Abanico Veterinario. January-December 2020; 10:1-14. http://dx.doi.org/10.21929/abavet2020.34
Original Article. Received: 08/05/2020. Accepted: 26/10/2020. Published: 30/11/2020. Code: 2020-37.

Productive behavior and composition of the carcass of the Guinea fowl (*Numida meleagris*)

Comportamiento productivo y composición de la canal de la gallina de Guinea (*Numida meleagris*)

Camas-Robles Georgina[*1] ID, Ruiz-Sesma Benigno[1] ID, Mendoza-Nazar Paula[1] ID, Portillo-Salgado Rodrigo[2] ID, Hernández-Marín Antonio[3] ID, Cigarroa-Vázquez Francisco[4] ID**

[1]Facultad de Medicina Veterinaria y Zootecnia, Universidad Autónoma de Chiapas. México. [2]Programa en Ganadería, Colegio de Postgraduados, Campus Montecillo. México. [3]Departamento de Veterinaria y Zootecnia. Universidad de Guanajuato. México. [4]Escuela de Estudios Agropecuarios Mezcalapa, Universidad Autónoma de Chiapas. México. *Responsible author: Camas-Robles Georgina. **Author for correspondence: Cigarroa-Vázquez Francisco. Carretera Chicoasén, Malpaso. Km. 24,3, San Miguel El cocal, C.P. 29625. Copainalá, Chiapas, México. E-mail: camasgeorgina@gmail.com, ruizsb71@gmail.com, paulamendozanazar@gmail.com, rps_1303@hotmail.com, jahmarin@ugto.mx. antonio.cigarroa@unach.mx.

ABSTRACT

This study aimed to evaluate productive indicators of growth, carcass aspects and the proximal composition of the meat of the Guinea Fowl (GF) reared under tropical conditions in Mexico. It was carried out from July 2016 to May 2017. The productive behavior (PB) of 100 keets in 14 weeks was evaluated and for the trait of the carcass (TC) samples of 5 males and 5 females were analyzed. It was evaluated in PB, Weight gain (WG), feed consumption (FC) and feed conversion (FCO) and in TC, carcass yield (CY), water retention capacity (WRC), pH and color. Descriptive statistics were performed and a generalized linear model (GLM) was used to detect differences between sexes, using the SAS statistical package (Ver. 9.4). The final average weight was 1161.56 ± 94.82 g with a WG of 10.98 ± 0.95 g/bird, FC of 62.04 ± 2.48 g and an FCO of 5.65 ± 0.57 g. Males were superior (79.3%) in the CY, without statistical differences (P> 0.05). The WRC and the pH were very similar. GF production is an alternative meat supply being a source of animal protein.
Keywords: growth, carcass quality, meat quality, Guinea fowl

RESUMEN

Este estudio tuvo como objetivo evaluar indicadores productivos del crecimiento, rasgos de la canal y la composición proximal de carne de la Gallina de Guinea (GG) criada bajo condiciones tropicales de México. Se realizó de julio 2016 a mayo 2017. Se evaluó el comportamiento productivo (CP) de 100 keets en 14 semanas y para los rasgos de la canal (RC) se analizaron muestras de 5 machos y 5 hembras. Se evaluó en CP, la Ganancia de peso (GPE), consumo de alimento (CAL) y conversión alimenticia (ECA) y en RC, rendimiento de la canal (RCA), capacidad de retención de agua (CRA), pH y color. Se realizó estadística descriptiva y para detectar diferencias entre sexo se usó un modelo lineal generalizado (GLM), usando el paquete estadístico SAS (Ver. 9.4). El peso final promedio fue de 1161.56 ± 94.82 g con una GPE de 10.98 ± 0.95 g/ave, CAL de 62.04 ± 2.48 g y una ECA de 5.65 ± 0.57 g. Los machos fueron superiores (79.3%) en la RCA, sin diferencias estadísticas (P>0.05). La CRA y el pH fueron muy similares. La producción de GG es una alternativa de suministro de carne siendo una fuente de proteína de origen animal.
Palabras clave: crecimiento, calidad de la canal, calidad de carne, gallinas de Guinea.

INTRODUCTION

Poultry contributes significantly to the food security of poor families in developing countries (FAO, 2014). In Mexico, for example, these birds play an important role in improving farmers' nutrition by providing them with food of good nutritional quality, with meat being the most important product (Gutiérrez-Triay *et al.,* 2007). The most commonly used birds are chickens and turkeys (Juárez and Gutiérrez, 2009; Itza-Ortiz *et al.,* 2016); However, due to the growing increase in the human population, there is a deficit of protein foods of animal origin, which is why it is necessary to diversify the poultry species raised for this purpose. A biologically and economically viable alternative is the guinea fowl (*Numida meleagris*), a native bird of the African continent, where its meat is appreciated as an important source of animal protein, which is why it is widely consumed by local families (Ebegbulem, 2018).

Breeding *N. meleagris* has considerable advantages; For example, birds adapt to various agroclimatic conditions, consume a wide variety of unconventional foods, and have the ability to protect themselves from predators, control ticks and other pests. They are tolerant of most common poultry diseases and it does not require too much labor and expensive infrastructure for its management (Ebegbulem, 2018; Koné *et al.,* 2018; Musundire *et al.,* 2018). Productively, the guinea fowl also shows good weight gain, feed conversion (Houndonougbo *et al.,* 2017; Eleroğlu *et al.,* 2018) and carcass performance (Mareko *et al.,* 2006; Chiroque *et al.,* 2018), even when compared to the performance of the chicken carcass (Musundire *et al.,* 2018). Another relevant quality of this bird is the nutritional quality of its meat. The high content of minerals and essential fatty acids has been determined (Bernacki *et al.,* 2012), in addition to its high protein content and low fat content (Hoffman and Tihong, 2012), characteristics that improve when the birds are raised semi-intensively or "in the open air" (Sarica *et al.,* 2019).

Therefore, in recent years, the demand for guinea fowl meat has been increasing (Sarica *et al.,* 2019), therefore some countries in the world are adopting the breeding of this bird, showing its good profitability (Nahashon *et al.,* 2006). In Mexico, there is no information on the guinea fowl production system, even less on its productive characteristics and the quality of its meat. The objective of this study was to evaluate productive indicators of growth, carcass traits and to determine the meat proximal composition of the guinea fowl raised under tropical conditions in Mexico.

MATERIAL Y MÉTODOS

Study area

This study was from July 2016 to May 2017 conducted, in the experimental unit of the Academic Body "Sustainable Tropical Animal Production" of the Autonomous University of Chiapas, located in the Ejido Loma Bonita of Tuxtla Gutiérrez municipality, Chiapas. It is located at geographical coordinates 19° 8.64´N and 98° 16.55´W, at an altitude of 522 m a.s.l. The region has a warm subhumid climate with rains in summer Aw_2 (García, 2004). The mean annual temperature and total annual precipitation vary between 20-28 ° C and 800-1200 mm, respectively (INEGI, 2017). This study was carried out in accordance with the standards for the use of research animals of the Faculty of Veterinary Medicine and Zootechnics of the Autonomous University of Chiapas and in accordance with the Official Mexican Standards NOM-024-ZOO-1995 and NOM-033 -ZOO-1995 (NOM-024-ZOO-1995; NOM-033-ZOO-1995).

Experimental animals

The animals used in this study came from eggs from a flock of 209 guinea fowls in the laying stage, which were under natural environmental conditions kept. Egg collection was carried out in the first hours of the day for a week, recording the collection date, the egg weight (g) and the total number of eggs collected/day. The eggs were in special 30 x 30 cm containers collected, previously disinfected, and they were stored at room temperature. A total of 200 eggs with an average weight of 38.5 g were artificially incubated for 25 days using a Texotronics® incubator (model CM108V1, Mexico), adjusted to a temperature and relative humidity range of 37.5-37.8 ºC and 70-98%, respectively (Eleroğlu *et al.,* 2016), managing to obtain a population of 120 chicks.

Evaluation of productive behavior

For this phase of the study, 100 chicks were without considering sex selected, due to the difficulty in sexing caused by the sexual monomorphism of Guinea fowls in the first weeks of age (Abdul-Rahman *et al.,* 2015). Subsequently, they were randomly into 10 groups divided with 10 individuals (repetitions) each. Each chick was with a tag attached to the wing identified. The birds were in conventional 2x1 m pens housed, made with chicken mesh, concrete floor and chip bed. Rustic drinkers and feeders made with polyvinyl chloride (PVC) tubes were used. From week 0 to 3 they were offered commercial chicken feed with a crude protein content of 21%, while from week 4 to 14 the commercial feed offered had a crude protein content of 13% (National Research Council, 1994). Both food and water were offered *ad libitum* throughout the experimental period. Every 15 days the body weight (BW) of the birds was using a Medidata® electronic scale measured (model PS-5, Mexico) to determine the weight gain (WG) using the following formula:

$$WG = BW\ final\ (g) - BW\ initial\ (g)$$

The feed consumption (FC) was also determined for each group using the following formula:

$$FC = \frac{food\ offered - food\ refused}{number\ of\ birds}$$

Likewise, the feed conversion efficiency (FCO) was determined with the formula used by Sebola *et al.* (2015), which is shown below:

$$FCO = \frac{food\ consumption}{weight\ gain}$$

Determination of carcass traits

This phase of the study was carried out in the Animal Nutrition Laboratory of the Postgraduate College, Montecillo Campus, Texcoco, Mexico. To evaluate the characteristics of the carcass, an individual from each group was randomly selected, considering five females and five males previously sexed through visual and morphometric evaluation (Arhin *et al.,* 2018). The BW of each bird was measured and later they were slaughtered in a conventional manner (stunning, bleeding, plucking and evisceration). Carcass yield (CY) was determined through the relationship of the weight of the hot carcass (gutted and without considering the head, neck and legs) and the WB of the animal*100 (Barbosa-Filho *et al.,* 2017). To determine the water retention capacity (WRC), pH and color, the methodologies suggested by Guerrero *et al.* (2002), which are described below:

To evaluate the WRC two samples of 5 g/bird of the *pectoralis major* muscle were used. Each sample was placed in a special mini blender, 8 mL of cold 0.6 M NaCl solution was added and subsequently they were ground for 30 s. The obtained mixtures were transferred to centrifuge tubes and they were placed in an ice bath for 30 min, shaking them periodically every 10 min. All tubes were then centrifuged for 15 min at a speed of 11,200 × g and 4 °C using a Beckman Coulter® centrifuge (Avanti J-E model, Jersey City, CA). The supernatant was decanted and measured using a 10 mL graduated cylinder. The amount of mL of solution retained in 100 g of sample was recorded to determine the WRC using the following formula:

$$WRC = \frac{Va - Vs}{sample\ weight}\ X\ 100$$

Where: Va is the volume of saline added to the centrifuge tube; Vs: is the volume of the supernatant.

The pH was determined with a penetration electrode in samples of the *pectoralis major* muscle immediately after the slaughter of the birds and 24 h later (*postmortem*) using a portable Hanna® potentiometer (model HI 99163, Bogotá, Colombia).

Color was measured 4 h after sacrifice in *pectoralis major* muscle samples approximately 1 cm² thick using a Konica Minolta® brand colorimetry meter (model CR-200, Osaka, Japan). The samples were to light for 30 min before the readings exposed. The values of luminosity (L*), redness (between green and red; a*) and yellowness (between blue and yellow; b*) were recorded in the CIE Lab system. The average values of L*, a* and b* were calculated from three readings in different positions considering the average of the readings for the statistical analyzes.

The analysis of the proximal composition of the meat was carried out considering the analytical methods of the AOAC (2000), determining the humidity and dry matter by the gravimetric method by drying in an oven at 110 °C for 24 h. Also was determined the ash content through from the oxidation of organic matter by incineration, the total protein by nitrogen determination using the micro Kjeldahl method and the ethereal extract by extraction with Soxhlet-type solvents. All analysis were done in duplicate.

Statistical analysis

All statistical analysis were performed using the SAS program, see 9.4 (SAS, 2016).
The data set was analyzed by descriptive statistics using the means procedure (PROC MEANS). To differentiate between sexes, the data set of the variables on the carcass traits and proximal composition of the meat, the generalized linear model procedure (PROC GLM) was used, the model used was:

$$Y_{ij} = \mu + S_i + ij$$

Where: Y_{ij} refers to the observation of animal $_j$ and treatment $_i$ for each of the dependent variables; µ is the general mean; *Si* is a fixed effect due to the sex of the guineas; and $_{ij}$ is the random residual effect associated with observation $_{ij}$. When significant differences ($P <0.05$) appeared when performing the F-test (ANOVA), the Tukey test was performed to differentiate the means from each other.

RESULTS AND DISCUSSION

Characterization of productive behavior

The results of the productive indicators of the growth of the guinea fowl are shown in table 1. Each bird consumed daily 62.04±2.48 g of commercial feed, achieving an average final weight at week 14 of 1161.56±94.82 g, with a minimum and maximum of 905 and 1365 g, respectively. A daily weight gain of 10.98±0.95 g/bird was obtained. These data were superior to those reported by Dahouda *et al*. (2008), who showed that guinea fowl reared under intensive conditions have an average feed intake of 41.8 g/day/bird in month 4 of age, a body weight of 831±141.5 and 846±146.7 g in females and males, respectively, and a daily weight gain of 4.16 g/bird. The variation in the data could be due to the type of production system used in the research, since the animals confined in very intensive conditions have higher levels of stress, which causes a lower consumption of feed and with it a lower gain in body weight (Lara and Rostagno, 2013).

In the study, an efficiency of feed conversion of 5.65 ± 0.57 g was obtained. In this regard, Seabo *et al*. (2011) showed that this parameter improves by increasing the levels of crude protein in the diets of guinea fowl, since they determined a feed conversion of 6.71, 6.37 and 6.23 g by increasing the level of crude protein by 14, 16 and 18%, respectively. In Creole chickens, a feed conversion of 3.41±0.27 and 3.34±0.25 g has been reported in females and males, respectively (Paredes *et al*., 2019). Rezaei *et al*., (2018) point out that the main factor of variation of feed conversion in poultry is the type of breed, line or genetic line used.

Table 1. Descriptive statistics of the productive characteristics of the guinea fowl raised under tropical conditions in Mexico

Variable	n	Mean	SD	Minimum	Maximum
Initial weight (g)	100	110.14	35.87	59	200
Final weight (g)	100	1161.56	94.82	905	1365
Weight gain (g/bird/day)	100	10.98	0.95	8.62	13
Feed consumption (g/bird/day)	100	62.04	2.48	55.36	64.91
Feed conversion efficiency (g)	100	5.65	0.57	4.62	7.39

n: Number of observations, SD: Standard deviation of the mean.

The growth curve of the guinea fowl during the first 14 weeks is in figure 1 shown. A slight decrease in weight gain can be between week 4 and 6 of age observed, possibly due to the adaptation stage caused by the change of feed offered to the birds, which contained a lower percentage of crude protein. The data obtained were superior to those found by Houndonougbo *et al.* (2017) when evaluating the growth of five genetic varieties of guinea fowl, since they found a range of variation between body weights at week 16 of 876.70±36.10 g to 965.00±22.00 g of the varieties known in the study as "black" and "common", respectively. However, they were lower than the reported ones by Nahashon *et al*. (2006) in French guinea fowls for 8-week-old females (1138.9 ± 118.9 g) and males (1145.6 ± 114.7 g). According to Seabo *et al*. (2011), the variation in the growth of Guineas is mainly due to factors associated with nutrition.

Another of the associated factors is the genetics of the birds, since the body weight in poultry is moderately to slightly heritable, which would imply that the selection of heavier individuals in a population of guinea fowl, should result in a genetic improvement of the trait (Oke *et al.,* 2004). However, environmental conditions can affect or improve growth (Porter *et al.,* 2010), since in production systems the increase in body weight is of economic importance (Aggrey, 2009).

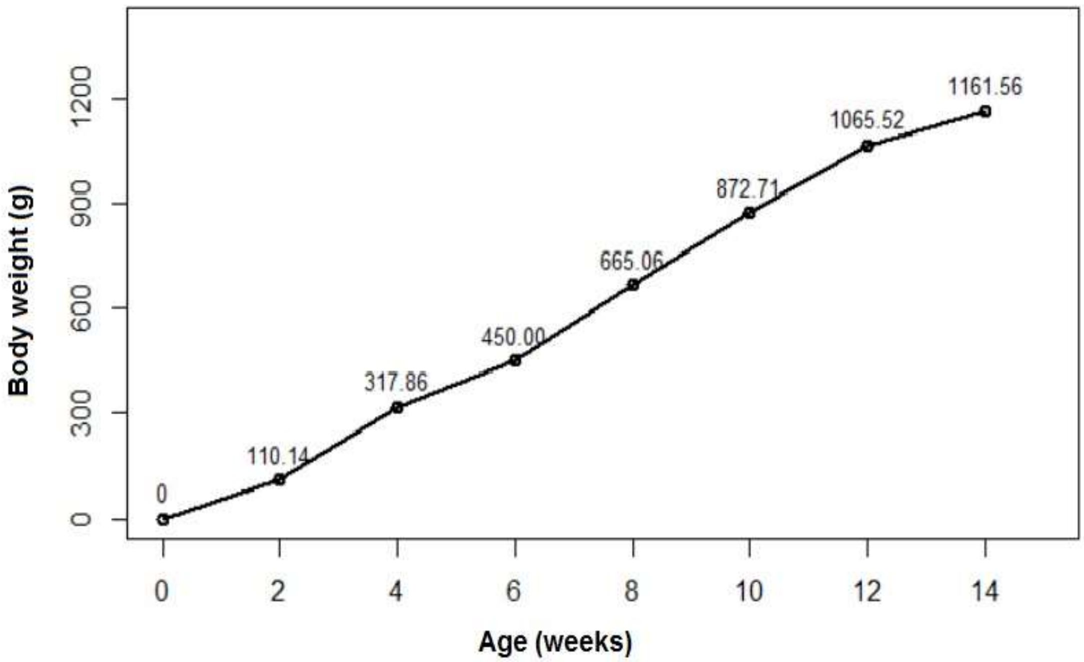

Figure 1. Growth curve of the guinea fowl raised under tropical conditions in Mexico

Analysis of carcass traits

No statistical differences (P> 0.05) were found in carcass yield due to the effect of sex; however, it was higher in males (79.3%) (Table 2). These results are consistent with those reported by Houndonougbo *et al*. (2017) in different varieties of guinea fowl: gray (85.1%), black (79.2%), bonaparte (78.5%), white (78.2%) and common (77.4%). For their part, Mareko *et al*. (2006) found carcass yields> 90% in African guinea fowls at different ages. Consumer demand for poultry meat is on high-weight carcass traits focused, with the muscle *pectoralis major* or commonly known as the breast being the most important (Faria *et al*., 2010). In this study, sex had no effect (P> 0.05) on any of the traits evaluated in the *pectoralis major* muscle of the guinea fowl (Table 2). A water retention capacity of 14.46 and 14.47% was obtained for females and males, respectively.

The pH is an important factor that affects the quality of meat, for example, a high pH shortens the shelf life of meat as it creates a more favorable environment for bacteria (Sarica *et al.,* 2019). In the present study, a pH of 6.04 and 6.03 was in females and males, respectively found. These results are similar to those found by Sarica *et al.* (2019) in the *pectoralis major* muscle of 14-week-old guinea fowls (6.56-6.79), also reported that the type of production system, age at slaughter and sex have an effect on this parameter. Another important factor that affects the sensory quality of poultry meat is color, since consumers associate this characteristic with the freshness of the meat. In general, primary pigments consisting of myoglobin, hemoglobin, and cytochrome C (Boz *et al.,* 2019) control the surface colors of meat. The values of luminosity (44.40 and 45.04), redness (15.58 and 14.95) and yellowness (7.51 and 7.11) found in this study for females and males, respectively, are similar to those reported by Tufarelli *et al*., (2015) in hens from Guinea 12 weeks old. Sarica *et al.* (2019) found that the yellowness values of Guineas breast were significantly affected by sex, with higher values for females than for males (8.21 vs 5.93), for which they attributed this difference to the higher fat content that females have. The color values obtained in the present study are consistent with the demands of consumers, who prefer white meat, particularly breast (Sarica *et al*., 2019).

Table 2. Descriptive statistics of the traits of the guinea fowl carcass, according to sex

Variable	Females (n=5)	Males (n=5)	Females and males (n=10)
	Mean ± SEM	Mean ± SEM	Mean ± SEM
Carcass yield (%)	77.15 ± 1.81[a]	79.30 ± 1.27[a]	78.23 ± 1.10
Water retention capacity (%)	14.46 ± 0.02[a]	14.47 ± 0.01[a]	14.47 ± 0.01
pH	6.04 ± 0.04[a]	6.03 ± 0.04[a]	6.04 ± 0.30
Color			
L*	44.40 ± 1.66[a]	45.04 ± 0.89[a]	44.72 ± 0.89
a*	15.58 ± 0.72[a]	14.95 ± 0.25[a]	15.27 ± 0.37
b*	7.51 ± 0.63[a]	7.11 ± 0.29[a]	7.31 ± 0.33

n: Number of observations, SEM: Standard error of the mean. Different literals in the same row between sexes indicate significant differences to the Tukey test (P <0.05).

Proximal meat composition

The results of the proximal analysis of the *pectoralis major* muscle or breast of the guinea fowl are shown in table 3. None of the evaluated nutrients presented statistical differences (P> 0.05) due to the effect of sex. The results of the moisture content (45.33 and 49.18%), crude protein (19.95 and 19.98%) and ether extract (2.59 and 2.61%) obtained in this study for females and males. Respectively, they were different from those reported by Premavalli *et al.* (2015) on meat from the breast of guinea fowl raised under traditional management in India; these authors also found that the value of these nutrients is significantly by the age of the birds affected. For their part, Musundire *et al*. (2017) found that the species (Guinea fowls vs chickens) and age of the birds had a significant effect on the content of dry matter and crude protein in breast meat samples, with higher values for Guineas. Likewise, they found that the content of the ether extract was affected by species, age and sex, while the ash content differed with the age of the birds. In the literature, it has been reported that the Guineas fowls´ breast cooking method has a significant effect on the moisture, protein and ash content (Hoffman and Tlhong, 2012).

Table 3. Proximal composition of nutrients of the *pectoralis major* muscle of the guinea fowl, according to sex

Variable	Females (n=5)	Males (n=5)	Females and males (n=10)
	Media ± SEM	Media ± SEM	Media ± SEM
Humidity (%)	45.33 ± 5.18[a]	49.18 ± 1.61[a]	47.26 ± 2.63
Dry material (%)	54.66 ± 5.18[a]	50.81 ± 1.61[a]	52.73 ± 2.63
Ash (%)	6.26 ± 0.90[a]	5.79 ± 0.31[a]	6.02 ± 0.45
Crude protein (%)	19.95 ± 2.15[a]	19.98 ± 0.87[a]	19.96 ± 1.09
Ethereal extract (%)	2.59 ± 0.24[a]	2.61 ± 0.31[a]	2.60 ± 0.18

n: Number of observations, SEM: Standard error of the mean. Different literals in the same row between sexes indicate significant differences to the Tukey test (P <0.05).

CONCLUSION

Guinea fowl production is an alternative meat supply being a protein source of animal origin, with carcass yields superior to other domestic birds.

CITED LITERATURE

ABDUL-RAHMAN II, Awumbila B, Jeffcoate IA, Robinson JE, Obese FY. 2015. Sexing in guinea fowls (*Numida meleagris*). *Poultry Science*. 94:311–318. https://doi.org/10.3382/ps/peu067

AGGREY, SE 2009. Logistic nonlinear mixed effects model for estimating growth parameters. *Poultry Science*. 88: 276-280. https://doi.org/10.3382/ps.2008-00317

AOAC. 2005. Association of Official Analytical Chemists. Official method of analysis. 18th ed. W. Horwitz, ed. AOAC Int., Gaitherburg, MD. Pp. 684. ISBN: 0935584676. http://sutlib2.sut.ac.th/sut_contents/H125800.pdf

ARHIN E, Annor SY, Kagya-Agyemang JK, Addsison D, Zagbede GA. 2018. Innovation for sexing Guinea fowls (*Numida meleagris*) at day one of hatching. *Livestock Research for Rural Development*. 30 (9). http://www.lrrd.org/lrrd30/9/askin30157.html

BARBOSA-FILHO JA, Almeida M, Shimokomaki M, Pinheiro JW, Silva CA., Michelan Filho T, Bueno FR, Oba A. 2017. Growth performance, carcass characteristics and meat quality of griller-type broilers of four genetic lines. *Brazilian Journal of Poultry Science*. 19: 109-114. http://dx.doi.org/10.1590/1806-9061-2016-0261

BERNACKI Z, Bawej M, Kokoszyński D. 2012. Quality of meat from two guinea fowl (*Numida meleagris*) varieties. *Archiv fur Geflugelkunde*. 76 (3): 203–207. ISSN 0003-9098. https://www.european-poultry-science.com/Quality-of-meat-from-two-guinea-fowl-span-classws-name-Numida-meleagrisspan-varieties,QUlEPTQyMjA5NDEmTUlEPTE2MTAxNA.html

BOZ MA, Oz F, Yamak US, Sarica M, Cilavdaroglu E. 2019. The carcass traits, carcass nutrient composition, amino acid, fatty acid, and cholesterol contents of local Turkish goose varieties reared in an extensive production system. *Poultry Science*. 98:3067–3080. http://dx.doi.org/10.3382/ps/pez125

CHIROQUE G, Vázquez G, Vázquez E, Vázquez E, Más D, Betancur C, Ruíz C, Botello A, Martínez Y. 2018. Growth performance, carcass traits and breast meat fatty acids profile of helmeted Guinea fowls (*Numida meleagris*) fed increasing level of linseed (*Linum usitatissimum*) and pumpkin seed (*Cucurbita moschata*) meals. *Brazilian Journal of Poultry Science*. 20: 665-674. http://dx.doi.org/10.1590/1806-9061-2018-0760

DAHOUDA M, Sènou M, Toléba SS, Boko CK, Adandédjan J.C, Hornick JL. 2008. Comparaison des caractéristiques de production de la pintade locale (*Meleagris numida*) en station et dans le milieu villageois en zone soudano-guinéenne du Bénin. *Livestock Research for Rural Development.* 20 (12). http://www.lrrd.org/lrrd20/12/daho20211.htm

EBEGBULEM VN. 2018. Prospects and challenges to guinea fowl (*Numida meleagris*) production in Nigeria. *International Journal of Avian & Wildlife Biology*. 3 (3): 182–184. https://doi.org/10.15406/ijawb.2018.03.00083

ELEROĞLU H, Yildirim A, Canikli A, Duman M, Bircan H. 2018. Analysis of growth curves of Guinea fowl (*Numida meleagris*) fed diets containing dry oregano (*Origanum vulgare* L.) in an organic system. *Ciencia e Investigación Agraria*. 45 (2):99-108. http://dx.doi.org/10.7764/rcia.v45i2.1833

ELEROĞLU H, Yildirim A, Duman M, Okur N. 2016. Effect of eggshell color on the egg characteristics and hatchability of Guinea fowl (*Numida meleagris*) eggs. *Brazilian Journal of Poultry Science*. https://doi.org/10.1590/1806-9061-2015-0154

FAO. 2014. Decision tools for family poultry development. FAO Animal Production and Health Guidelines No. 16. Rome, Italy. http://www.fao.org/3/a-i3542e.pdf

FARIA PB, Bressan MC, Souza XR de, Rossato LV, Botega LMG, Gama LT da. 2010. Carcass and parts yield of broilers reared under a semi-extensive system. *Brazilian Journal of Poultry Science.* 12 (3): 153-159. https://doi.org/10.1590/S1516-635X2010000300003

GARCÍA, E. 2004. Modificaciones al Sistema de Clasificación Climática de Köppen, Serie Libros, núm. 6, Instituto de Geografía, UNAM, México. http://www.publicaciones.igg.unam.mx/index.php/ig/catalog/book/83

GUERRERO LI, Pérez CML, Ponce AE. 2002. Curso práctico de tecnología de carnes y pescado. UAM, Unidad Iztapalapa. México, D.F. http://publicacionescbs.izt.uam.mx/DOCS/carnes.pdf

GUTIÉRREZ-TRIAY MA, Segura-Correa JC, López-Burgos L, Santos-Flores J, Santos-Ricalde RH, Sarmiento-Franco L, Carvajal-Hernández M, Molina-Canul G. 2007. Características de la avicultura de traspatio en el municipio de Tetiz, Yucatán, México. *Tropical and Subtropical Agroecosystems*. 7: 217 – 224. https://www.redalyc.org/pdf/939/93970308.pdf

HOFFMAN LC, Tlhong TM. 2012. Proximate and fatty acid composition and cholesterol content of different cuts of guinea fowl meat as affected by cooking method. *Journal of Science of Food Agriculture*. https://doi.org/10.1002/jsfa.5682

HOUNDONOUGBO PV, Mota RR, Chrysostome AAC, Bindelle J, Hammami H, Gengler N. 2017. Growth and carcass performances of guinea fowls reared under intensive system in Benin. *Livestock Research for Rural Development*. 29 (10). http://www.lrrd.org/lrrd29/10/rrmo29193.html

INEGI. Instituto Nacional de Estadística y Geografía e Informática. 2017. Anuario estadístico y geográfico de Chiapas. Pp. 736. ISBN 978-607-739-993-3. https://www.datatur.sectur.gob.mx/ITxEF_Docs/CHIS_ANUARIO_PDF.pdf

ITZA-ORTIZ MF, Carrera-Chavéz JM, Castillo-Castillo Y, Ruíz-Barrera O, Aguilar-Urquiso E, Sangines-García JR. 2016. Caracterización de la avicultura de traspatio en una zona urbana de la frontera norte de México. *Revista Científica. FCV-LUZ*. 26(5):300-305. http://www.saber.ula.ve/handle/123456789/43067

JUÁREZ A y Gutiérrez E. 2009. Control de cloequez y comportamiento productivo de guajolotas criollas. *Avances en Investigación Agropecuaria*. 13 (1): 59-70. http://ww.ucol.mx/revaia/portal/pdf/2009/enero/5.pdf

KONÉ GA, Kouassi GF, Kouakou NDV, Kouba M. 2018. Diagnostic of guinea fowl (*Numida meleagris*) farming in Ivory Coast. *Poultry Science*. 97:4272–4278. https://doi.org/10.3382/ps/pey290

LARA LJ, Rostagno MH. 2013. Impact of heat stress on poultry production. *Animals*. 3: 356-369. https://doi.org/10.3390/ani3020356

MAREKO MHD, Nsoso SJ, Thibelang K. 2006. Preliminary carcass and meat characteristics og Guinea fowl (*Numida meleagris*) raised on concrete and earth floors in Botswana. *Journal of Food Technology*. 4: 313-317. http://medwelljournals.com/abstract/?doi=jftech.2006.313.317

MUSUNDIRE MT, Halimani TE, Chimonyo M. 2017. Physical and chemical properties of meat from scavenging chickens and helmeted guinea fowls in response to age and sex. *British Poultry Science*. https://doi.org/10.1080/00071668.2017.1313961

MUSUNDIRE MT, Halimani TE, Chimonyo M. 2018. Effect of age and sex on carcass characteristics and internal organ weights of scavenging chickens and helmeted guinea fowls. *Journal of Applied animal Research*. 46: 860–867. https://doi.org/10.1080/09712119.2017.1411266

NAHASHON SN, Aggrey SE, Adefope NA, Amenyenu A. 2006. Modeling growth characteristics of meat-type Guinea fowl. *Poultry Science*. 85: 943–946. https://doi.org/10.1093/ps/85.5.943

NORMA Oficial Mexicana. NOM-024-ZOO-1995. Especificaciones y características zoosanitarias para el transporte de animales, sus productos y subproductos, productos químicos, farmacéuticos, biológicos y alimenticios para uso en animales o consumo por éstos. https://www.gob.mx/cms/uploads/attachment/file/202301/NOM-024-ZOO-1995_161095.pdf

NORMA Oficial Mexicana. NOM-033-ZOO-1995. Sacrificio humanitario de los animales domesticos y silvestres. México. https://www.dof.gob.mx/nota_detalle_popup.php?codigo=5376424

NRC. 1994. Nutrient Requirements of Domestic Animals. Nutrient Requirements of Poultry, 9th Rev. edn. Washington, DC: National Academy Press. https://www.nap.edu/catalog/2114/nutrient-requirements-of-poultry-ninth-revised-edition-1994

OKE UK, Herbert U y Nwachukwu. 2004: Association between body weight and some egg production traits in the guinea fowl (Numida meleagris galeata. Pallas). *Livestock Research for Rural Development*. 16:72. http://www.lrrd.org/lrrd16/9/oke16072.htm

PAREDES AM., Romero CA, Torres RM, Vallejos FL, Mantilla GJ. 2019. Crecimiento y comportamiento reproductivo de la gallina criolla de huevos con cáscara verde de la provincia de Chota, Cajamarca. *Revista de Investigaciones Veterinarias del Perú*. 30 (2): 733-744. http://dx.doi.org/10.15381/rivep.v30i2.16070

PORTER, T., E. Kebreab, H. Darmani Kuhi, S. Lopez, AB Strathe y J. France. 2010. Flexible alternatives to the Gompertz equation for describing growth with age in turkey hens. *Poultry Science*. 89: 371-378. https://doi.org/10.3382/ps.2009-00141

PREMAVALLI K, Ramamurthy N, Omprakash AV, Balakrishnan V, Appa Rao V, Natarajan A, Senthil Kumar RP. 2015. Influence of age on proximate composition of Guinea fowl meat. *The Indian Veterinary Journal*. 92 (6): 75-77. http://krishikosh.egranth.ac.in/handle/1/5810045224

REZAEI M, Yngvesson J, Gunnarsson S, Jönsson L, Wallenbeck A. 2018. Feed efficiency, growth performance, and carcass characteristics of a fast- and a slower-growing broiler hybrid fed low- or high-protein organic diets. *Organic Agriculture*. 8:121–128. https://doi.org/10.1007/s13165-017-0178-6

SARICA M, Boz MA, Yamak US, Ucar A. 2019. Effect of production system and slaughter age on some production traits of guinea fowl: Meat quality and digestive traits. *South African Journal of Animal Science*. 49: 192-199. http://dx.doi.org/10.4314/sajas.v49i1.22

SAS. Institute Inc. 2016. SAS/STAT® 14.2 User's Guide. Cary, NC: SAS Institute Inc.

SEABO D, Moreki JC, Bagwasi N, Nthoiwa GP. 2011. Performance of Guinea fowl (*Numida meleagris*) fed varying protein levels. *Online Journal of Animal and Feed Research*. 1 (6): 255-258.
http://www.ojafr.ir/main/attachments/article/80/OJAFR,%20A43,%20255-258,%202011.pdf

SEBOLA NA, Mlambo V, Mokoboki HK, Muchenje V. 2015. Growth performance and carcass characteristics of three chicken strains in response to incremental levels of dietary *Moringa oleifera* leaf meal. *Livestock Science*. https://doi.org/10.1016/j.livsci.2015.04.019

TUFARELLI V, Demauro R, Laudadio V. 2015. Dietary micronized-dehulled white lupin (*Lupinus albus* L.) in meat-type guinea fowls and its influence on growth performance, carcass traits and meat lipid profile. *Poultry Science*. 94:2388–2394. http://dx.doi.org/10.3382/ps/pev218