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ANIMAL PRODUCTION

Growth and meat quality of three free-range chickens and commercial broiler under the same breeding conditions

Azdinia Zidane[1*], Adda Ababou[1], Sarra Metlef[2], Abdellatif Niar[3] and Kaddour Bouderoua[4]

*[1]Laboratory of Natural Bio-Resources, Department of Biology, Faculty of Nature and Life Sciences, University Hassiba Benbouali of Chlef, PO Box 151, 02000, Chlef, Algeria. [2]Laboratory of Natural Bio-Resources, Department of Nutrition and Food Sciences, Faculty of Nature and Life Sciences, University Hassiba Benbouali of Chlef, Chlef, Algeria. [3]Laboratory of Animal Farm Reproduction, National Institute of Veterinary Sciences, University Ibn Khaldoun of Tiaret, Tiaret, Algeria. [4]Laboratory of Food Technology and Nutrition, Faculty of Nature and Life Sciences, University Abdelhamid Ibn Badis of Mostaganem, Mostaganem, Algeria. *Author for correspondence. E-mail: azdinia.zidane@yahoo.fr*

ABSTRACT. Commercial breed has taken over the Algerian poultry production market which participated in the weakening of the village poultry farming, highly dominant prior to the 1980s. Fortunately, the dietary preferences of consumers, strongly participated in the preservation of the local animal breed diversity. In this context, the aim of this work was to study the growth performances and meat quality of 3 local chicken phenotypes *versus* commercial broiler chicken in the same breeding conditions in the region of Chlef in Algeria. A week after hatching, 4 randomly chosen samples of 30 chicks from each phenotype normal plumage free-range chicken (NPFRC), crested free-range chicken (CFRC), feathered tarsus free-range chicken (FTFRC) and commercial broiler chicken (CBC) were reared from the age of 1st until 8th week (slaughter age). The three local breed (FTFRC, CFRC and NPFRC) had the comparable body weight, but low ($p < 0.05$) to those of CBC. In terms of meat quality, the principal components analysis (PCA) and the analysis of variance showed that the free-range chickens were more interesting than the commercial broiler chicken very fat, especially the crested phenotype (CFRC), due to its very high protein 24.6% and very low fat content 1.20%.

Keywords: body weight; fat; phenotypes; protein; Chlef.

Crescimento e qualidade de carne de três galinhas de livre-gama e grelha comercial nas mesmas condições de criação

RESUMO. Raça comercial de aves tem assumido papel importante no mercado de produção de aves na Argélia que determinou uma redução na produção caipira, altamente dominante antes dos anos oitenta. Felizmente, as preferências dietéticas de consumidores, fortemente contribuiu para preservação da diversidade das raças locais. Neste contexto, o objetivo deste trabalho foi estudar o desempenho animal e qualidade de carne de 3 fenótipos de galinha locais *versus* galinha de linhagem comercial na mesma criação na região de Chlef na Argélia. Uma semana depois de chocar, 4 amostras foram escolhidas ao acaso de 30 pintinhos de cada fenótipo galinha comum de plumagem normal (NPFRC), criadas galinha comum coroada (CFRC), galinha comum de perna emplumada (FTFRC) e galinha de linhagem comercial (CBC) de 1ª a 8ª semana de idade. A três raças comuns (FTFRC, CFRC e NPFRC) tiveram o peso de corpo comparável, mas menor ($p < 0.05$) do que para a linhagem CBC. Em termos de qualidade de carne, a análise de componentes principais (PCA) e a análise de discrepância mostrou que as galinhas comuns eram mais interessantes que a galinha de linhagem comercial (muito gorda), especialmente o fenótipo coroado (CFRC), devido ao seu elevado teor em proteína (24.6%) e baixo conteúdo de gordura (1.20%).

Palavras-chaves: peso corporal; gordura; fenótipos; proteína; Chlef.

Introduction

In the developing countries, the poultry production in rural areas is highly important as a major source of animal protein for the rural population (Hassaballah, Zeuh, Mopate, & Sembene, 2015). According to Sanka and Mbaga (2014a), the African countries are currently witnessing an increasing demand for local chicken meat and eggs, due to their nutritional quality and good taste compared to commercial strains. However, nowadays the commercial breed as ISA strain have taken over the Algerian poultry production market, because the local chickens generally have a slower growth than commercial broilers. Fortunately, the dietary preferences of consumers, strongly participated in the preservation of the local animal genetic diversity (Ait Kaki & Moula, 2013). Indeed, in Morocco, poultry products

from traditional farms are still a source of meat that is highly appreciated, economical and easily available to the rural populations (Benabdeljelil & Arfaoui, 2001). According to Silva, Plácido, Bento, Junnyor, and Silva (2015), in recent years, the seek of healthier food strongly affected the meat consumer eating habits; thus for all its sensory and nutritional quality, an increasing number of consumers are currently more interested in consuming free-range poultry products (Fanatico et al., 2006). However, compared to the commercial strains, the indigenous chickens are generally characterized by a slower growth rate, which may remarkably contribute in the differentiation between the chemical and physical properties of their meat (Wattanachant, Benjakul, & Ledward, 2004). Although, Sonaiya and Swan (2004) revealed that the productivity of the scavenging chickens could be improved through the intervention in the management systems and the improvement of the amount and quality of offered food, and according to Nakkazi et al. (2015), these chickens are likely to respond differently when subjected to different management and feeding systems.

Thus, the supply of safe, healthy and appropriate complementary foods should improve the growth and the quality of the meat (Fanatico, Pillai, Emmert, & Owens, 2007).

This research was realized to study the growth performances and meat quality of 3 local chicken phenotypes compared to the commercial broiler chicken in the same rearing conditions.

Material and methods

Study area

The chicken samples were collected from the region of Chlef; an area located in the North western part of Algeria, in North Africa, and comprised between 0°41′22″ and 1°43′15″ of East longitude and 35°50′33″ and 36°33′35″ of North latitude.

Bird samples

The experiment involved a sample of 120 free-range chickens' eggs of 3 most consumed phenotypes, by the population of the region. All of the local and commercial eggs were artificially incubated in a Petersime incubator at a temperature of 99.7° F and a humidity of 85% during 18 days, then in Petersime hatcher at 99.7° F and 92% of moisture during 3 days. A week after hatching, 4 randomly chosen samples of 30 chicks from each phenotype (normal plumage free-range chicken (NPFRC), crested free-range chicken (CFRC), feathered tarsus free-range chicken (FTFRC) and commercial broiler chicken (CBC) were experimentally monitored.

Birds rearing

The rearing was conducted in a closed building of 50 m^2, all the chicks were floor-bred on a litter bedding of 6 cm thick and homogeneously distributed over the surface of the rearing building. Each bird was identified individually. The chicks' strains were divided into lots and separated by nets: the first one was that of the CBC and the second one concerning the three phenotypes of FRC, with a density of 4 chicks m^{-2}. The temperature of the building was set manually according to the age of birds; with 30° C during the first three weeks and 21° C during the last weeks during winter, also a continuous light program using 75 watt lamps was adopted for the whole breeding period. The aeration and ventilation were ensured by ventilators and the building openable windows. The chicks were fed *ad libitum*, with starter diets (2,762 ME kg^{-1}, 20% CP, 3.6% fat) until the 21st day, and then by finisher diets (2,950 ME kg^{-1}, 19.5% CP, 4.1% fat) to slaughter. Fresh drinking water was freely available at all times. All birds were vaccinated for Newcastle disease and infectious bronchitis

Measures and analysis

The chicks were marked using a numbered metal band placed on their legs. In order to evaluate the growth performances, the birds were weighed individually once a week until the 8th week (age of slaughter), using a high precision (0.05 g) electronic balance. At 56 days of age, after 12 hours of fasting period all chickens were slaughtered by section of the jugular vein processed and eviscerated in a local commercial slaughterhouse. Pectoral muscles (*Pectoralis major*) meat samples were collected, packed in plastic bags and stored for 24 hours at 4° C; frozen samples were later dissected into small pieces and then homogenized in a blender.

Meat analysis

The chemical analysis (moisture, proteins, fat and ash) were performed according to the methods of Association of Official Analytical Chemists (AOAC, 2000). The pH was determined using a pH meter (HI 22 11 PH/ORP meter. HANNA instrument) equipped with an insertion glass electrode. Each analysis was repeated three times.

Statistical analysis

The collected data were firstly subject to descriptive statistical analysis using Excel software. Secondly, in order to identify the different

relationships between the analyzed parameters, the phenotypes and phenotypes- parameters, the principal components analysis (PCA) technic was applied, according to Li, Xiao-jing, Khan, and Gul (2008). The principal components are enough explanatory if their cumulative percentage of variance is greater than 70. Finally, the comparison between the performances of the 4 phenotypes was achieved through the analysis of variance (ANOVA) using a trial version of XLSTAT 2016.1.

Results and discussion

Growth performances

During the study period, the four phenotypes showed a linear growth curves (Figure 1). In comparison with the three free-range phenotypes, the commercial broiler chicken showed the highest ($p < 0.05$) growth performances. Indeed, at 8 weeks of age, the broiler has recorded an average weight of 2,384.8 g against the respective weights of 620.0 g, 611.3 g and 570.2 g for the feathered tarsus, the crested and normal plumage. According to the high determination coefficients (R^2) showed by the four phenotypes (Figure 1), the body weight development was closely related to the age of birds. The difference in weight growth observed in this study was consistent with the works of Fotsa and Manjeli (2001), Gnakari, Beugré Grah, and Agbo Adouko (2007), Fotsa et al. (2010) and Yapi-Gnaore et al. (2011) who showed that under the similar conditions, the performances of local chickens were lower than those of broiler chicken, characterized by a better use of feed, and then a better animal performance.

The four phenotypes showed also a growing average daily gain (ADG) from the 1st to the 7th week and a decreasing one during the 8th and end of cycle (Figure 2). According to the t-test the broiler chicken ADG was much higher ($p < 0.01$) compared to the free-range chickens. Indeed, as showed by the results (Figure 2) the broiler chicken ADG was averagely 3 to 4 times higher than the free range chickens throughout the rearing period. Concerning the free-range chickens, in spite of a slight superiority of the crested (CFRC) and the feathered tarsus (FTFRC) over the normal plumage (NPFRC) phenotype the t-test did not show any difference; these results match those of Moula, Michaux, Philippe, Antoine-Moussiaux, and Leroy (2013) and Miah, Chowdhury, and Bhuiyan (2016), justifying the supplemented diet effects on the animal performances of the local chickens. According to Youssao et al. (2012) as long as animals are reared in the same building, under the same conditions and compared at the same age, any recorded growth differences between them are purely genetic.

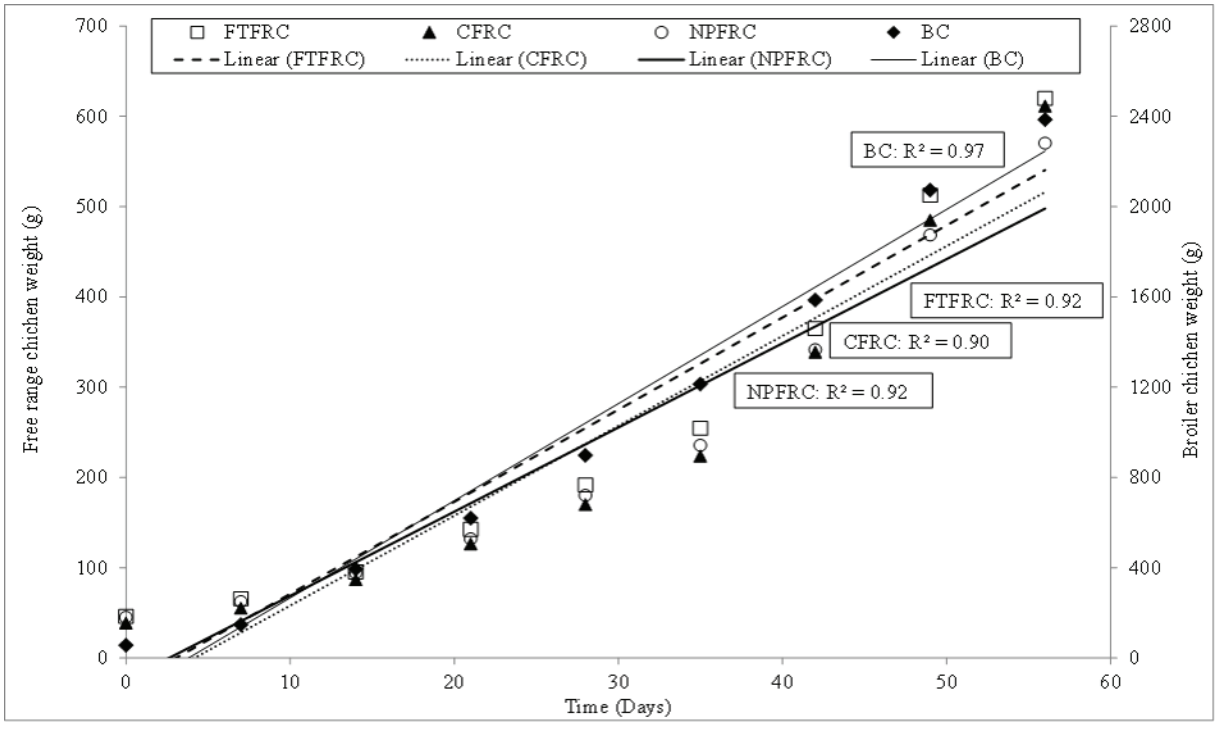

Figure 1. Evolution of the weight of the four phenotypes, expressed in grams and relative to the age in weeks.

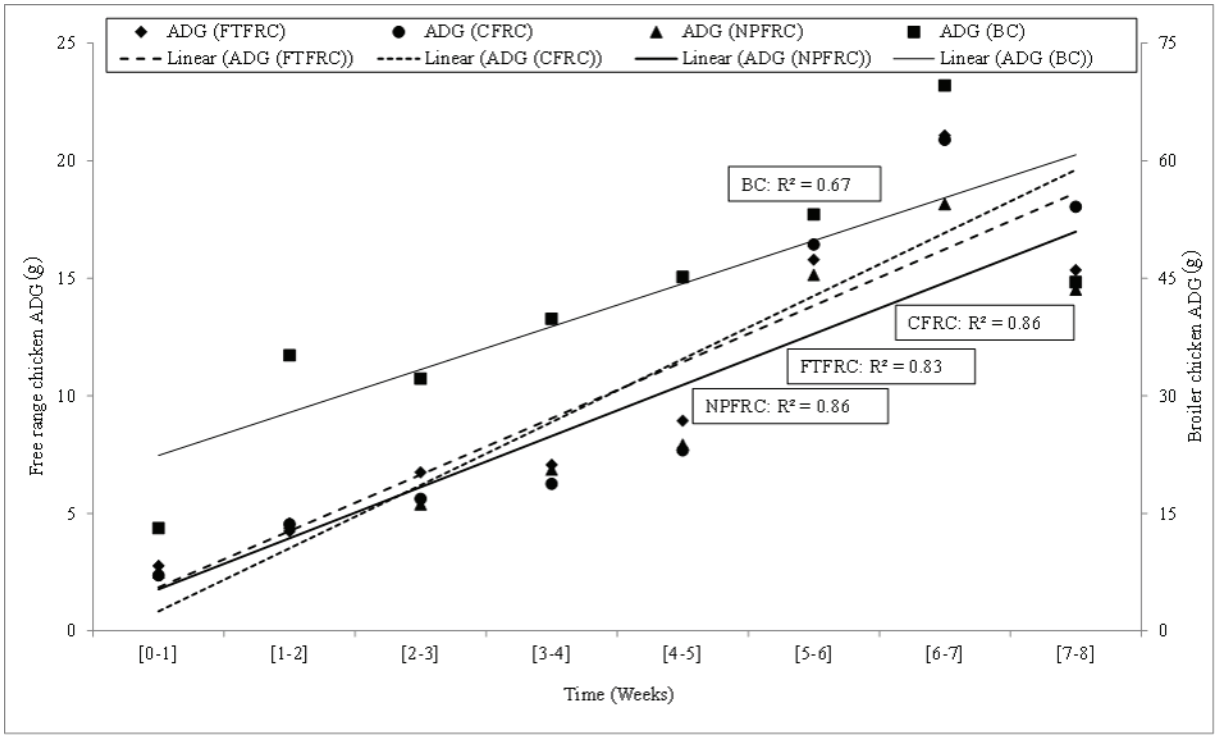

Figure 2. Evolution of the average daily gains throughout the rearing period of the four phenotypes, expressed in grams.

Multivariate analysis

The principal components analysis (PCA) applied on the four phenotypes parameters showed that all the analyzed parameters were significant on the first two components. According to the loadings (LF) (Table 1) three of the five parameters loaded heavily on the first component; including the pH (LF = 0.99), proteins (LF = -0.78) and fat (LF = 0.91); whereas moisture (LF = 0.69) and ash (LF = 0.71) were mostly important on the second component. The two first components (with eigenvalue ≥ 1) explained 89.6% of the total variance. The first component with 58.3% of explained variability was highly positively related to pH, fat and negatively related to proteins (Figure 3); thus, this axis was qualified as fat-proteins component. As showed by the factor scores (FS) (Table 1), the most important phenotypes on this axis were the broiler chicken (BC) (FS = 2.31) highly related to fat and pH and the crested free-range chicken (CFRC) (FS = - 1.81) rich in proteins (Figure 4). The part of variability explained by the second component was 31.3%. This component qualified as ash-moisture axis, was strongly positively related to ash, moisture and to a lesser degree with proteins (LF = 0.63), the most significant phenotypes on this axis according to the factor scores were the crested free-range chicken (FS = 1.31) positively related to proteins, ash and moisture and the normal plumage free-range chicken (NPFRC) negatively related to ash and moisture and slightly positively related to fat.

Table 1. Summary of the principal component analysis showing the eigenvalues, the explained variability, the variables loadings and phenotypes factor scores.

	F1	F2	F3
Eigenvalues	2.92	1.56	0.52
Variability (%)	58.3	31.3	10.4
Cumulative (%)	58.3	89.6	100
pH	0.99	0.16	-0.07
Moisture	0.47	0.69	0.55
Protein	-0.78	0.63	-0.08
Fat	0.91	-0.42	-0.01
Ash	0.54	0.71	-0.45
BC	2.31	0.77	-0.13
FTFRC	-0.17	-0.73	0.99
CFRC	-1.81	1.31	-0.13
NPFRC	-0.33	-1.36	-0.73

Meat quality analysis

In order to compare the 4 chickens' phenotypes in terms of meat chemical properties, an analysis of variance (ANOVA) was performed.

In terms of pH no difference was detected between the different phenotypes ($p > 0.05$). The ANOVA results showed that the 4 phenotypes belong to the same group (Table 2). However, the broiler chicken pH (6.5) was slightly higher than those of the free-range chickens (6.1 to 6.2). These results were similar to those of Sarsenbek, Wang, Zhao, and Jiang (2013) for the local Baicheng-You

chicken of China and Sanka and Mbaga (2014b) for the Tanzanian local chickens. According to Woelfel, Owens, Hirschler, Martinez-Dawson, and Sams (2002) in a living state, the pH muscle is around 7, and then decreases rapidly to a value ranging from 5.4 to 6.2 following slaughter, indicating a high quality meat. Husak, Sebranek, and Bregendahl (2008) reported also, that a high pH is more efficient in keeping the color of meat and increasing moisture absorption.

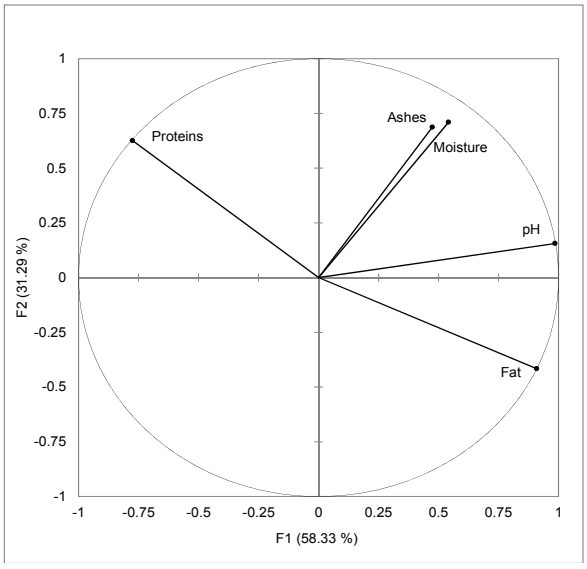

Figure 3. Projection of the five variables in 2D plan on the first two axes of the PCA (Axis 1 and 2).

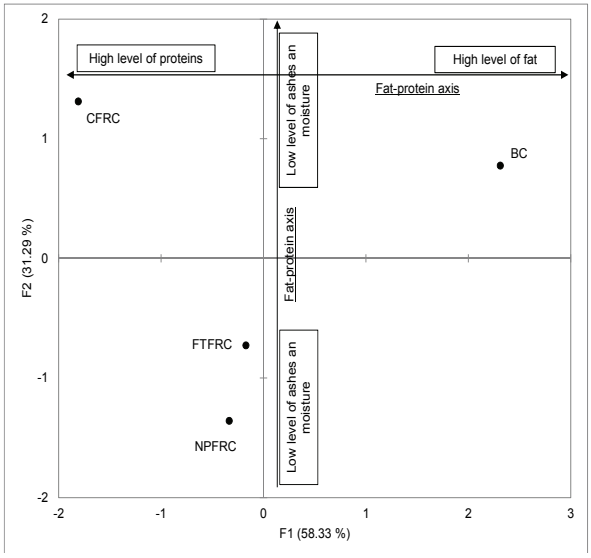

Figure 4. Projection of the four phenotypes in 2D plan on the first two axes of the PCA (Axis 1 and 2).

Unlike the pH, the 4 phenotypes were different ($p < 0.001$) in terms of moisture according to the ANOVA (Table 2). The highest level of moisture was registered by the broiler chicken (BC), the lowest level was observed in the normal plumage free-range chicken (NPFRC); whereas the feathered tarsus (FTFRC) and the crested (CFRC) chickens were in between. A high moisture level content reflects a better water retention capacity, which is very important according to Tong et al. (2014) for the meat quality, tenderness and during the subsequent meat transformations. Overall, with an average moisture of 75.5% the results of our three free range chickens were very consistent with those from Wattanachant et al. (2004), but in comparison to our results those of Wang, Shi, Dou, and Sun (2009) and Sarsenbek et al. (2013) were lower, 71% and 73% respectively. This difference is due to the rearing conditions. Indeed Tong et al. (2015) reported that the physical effort and the ambient temperature are the main factors influencing the tissues water retention capacity, this implies that the highest moisture values recorded by our 3 free range chickens were mostly related to the sedentary rearing and to the mild and stable temperatures registered during the study period.

As for the proteins the ANOVA showed 2 groups of chickens different ($p < 0.05$). The lowest level of proteins (22%) was registered within the first group composed of the broiler (BC), the feathered tarsus (FTFRC) and the normal plumage (NPFRC) chickens; whereas the highest protein level (24%) was registered by the crested free range chicken (CFRC) (Table 2). This result corroborates that of Wang et al. (2009) for the Chinese local chicken "Gushi".

Table 2. Analysis of variance of 5 meat parameters related to the 4 phenotypes, showing the average at 95% confidence interval, the different groups and the p-value of each parameter.

	pH	Moisture	Protein	Fat	Ash
BC	6.50 ± 0.66^{a}	76.2 ± 0.43^{a}	22.5 ± 1.37^{a}	1.51 ± 0.08^{a}	1.18 ± 0.04^{a}
FTFRC	6.20 ± 0.25^{a}	75.9 ± 0.52^{ab}	22.8 ± 1.65^{a}	1.40 ± 0.04^{b}	1.11 ± 0.08^{b}
CFRC	6.10 ± 0.43^{a}	75.8 ± 0.52^{b}	24.6 ± 1.15^{b}	1.20 ± 0.08^{c}	1.15 ± 0.05^{ab}
NPFRC	6.20 ± 0.43^{a}	75.0 ± 0.29^{c}	22.7 ± 2.25^{a}	1.42 ± 0.10^{b}	1.13 ± 0.04^{b}
F	2.57	25.1	6.50	52.1	4.96
Pr > F	> 0.05	< 0.001	< 0.05	< 0.0001	< 0.05

With respect to the fat, three groups different ($p < 0.0001$) were detected, the highest fat level (1.51%) was recorded by the broiler chicken; whereas the lowest fat level was observed in the crested free range chicken (CFRC) (Table 2). It's admitted that due to its scavenging and physical effort, the local chicken accumulates less fat. Hence, the rates of fat recorded in our results were caused by the sedentary rearing system adopted in this study. Indeed, as reported by Leclercq (1989), the

sedentary rearing leads to significantly fattier animals. In comparison with the Gushi chicken of China studied by Wang et al. (2009), the amount of fat recorded in this study was higher; this superiority was the result of the slaughter age (8 weeks in this research versus 16 weeks for the Gushi chicken), this is consistent with the findings of Grey, Robinson, Jones, Stock, and Thomas (1983), who observed a decrease in the amount of fat after eight weeks of age.

Finally, in terms of ash content, 2 groups of chickens different ($p < 0.05$) were detected (Table 2). The highest content (1.18%) was related to the broiler chicken; while the lower content (1.11%) was that of the feathered tarsus free range chicken. In fine the meat quality results strongly consolidate the results of the PCA.

Conclusion

The findings of this study highlighted the importance of three free-range chickens in terms of meat quality compared to the commercial broiler chicken, under the same rearing conditions. Among the four phenotypes, the "crested" phenotype showed the highest meat quality, and therefore constitutes a promising local breed that may represent an indispensable asset in establishing selection programs, aiming to increase the production of meat of superior quality and improving the food security of the consumer. It could be very interesting to conduct this study on other local poultry breeds whose potentials are poorly known.

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