale. Where 1 = extremely dislike and 5 = extremely like.

Statistical analysis

The data collected through this experimentation were subject to descriptive statistical analysis using Excel software. In order to compare the meat quality of the 3 phenotypes, the data were analyzed using ANOVA, followed by a pairwise comparison Tukey test using a trial version of Xlstat 2019.1 (Addinsoft, 2019). Finally, the sensorial characteristics of the chest meat were analyzed using a discriminant analysis.

Results and discussion

Growth performances

The three phenotypes showed a slower and very similar weight growth during the first six weeks. It is only after 6 weeks of age that the growth became relatively rapid and the differences in body weights between the three phenotypes became more evident, in this context the comparison of the regression (Table 1) showed highly significant differences in terms of slopes ($p < 0.01$) and intercepts ($p < 0.001$). The highest growth performance was shown by the crested free-range chicken (CFRC) (Figure 1). Indeed, at the end of the rearing period (18 weeks of age) the highest average weight was recorded by CFRC (1140.6 g) followed by the normal plumage (NPFRC) (1008.3 g), while the naked neck phenotype was way behind with only 836.9 g. The slow growth rate shown by the three free range phenotypes was in concordance with the results of Raach-Moujahed and Haddad (2013); Choo et al. (2014); Nakkazi, Kugonza, Kayitesi, Mulindwa, and Okot (2015); Sharma et al. (2015). According to Wang, Shi, Dou, and Sun (2009), despite the fact that the birds raised in a free-range system have access to various forages, insects, and worms, it was expected that the growth performances of the birds reared in this mode would be inferior compared to those reared in a more controlled environment, under the effects of temperatures fluctuations and excessive energy expenditure in free range mode.

Table 1. Comparison of regression lines - Growth versus time by Phenotypes.

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
time	4.93684E6	1	4.93684E6	560.5	0.0000
Intercepts	174538	2	87269.1	9.91	0.0002
Slopes	116770	2	58385.2	6.63	0.0028

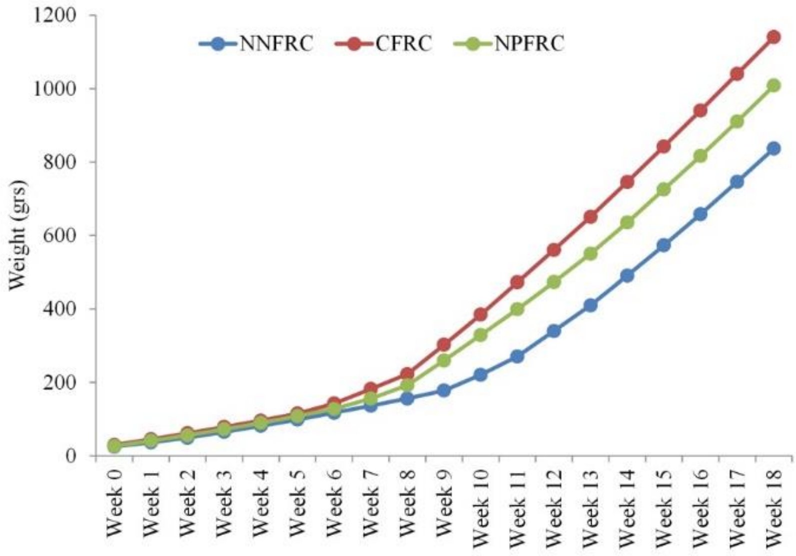

Figure 1. Increase of the body weight of the 3 phenotypes during 18 weeks.

In terms of average daily gain (ADG), the three phenotypes showed 3 phases, the first phase from the 1st to the 6th week, was characterized by almost a stable and similar average daily gain (ADG), during the second phase from the 6th to the 11th week the three phenotypes showed an increasing ADG, finally a very significant slowdown in ADG was observed during the third phase from the 11th to the 18th week (Figure 2). The highest ADG was shown by the crested phenotype (CFRC) followed by the normal plumage phenotype (NPFRC), while the naked neck phenotype (NNFRC) showed the lowest ADG. A two way ANOVA test showed that the highest and most significant difference in ADG (Table 2) was observed between CFRC and NNFRC ($p < 0.001$) between the 6th and the 11th week, whereas the remaining differences were not significant ($p > 0.05$). Nevertheless, regardless of the differences, the three phenotypes showed a very low ADG, in such a way that the maximum gain did not exceed 15 gr day^{-1} throughout the rearing period, which was very consistent with the conclusions of Castellini, Mugnai, and Dal Bosco (2002) and Tong et al. (2014). According to Gondwe and Wollny (2005) feed resources in scavenging mode are often quantitatively and qualitatively inadequate, which represents a serious constraint to local chicken average daily gain and growth.

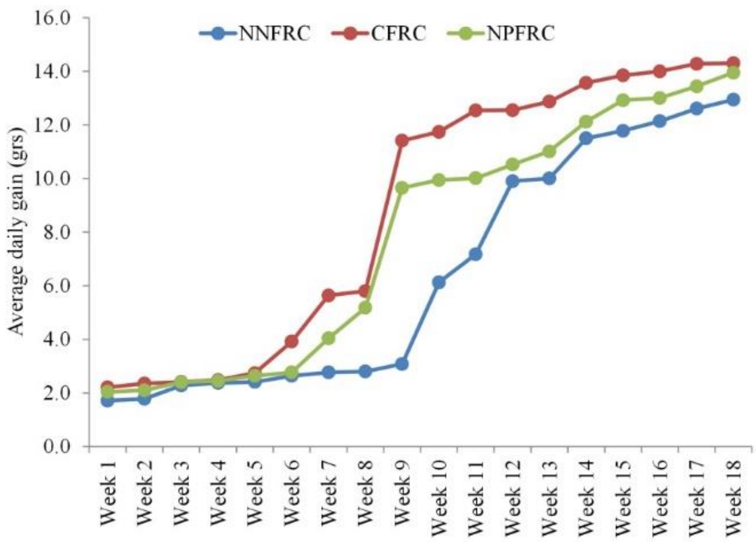

Figure 2. Average daily gain (in grams) of the 3 phenotypes.

Meat quality analysis

The importance of pH in meat quality, preservation, stability and color was pointed out by many authors. According to Solomon, Van Laack, and Eastridge, (1998), a rapid pH decline is responsible of protein denaturation and results in tenderness and juiciness decrease. In the current study the three phenotypes showed a very similar pH ranging between 6 to 6.2, no statistical difference was detected between the different phenotypes ($p > 0.05$) (Table 3). The same findings were reported by Tong et al. (2014); Puchała, Krawczyk, Sokołowicz, and Utnik-Banaś, (2015) who reported a slightly high pH in a free-range rearing. In contrary, Wang et al. (2009) mentioned a low pH values. For meat moisture, Wang et al. (2009) reported that low water content leads to a lack in meat juiciness. According to our study, the three phenotypes were significantly different ($p < 0.05$), CFRC showed the highest and most significant difference compared to NPFRC moisture (Table 3). With an overall moisture average of 73.03%, our local chickens were in accordance with the Malawian indigenous chicken's results reported by Pambuwa and Tanganyika (2017).

Table 2. Two way ANOVA and pairwise comparison between the ADG of the three phenotypes, using Tukey test.

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	8	1077.08	134.64	49.606	< 0.0001
Error	45	122.14	2.714		
	Mean		Groups		
Phase 1*CFRC	2.6905	A			
Phase 1*NPFRC	2.4024	A			
Phase 1*NNFRC	2.2024	A			
Phase 2*CFRC	9.4286		B		
Phase 2*NPFRC	7.7686		B	C	
Phase 2*NNFRC	4.3914			C	
Phase 3*CFRC	13.6347				D
Phase 3*NPFRC	12.4286				D
Phase 3*NNFRC	11.5551				D

Table 3. One way ANOVA and pairwise comparison between the meat quality of the three phenotypes, using Tukey test.

Phenotypes	Protein%	Fat%	pH	Moisture%	Ashes%
CFRC	24.08^{a}	1.09^{a}	6^{a}	73.4^{a}	1.1^{a}
NNFRC	24.02^{a}	1.06^{a}	6.1^{a}	73.1^{ab}	1^{a}
NPFRC	23.88^{b}	1.08^{a}	6.2^{a}	72.6^{b}	0.9^{a}
P-value	0.005**	0.3 NS	0.5 NS	0.036*	0.3 NS

$^{a, b}$ refer to the three phenotypes averages. The non-significantly (NS) different averages are assigned the same index, whereas the significantly different averages are assigned different indices (** highly significant, * significant).

In our work, the protein content was highly significantly different ($p < 0.01$) between the three free range chickens as shown by the ANOVA test (Table 3), according to the pairwise analysis the Tukey test showed that CFRC protein level was highly significantly superior ($p < 0.01$) than NPFRC and NNFRC was significantly higher ($p < 0.05$) than NPFRC. Overall, the three indigenous phenotypes showed an average percentage of 24%, almost the same protein content was reported by Wattanachant (2008) for Thai indigenous chickens, whereas a significant lower protein content was pointed out by Da Silva, De Arruda, and Gonçalves (2017). These differences could be related to environmental conditions. Indeed, Pambuwa and Tanganyika, (2017) observed a positive relation between the local chickens protein content and the rainy season, according to these authors this season is characterized by an excessive availability of food in the surrounding areas and consequently less loss of energy on food searching.

Compared to protein, the fat content was very low, and no significant difference was detected ($p > 0.05$) between the three phenotypes (Table 3). The low fat content showed by our local chickens (1.07%) was almost similar to that recorded by Tougan et al. (2013) in Benin (1.76%), whereas Chuaynukool, Wattanachant, and Siripongvutikorn (2007) and Pambuwa and Tanganyika (2017) recorded much higher fat content, up to 3.11% in Thailand and 5.66% in Malawi respectively. This considerable fat content variability could be related to the analyzed part, which can either be thigh, chest or skin (Tougan et al., 2013). According to Gordon and Charles (2002) the fat content in free range chickens is influenced by temperature fluctuations; high temperature may increase fat deposit and *vice versa*, while Puchała et al. (2015) pointed out the influence of the locomotor activity in reducing body fatness.

Ashes analysis is very important as it reflects the availability of minerals in food (Daniel, 2015), on this basis very low ash content was recorded in the three phenotypes chest meat (1%) (Table 3), in concordance with the ash content of the Thai indigenous chickens and broiler chicken reported respectively by Wattanachant, Benjakul, and Ledward (2004) and Lember et al. (2006). However, Ogunmola, Taiwo, and Ayankoso (2013) reported a higher ash percentage of (2%) of locally breed chicken in Nigeria. According to Pambuwa and Tanganyika (2017), the increase in ash content might be related to the availability of tender grass rich in minerals during the rainy season.

Sensory evaluation

It is recognized that because of their highly varied diet, the free range poultry meat is more flavorful (Sokołowicz et al., 2016); this perception is influenced by the interactions of various compounds (Calkins and Hodgen, 2007). According to the results (Table 4), whatever the sensory parameter was, the highest scores were always registered by NNFRC, while NPFRC registered the lowest scores.

Table 4. Average and standard error of the sensory parameters of the three phenotypes.

	Flavor	Tenderness	Juiciness	Overall acceptability
CFRC	4.4 ± 0.16	4.8 ± 0.13	4.7 ± 0.15	4.8 ± 0.13
NNFRC	4.6 ± 0.16	4.9 ± 0.1	4.7 ± 0.15	4.8 ± 0.13
NPFRC	4.3 ± 0.21	4.3 ± 0.15	4.1 ± 0.23	4.3 ± 0.15

According to the discriminant analysis, 98.39% of variance was explained by the first axis (Table 5), this axis was mainly positively correlated with tenderness (R = 0.7) and overall acceptability (R = 0.6) (Figure 3). The phenotype NPFRC was clearly discriminated on the first axis, whereas the sensorial similarity between NNFRC and CFRC was reflected by a strong overlap of these two phenotypes on the first axis (Figure 4). The confusion analysis showed that 90% of NPFRC, 80% of NNFRC and 70% of CFRC individuals were well classified by the discriminant analysis. Indeed the *Mahalanobis* distance (Table 6) showed a highly significant difference (p < 0.01) between NNFRC and NPFRC and a significant difference (p < 0.05) between CFRC and NNFRC, while the difference between NNFRC and CFRC was not significant. The most significant discriminating sensorial parameters between the three phenotypes were the tenderness and the overall acceptability as shown by their high standardized canonical discriminant coefficients of 0.77 and 0.74 respectively (Table 5). Indeed according to Hill and Lewicki (2005), the larger the standardized coefficient, the greater is the contribution of the respective variable in the discrimination between groups. Thus, it was concluded through the discriminant analysis that CFRC and NNFRC were way better in terms of tenderness and overall acceptability compared to NPFRC.

Table 5. Summary of the discriminant analysis between the three phenotypes showing the eigenvalues, the cumulative discrimination and the standardized canonical discriminant coefficients.

	D1	D2
Eigenvalue	1.7034	0.0279
Discrimination (%)	98.3901	1.6099
Cumulative %	98.3901	100.00
Standardized canonical discriminant function coefficients		
Flavor	0.2170	0.9766
Tenderness	0.7738	0.1911
Juiciness	0.6549	-0.0185
Overall acceptability	0.7382	-0.5359

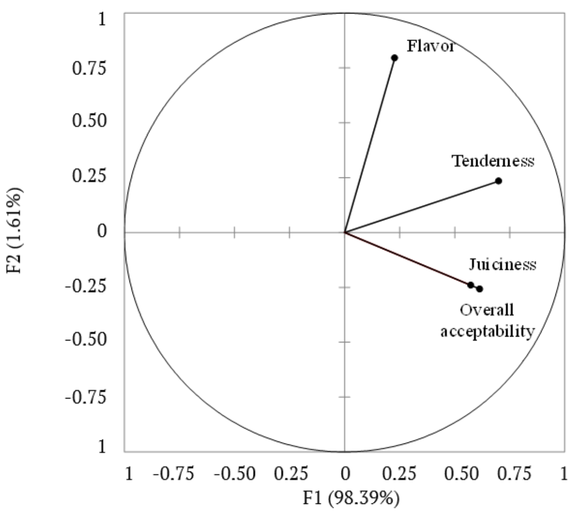

Figure 3. Scatter plot of the discriminant analysis (DA), showing the variation of the four sensory variables. Vectors indicate the direction and strength of each variable.

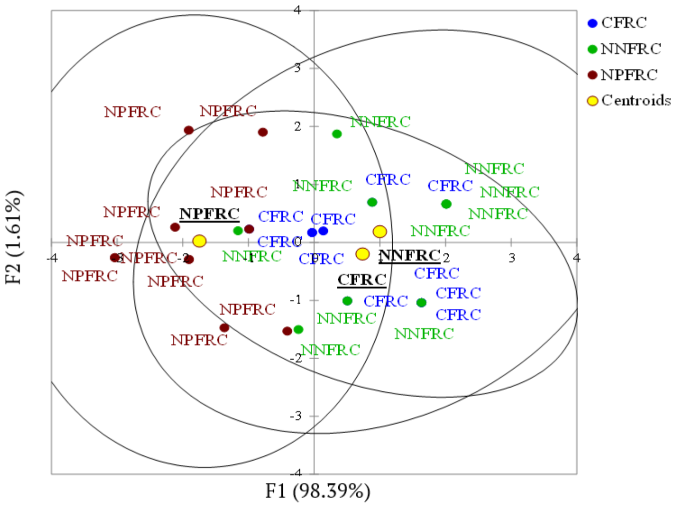

Figure 4. Scatter plot of the discriminant analysis (DA), based on sensory data showing the clear distinction of NPFRC and the overlap between NNFRC and CFRC.

Table 6. Mahalanobis distance between the three phenotypes (* p < 0.05, ** p < 0.01).

	NNFRC	NPFRC
CFRC	0.187 NS	8.491*
NNFRC	0	10.587**

Conclusion

In this work, the highest growth performances and average daily gain were shown by the crested phenotype; this phenotype showed also the best nutritional meat qualities especially proteins and moisture, whereas the best sensorial qualities were shown by the naked neck phenotype. As consequence of these very interesting qualities, these local breeds should be considered for extensive production in order to provide a good quality meat, while assuring their preservation.

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