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ANÁLISIS DE CALIDAD DE LA CARNE DEL GUAJOLOTE NATIVO

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ANÁLISIS DE CALIDAD DE LA CARNE DEL GUAJOLOTE NATIVO

Rodrigo Portillo Salgado, D.C.
Colegio de Postgraduados, 2023

RESUMEN

La presente investigación tuvo como objetivos: *i*) determinar el rendimiento y la composición de la canal, así como la calidad de la carne del Guajolote Nativo Mexicano (GNM) con base en sus características físico-químicas, perfil de ácidos grasos y atributos sensoriales, *ii*) investigar los efectos de la edad al sacrificio y el género en las características de la canal y la calidad de la carne del GNM criado en un sistema de producción extensivo, y *iii*) desarrollar ecuaciones de predicción de las características de la canal y el peso de los cortes primarios del GNM usando medidas corporales. Para ello, se registró el peso al sacrificio y los rasgos de la canal de guajolotes machos y hembras criados en sistemas extensivos. Además, se determinaron las características físico-quimicas, la composición proximal, el perfil de ácidos grasos y los atributos sensoriales en la carne de pechuga y pierna del GNM. Los resultados mostraron que los machos presentaron mayor ($P < 0.001$) peso al sacrificio, pesos y rendimiento de la canal fría y caliente; así como pesos de las partes de la canal. Las hembras presentaron mayor ($P < 0.001$) peso de la grasa abdominal. Las características físico-quimicas, el contenido de acidos grasos y los atributos sensoriales fueron afectados significativamente ($P < 0.05$) por el género. La carne de pechuga de los machos tuvo mayor ($P < 0.05$) contenido de humedad, proteína cruda, ácido erúcico (C22:1n9), ∑ MUFA, ∑ UFA, ∑ DFA, relación ∑ UFA/∑ SFA y relación ∑ PUFA/∑ SFA, y masticabilidad, mientras que las hembras presentaron alto contenido de grasa en la carne de pierna. El rendimiento de la canal; así como la calidad de carne fueron mejores en machos adultos que en machos jóvenes y hembras adultas. Las ecuaciones generadas para predecir los rasgos de la canal tuvieron un R^2 que varió de 0.40 a 0.96, mientras que para el peso de cortes primarios varió de 0.58 a 0.91. En general, la carne del GNM es un alimento saludable que se puede incorporar idealmente a la dieta humana.

Palabras clave: Ácidos grasos, análisis sensorial, calidad de la carne, peso de cortes primarios, *Meleagris gallopavo*, peso corporal.

ANALYSIS OF MEAT QUALITY FROM NATIVE MEXICAN TURKEY

Rodrigo Portillo Salgado, D.C.
Colegio de Postgraduados, 2023

ABSTRACT

The present research had as objectives: *i*) to determine the yield and composition of the carcass; as well as the meat quality from Native Mexican Turkey (NMT) based on its physical-chemical characteristics, fatty acid profile and sensory attributes, *ii*) investigate the effects of slaughter age and gender on carcass characteristics and meat quality of NMT reared in extensive production system, and *iii*) develop equations for predicting carcass characteristics and the primal cuts weight of NMT using body measurements. For this, the slaughter weight and carcass traits of male and female guajolotes reared in extensive systems were recorded. Also, the physicochemical characteristics, proximal composition, fatty acid profile, and sensory attributes of breast and leg meat from NMT were determined. The results showed that the males presented higher (P < 0.001) slaughter weight, hot and cold carcass weights and yield; as well as the carcass parts weights. The females presented greater (P < 0.001) abdominal fat weight. Physico-chemical characteristics, fatty acid content, and sensory attributes were significantly (P < 0.05) affected by gender. Breast meat from males had higher (P < 0.05) moisture content, crude protein, erucic acid (C22:1n9), ∑ MUFA, ∑ UFA, ∑ DFA, ∑ UFA/∑ SFA ratio and ∑ PUFA/∑ SFA ratio, and chewiness; while females presented high fat content in leg meat. The carcass yield; as well as meat quality were better in adult males than in young males and adult females. The equations generated to predict the carcass traits had an R^2 that varied from 0.40 to 0.96, while for the primal cuts weight varied from 0.58 to 0.91. In general, meat from GNT is a healthy food that can be ideally incorporated into the human diet.

Key words: Fatty acids, sensory analysis, meat quality, primal cuts weight, *Meleagris gallopavo*, body weight.

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Todo esto es por y para Ustedes.

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INTRODUCCIÓN GENERAL

Las aves de corral se encuentran entre las que más contribuyen a la producción animal en todo el mundo, siendo el subsector agrícola con mayor crecimiento, especialmente en los países en desarrollo (Restoux et al., 2012). Las aves de corral contribuyen de forma sustancial a la seguridad alimentaria y la nutrición, ya que proporcionan energía, proteínas y micronutrientes esenciales a los seres humanos. Además, se caracterizan por ciclos de producción cortos y la capacidad de convertir una amplia gama de subproductos y desechos agroalimentarios en carne y huevos comestibles para el ser humano (Mottet y Tempio, 2007).

Las razas nativas, autóctonas o locales representan la mayor proporción de la diversidad genética avícola mundial y son parte integral de la diversidad evolutiva de cada región (González-Ariza et al., 2021). La mayoría de estas razas no han sido seleccionadas de forma intensiva y tienen un rendimiento productivo inferior al de las razas comerciales. Si bien estas razas no son tan valiosas económicamente como las razas comerciales, representan un recurso genético importante debido a su buena fertilidad y habilidad materna, capacidad de aprovechar alimentos de baja calidad, así como de prosperar en condiciones ambientales adversas y con bajo nivel de insumos (Samaraweera et al., 2021). Adicionalmente, algunas de estas razas tienen mejor calidad de carne, alta inmunidad a las enfermedades, mejor adaptabilidad al manejo extensivo y son reservorios de material genético de importancia económica y biológica, valiosos para la industria avícola (Gao et al., 2017).

Sin embargo, en los últimos años se ha observado una disminución de los recursos genéticos avícolas (RGAv) como resultado de la sustitución masiva de razas locales de baja productividad por otras altamente productivas (Cendron et al., 2021). Esta reducción en su diversidad genética puede ocasionar la perdida no solo de su riqueza genética, sino también reducir la posibilidad de que las especies se adapten a las condiciones ambientales cambiantes, lo que es importante para las futuras demandas de producción (Gao et al., 2017). Además, esto se traduce simultáneamente en la pérdida irreversible de recursos sociales, culturales y patrimoniales (González-Ariza et al., 2021). Por ello, actualmente existe un creciente interés por la conservación y recuperación de los RGAv, con la finalidad de conservar los rasgos de adaptabilidad y producción, requeridos en la producción animal (Cendron et al., 2021).

México es uno de los países productores de aves de corral más grandes del mundo. La producción avícola se desarrolla bajo diferentes contextos, siendo la avicultura de traspatio la forma de producción más importante y generalizada (Itza-Ortiz et al., 2016). Esta actividad pecuaria se realiza desde la época de la colonia, y en la actualidad se encuentra presente en más del 85% de las unidades de producción pecuarias en el país. Se basa en un manejo técnico deficiente, uso de instalaciones rústicas, alimentación basada en el pastoreo y nulo manejo sanitario. Sin embargo, en la avicultura de traspatio coexisten poblaciones de aves de corral consideradas de alto valor genético, debido a su adaptación y rusticidad para producir en condiciones ambientales adversas, como los guajolotes (Hortúa-López et al., 2021; Romero-López, 2021).

El Guajolote (*Meleagris g. gallopavo*) es un recurso genético nativo de México que constituye un reservorio genético con características de importancia económica únicas y gran adaptación. Esta ave de corral tiene alta variabilidad fenotípica y genética, en comparación con las razas y variedades de pavos comerciales, como consecuencia del largo período de adaptación a las condiciones ambientales adversas que caracterizan a varias regiones de México (Strillacci et al., 2020; Portillo-Salgado et al., 2022). Actualmente, la cría de guajolotes nativos se practica principalmente en condiciones de traspatio, tanto de zonas rurales como suburbanas. Estas aves de corral poseen un importante valor cultural y gastronómico, ya que forman parte de las tradiciones y costumbres que aún se mantienen en los pueblos. Asimismo, son fuente de ingresos y ahorro económicos para las familias rurales (Ángel-Hernández et al., 2014).

En particular, el consumo de carne de guajolote en el país es bajo, limitándose a celebraciones navideñas, y de fin de año, festividades familiares y religiosas. En algunas regiones del país (centro sur y sureste) se tiene un alto consumo de ésta carne por ser utilizada como ingrediente principal en platillos tradicionales (Cuca-García et al., 2015). La carne de Guajolote además de ser muy sabrosa es muy sana, ya que tiene alta calidad proteica y es baja en grasas (SIAP, 2016). En este sentido, teniendo en cuenta la abundante oferta de productos avícolas en el mundo actual, el concepto de calidad tiene especial importancia. La calidad de la carne de ave de corral incluye su inocuidad, valor nutritivo y características sensoriales. La calidad nutricional depende del contenido de proteínas de alto valor, perfil de ácidos grasos, vitaminas, y otros compuestos biológicamente activos (Sokołowicz et al., 2016). Los principales factores que influyen en la variabilidad de la calidad de la carne y de la canal en el guajolote se relacionan con su especie, genotipo o estirpe, edad, genero, alimentación, sistema de producción, así como de las condiciones previas al sacrificio.

Se ha observado que los guajolotes nativos de estirpes locales mantenidos en sistemas de producción extensivos, tradicional u orgánicos producen carne con mejor calidad nutritiva y organoléptica, en comparación con las razas comerciales. De hecho, el interés de los consumidores por carne de aves de corral locales criadas de forma orgánica está creciendo (Fanatico et al., 2007). No obstante, en los últimos años la cría de guajolotes nativos ha perdido cierto protagonismo en las zonas urbanas, y sólo se conservan algunas poblaciones en las zonas rurales, debido al mayor aprovechamiento de razas especializadas en la producción de carne, poniendo en peligro su existencia a largo plazo (Canales et al., 2022). De acuerdo a los datos del SIAP (2021), la población nacional de Guajolote ha disminuido en los últimos 10 años, pasando de 4 millones a 3.8 millones de aves (Figura 1). En el 2021, la mayor población de guajolotes se concentró en los estados de Puebla (655,500 aves), Estado de México (538,078 aves), Oaxaca (420,300 aves), Yucatán (348,326 aves), Tabasco (340,500 aves), Chiapas (290,080 aves), Guerrero (261,900 aves) y Veracruz (250,939 aves), principalmente.

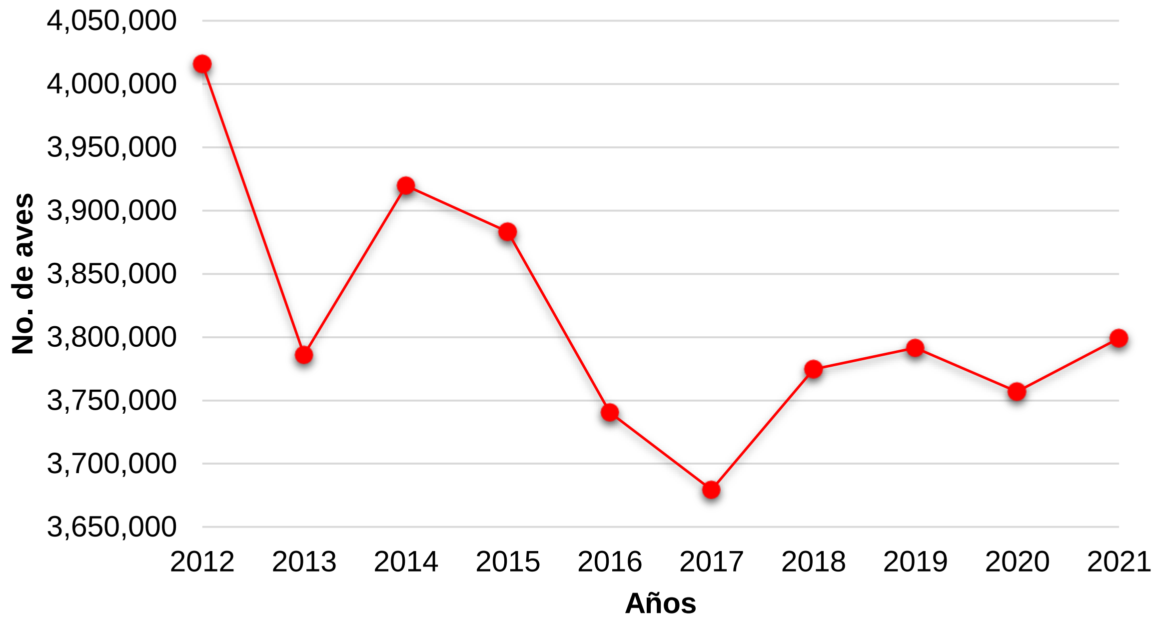

Figura 1. Comportamiento de la población nacional de Guajolote en México del periodo 2012 a 2021. Elaboración propia con datos del SIAP (2021).

De acuerdo con González-Ariza et al., (2021), la resistencia de los RGAv de razas locales y su capacidad para prosperar en el marco de sistemas sostenibles garantiza la consolidación de estos. La potenciación de las oportunidades comerciales de los productos avícolas locales puede ser una de las estrategias más eficientes para su conservación. La diferenciación de productos asegura la satisfacción de nichos particulares de manera más adecuada que los productos convencionales. Por ello, el correcto desarrollo de estrategias de conservación sólo puede lograrse si se conocen a fondo los productos y los animales que los producen.

Por lo anterior, se planteó la presente investigación con los siguientes objetivos: *i*) determinar el rendimiento y la composición de la canal, así como la calidad de la carne del GNM con base en sus características físico-químicas, perfil de ácidos grasos y atributos sensoriales, *ii*) investigar los efectos de la edad al sacrificio y el género en las características de la canal y la calidad de la carne del GNM criado en un sistema de producción extensivo, y *iii*) desarrollar ecuaciones de predicción de las características de la canal y el peso de los cortes primarios del GNM usando medidas corporales tomadas *in vivo*.

CHAPTER I. CARCASS COMPOSITION AND PHYSICOCHEMICAL, FATTY ACID AND SENSORY ATTRIBUTES OF BREAST AND LEG MEAT FROM NATIVE MEXICAN GUAJOLOTE (*Meleagris g. gallopavo*) AS INFLUENCED BY GENDER

1.1 ABSTRACT

The aim of the study was to compare carcass composition and physicochemical, fatty acids and sensory attributes of breast and leg meat from native Mexican Guajolote (*Meleagris g. gallopavo*) as influenced by gender. For this, slaughter weight and carcass characteristics of male (n = 8) and female (n = 8) guajolotes raised traditionally under extensive systems with similar housing and feeding conditions were recorded. Also, physical characteristics, proximate composition, fatty acid profile, and sensory attributes were determined in breast and leg meat. The results showed that males had higher (P < 0.001) slaughter weight, hot and cold carcass weights, dressing porcentaje, as well as carcass parts weights, while females had higher (P < 0.001) abdominal fat weights, than males. The lightness (L*), yellowness (b*) and drip loss values of breast meat, as well as redness (a*) and water-holding capacity values of leg meat were significantly (P < 0.05) influenced by gender. Male breast meat had higher (P < 0.05) moisture content, crude protein, erucic acid (C22:1n9), ∑ MUFA, ∑ UFA, ∑ DFA, ∑ UFA/∑ SFA ratio, and ∑ PUFA/∑ SFA ratio, and chewiness scores than females. Likewise, leg meat from males showed higher (P < 0.05) ash content, myristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1n9c), palmitoleic acid (C16:1n7), ∑ SFA, ∑ OFA, thrombogenic index, and atherogenic index, whereas females had high fat content. In conclusion, it would be suggested that, from a nutritional point of view, the meat from male guajolotes were preferable to those of meat from females.

1.2. INTRODUCTION

The poultry sector in developing countries is largely based on traditional production systems or free-range (extensive) that are characterized by low-input and more limited production outputs (Manyelo et al., 2020). In these poultry production systems, native or local poultry breeds are mainly used, and they play a substantial role for the rural poor and marginalised section of the people with respect to their subsidiary income and food security, since they provide them with meat and egg for consumption and sale (Padhi, 2016; Pius et al., 2021; Kanakachari et al., 2022). These poultry genotypes are well known for their desirable biological characteristics, such as good adaptability, thermo-tolerance and resistance to diseases (Padhi, 2016; Mengesha et al., 2022). In addition, their meat is considered to have a desirable taste and flavour; therefore, there is growing interest among the poultry farmers and meat consumers in native germplasm because of their unique characteristics (Rajkumar et al., 2016).

In recent years, there is a new trend in poultry meat consumption with a strong demand for meat from free-range or organic systems, which ensures food security and animal welfare combined with environmental responsibility, consumer health, and better meat quality (Özbek et al., 2020). Poultry meat quality can be observed by its nutritive value and sensory characteristics. Poultry meat is an essential source of food due to its favourable effects on human health derived from its protein, fats, minerals, vitamins and its bioactive components (Attia et al. 2017). The sensory attributes include meat color, aroma, texture, and flavor, and are important factors that determine consumer preference for a product (Uhlířová et al., 2018). Consumers often seek meat that is low in fat, tender, and juicy with a good aroma and flavor (Selamat et al., 2022). However, carcass characteristics and meat quality in poultry may be influenced by several factors such as gender, breed, origin, weight and age at slaughtering, feeding, breeding, management (pre-slaughter, stunning, slaughter and post-slaughter procedures, chilling, and storage conditions) and environmental factors (Onk et al., 2019; El-Tarabany et al., 2022; González Ariza et al., 2022). On the other hand, carcass quality is also determined by the distribution of tissue components. Lean meat should be located in the most valuable carcass parts (breast and legs). The tissue composition of poultry carcasses changes with age because the growth rates of tissue components vary across gender and species (Murawska, 2017).

The native Guajolote (*Meleagris g. gallopavo*) is the second most important poultry species in Mexico, after chicken (Romero-López, 2021), and is known to be the genetic base of the breeds and varieties of turkeys that are known nowadays (Portillo-Salgado et al., 2022a). The native Guajolote has more genetic variation than the commercial turkey due to genetic isolation and a longer period of genetic adaptation to local environmental conditions, but is less studied than the commercial turkey (Camacho-Escobar et al., 2008). In this context, the native Guajolote is noted for its good adaptability and high rusticity that allows it to reproduce under different environmental and management conditions. Also, it has a good capacity to convert feed into meat due to its good muscle development (Portillo-Salgado et al., 2022a). It is raised mainly in rural and sub-urban regions, under backyard conditions or extensive systems based on grazing and limited use of inputs. Their products (meat and eggs) constitute a main source of protein and income, being a source of investment and security for rural households (Portillo-Salgado et al., 2022b). Guajolote meat is considered one of the healthiest, characterized for having little fat and a low cholesterol level (Portillo-Salgado et al., 2022a). An important attribute given by consumers to Guajolote meat is that this meat has a better taste than that of the commercial turkey (Ramírez-Rivera et al., 2012). However, the suitability of this native poultry species for niche poultry markets has not been well researched with regard to carcass composition, meat quality, nutritional content and sensory acceptability. Therefore, the aim of this study was to compare carcass composition and physicochemical, fatty acids and sensory attributes of breast and leg meat from native Mexican Guajolote (*Meleagris g. gallopavo*) as influenced by gender.

1.3. MATERIALS AND METHODS

1.3.1. Location, birds and experimental design

All experimental procedures were conducted at the Laboratory of Animal Science of the Colegio de Postgraduados, Campus Campeche (Campeche, México). For the study, a sample of sixteen native guajolotes (male, n = 8 and female, n = 8) were used. The birds were aged between 10 and 12 months. The main criterion for the selection of birds was average body weight commonly used by local producers in marketing of this poultry species (5 and 3 kg for male and female, respectively). All birds were purchased from local poultry farms located in the municipalities of Champoton (19°21' N and 90°43' E; 10 masl) and Hopelchén (19°44' N and 89°50' E; 89 masl), where they were raised traditionally under extensive systems with similar housing and feeding conditions (Portillo-Salgado et al., 2018). The guajolotes had access to the outdoor environment during the day and were confined in shelters at night. The birds diet was based on inputs that they collect during grazing in the backyard or cultivated areas, such as grasses, plants, seeds, fruits and insects. Additionally, they received other complementary feeds such as corn, corn dough, wheat salvadillo and kitchen waste (corn tortilla, bread, fruits and vegetables). Birds had free access to clean water. The study region is characterized by a warm sub-humid climate with summer rainfall A(w); it presents temperatures that oscillate between 18 and 30 °C, and a total annual precipitation of 1600 mm.

1.3.2. Slaughter and carcass traits

Before slaughtering, the birds were subjected to feed withdrawal for 10 h; however, drinking clean water was provided *ad libitum* during this feed withdrawal period. All birds were weighed and manually slaughtered by exsanguination following the Official Mexican Standards (NOM-008-ZOO-1994, NOM-009-ZOO-1994, and NOM-033-ZOO-1995) established for the humane slaughter of animals intended for meat production. After bleeding for 2 min, the carcasses were scalded in water bath between 60-65 °C for 2 min to facilitate manual plucking. Subsequently, neck, head, feet, edible internal organs (heart, liver and gizzard), and abdominal fat were removed and weighed using an electronic balance. Carcasses were weighed to obtain the hot carcass weights. Cold carcass weights were determided after carcasses were stored at +4 °C for 24 h. Dressing percentage was calculated as the percentage of cold carcass weight from slaughter weight. Carcasses were dissected into breast, thigh, drumstick, wings and back as described by Hahn and Spindler (2002). The carcass parts were weighed using an electronic balance, and their yields were calculated as a percentage of cold carcass weight. Three right breast (*Pectoralis major* and *Pectoralis minor*) and leg (including drumstick and thigh) muscles for each gender were individually vacuum-packed and stored during 30 d at –20 °C for descriptive sensory analysis.

1.3.3. Physical and chemical analysis

Before dissection (24 h post-mortem), pH value and colour parameters of breast (*Pectoralis major*) and leg muscles without skin, were measured. The pH_{24h} value was measured with a portable digital pH-meter (Model HI 99161, Hanna Instruments®, USA), equipped with a glass electrode, which was introduced to a depth of one cm in the cross-section of muscle. Before measurement, the pH-meter was calibrated using buffers of pH 4.0 and pH 7.0 at room temperature according to the manufacturer's instructions. The pH was evaluated at three points within the muscle, adopting the average value of these three readings. The colour parameters were measured using a colorimeter (Model CR-400, Konica Minolta®, Tokyo, Japan), and were expressed in terms of CIELab colour coordinates reporting values for lightness (L^*; black/white), redness (a^*; green/red) and yellowness (b^*; blue/yellow). The average value of three repeated readings recorded from different points on the surface of the muscles was used.

Water-holding capacity (WHC; %) was evaluated by the filter paper press method (Grau and Hamm, 1953) modified by Biesek et al. (2021). Ground meat samples (3 g) were placed between two sheets of filter paper (Whatman® No. 1). The set was pressed with standard weight of 2 kg for 5 min. The samples were then removed from the filter paper and weighed. WHC was calculated as the difference between the initial sample weight and the final weight. Cooking loss (CL; %) was determined by placing ground meat samples (20 g) on a absorbent gauze inside sealed plastic bags, and cooked in a water bath at 85 °C for 10 min (Kokoszyński et al., 2020). Cooked meat samples were chilled at +4°C for 30 min and dried with paper towels. CL was expressed as the ratio between the weight before and after cooking. Drip loss (DL; %) was determined by placing ground meat samples (20 g) in two sealable bags (one of the bags was perforated to allow dripping) and storing them at +4 °C for 24 h (Kokoszyński et al., 2020). DL was expressed as the percentage of weight loss of the sample relative to its weight recorded before the refrigeration period.

The proximate composition of breast and leg meat was analyzed according to the methods described by the Association of Official Analytical Chemists (AOAC, 1990). The moisture content (%) of the meat was determined by freeze-drying using a freeze-dryer (Labconco®, Kansas, City, USA). The total crude protein content (%) was obtained according to the Dumas combustion method 990.03 (AOAC, 2005), while the crude fat content (%) was obtained by the submersion Soxtec method 991.36 (Thiex et al., 2003).

Finally, the ash content (%) was analysed by incineration at 600 °C for 2 h according to the method 942.05 (Thiex and Novotny, 2012).

1.3.4. Fatty acid analysis

Fatty acids profile was determined from one pool per muscle type and per gender by gas chromatography following the methods of AOAC Official Method 996.06 (Analysis of Methyl Esters by Capilary GLC) and AOCS Official Method Ce 2–66 (Preparation of Methyl Esters of Fatty Acids). A total of 4 pools were formed (1 pool of breast meat/gender and 1 pool of leg meat/gender). Each pool was comprised of 12 g of lyophilized meat (2 g/bird).

The average amount of each fatty acid was used to calculate the sum of the total saturated (∑ SFA = C12:0 + C14:0 + C16:0 + C18:0 +C20:0 + C24:0), total monounsaturated (∑ MUFA = C16:1n7 + C18:1n9c + C22:1n9), and total polyunsaturated (∑ PUFA = C18:2n-6c) fatty acids. Unsaturated fatty acids (UFA) were the sum of MUFAs and PUFAs. Desirable fatty acids (DFA) were C18:0 and UFAs. Odd fatty acids (OFA) were the sum of C14:0 and C16:0 (Belhaj et al., 2020). Nutritional indices of lipids were calculated as follows: Thrombogenic index (TI) = (C14:0 + C16:0 + C18:0)/[(0.5 × ∑ MUFA) + (0.5 × ∑ *n-6*) + (3 × ∑ *n-3*) + (∑ *n-3*/∑ *n-6*)]. Atherogenic index (AI) = (C12:0 + 4 × C14:0 + C16:0)/∑UFA (Ulbricht and Southgate, 1991), and Nutritive value index (NVI) = (C18:0 + C18:1)/C16:0 (Chen et al., 2016).

1.3.5. Descriptive sensory evaluation

The frozen breast and leg muscles were defrosted for 24 h at 4 °C. Later, the muscles were deboned to obtain several meat fillets, which were tagged with codes and cooked in boiling water during 30 min at 100˚C until reach a core temperature of 76 °C, without adding salt or seasoning (Ramírez-Rivera et al., 2012). The samples were prepared following appropriate food handling practices (Toomer et al., 2019). All fillets were cooked in the same amount of water, at the same temperature and time duration. The core temperature was determined using digital meat thermometer inserted after removing the cooked meat fillets from hot water. Cooked meat fillets were allowed to cool for 20 min and then cut into cubes of 1 × 1 × 1 cm. Subsequently, meat portions placed in aluminum pans and covered with aluminum foil. To ensure meat sample quality, they were kept in an oven at a constant temperature (75-80 °C) throughout the sensory test time.

For sensory evaluation, a panel of 20 individuals (fifteen males and five females with ages between 23 to 62 years) from the academic and student population of Colegio de Postgraduados (Campeche, México) was selected. All panelists had previous experience in consumption of poultry meat. Each panelist received a set of four meat samples (one sample by each gender and muscle type), as well as the list of sensory attributes evaluated. There was a 5 min interval between serving each meat sample. Consumers evaluated various liking attributes (flavor, tenderness, chewiness, juiciness), intensity (aroma and colour), and overall acceptance using a seven-point hedonic scale (Tan et al., 2022); where 1 = dislike extremely or low intensity and 7 = like extremely or high intensity. The sensory attributes and their description are described by Semwogerere et al. (2019). Consumers were provided with water at room temperature and fresh bread for palate cleansing and neutralize their sensory percepts (Uhlířová et al., 2018; Toomer et al., 2019).

1.3.6. Statistical analysis

Data collected for carcass composition and meat quality were analysed using the general linear model (GLM) procedure of SAS Version 9.4 statistical package (SAS Institute Inc. Cary, NC, USA; 2016). The linear model used for carcass composition traits (carcass characteristics, internal organs and non-carcass components) was: $Y_{ij} = \mu + G_i + e_{ij}$, where Y_{ij} = response variable, μ = the common mean, G_i = the effect of gender (male and female), and e_{ij}, = random observation error. Whereas meat quality traits (physicochemical, fatty acid and sensory attributes) were analyzed using the following linear model: $Y_{ijk} = \mu + G_i + M_j + e_{ijk}$, where Y_{ijk} = response variable, μ = the common mean, G_i = the effect of gender (male and female), M_j = the effect of muscle type (breast and leg), and e_{ijk}, = random observation error. Normal distribution of the variables was analyzed according to the Shapiro–Wilk test. The results are presented as least square means ± standard error of the mean (SEM). Differences were considered significant at the level of $P \leq 0.05$. For statistical analyses, each bird was considered as the experimental unit.

1.4. RESULTS

1.4.1. Carcass characteristics

The results on slaughter weight and carcass characteristics of native Mexican guajolotes are reported in Table 1. Males had higher ($P < 0.001$) slaughter weight, hot and cold carcass weights, as well as dressing porcentaje than females. The carcass parts weights were heavier ($P < 0.001$) in males, while females had higher drumstick ($P < 0.05$) and wings ($P < 0.001$) yields. The thigh and back yields did not vary significantly by gender ($P > 0.05$). Heart and liver were heavier ($P < 0.001$) in males than in females; although significantly higher ($P < 0.001$) abdominal fat weights were obtained in females. Males had heavier ($P < 0.001$) neck, head, and feet than females.

1.4.2. Physical characteristics

The physical attributes of breast and leg meat from native Mexican guajolotes are shown in Table 2. The lightness (L^*), yellowness (b^*) and drip loss values of breast meat, as well as redness (a^*) and water-holding capacity values of leg meat were significantly ($P < 0.05$) influenced by gender. On the other hand, the breast meat from males was characterized by higher ($P < 0.05$) lightness (L^*) and water-holding capacity values, and lower ($P < 0.05$) redness (a^*) and yellowness (b^*) values compared to leg meat. Similarly, in females, the breast meat presented higher ($P < 0.05$) water-holding capacity and drip loss values, but lower ($P < 0.001$) pH_{24h} and redness (a^*) values than leg meat.

1.4.3. Proximate composition

The chemical composition of breast and leg meat from native Mexican guajolotes is presented in Table 3. Male breast meat had higher ($P < 0.05$) moisture content and crude protein, but lower ash content than that of females. Regarding leg meat, males showed higher ($P < 0.05$) ash content, whereas females had high fat content. In addition, it was observed that in both genders, the moisture and fat contents were higher ($P < 0.001$) in leg meat than in breast meat. However, breast meat had higher ($P < 0.001$) crude protein values than leg meat. In females, breast meat had higher ($P < 0.001$) ash content than leg meat.

1.4.4. Fatty acid profile

The composition of individual fatty acids and nutritive indices of breast and leg meat from native Mexican guajolotes are described in Tables 4 and 5. Male breast meat had higher (P < 0.05) proportions of erucic acid (C22:1n9), ∑ MUFA, ∑ UFA, ∑ DFA, ∑ UFA/∑ SFA ratio, and ∑ PUFA/∑ SFA ratio than females. In contrast, the proportions of arachidonic acid (C20:0), ∑ SFA, and ∑ OFA were higher in breast meat of females than those of males. Meanwhile, leg meat of males presented a higher (P < 0.05) content of erucic acid (C22:1n9), ∑ UFA, and ∑ DFA, but a lower content of arachidonic acid (C20:0), ∑ SFA, ∑ OFA, and atherogenic index (AI) than leg meat of females.

On the other hand, the fatty acid profiles were significantly different among muscle types. In males, the proportions of myristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1n9c), palmitoleic acid (C16:1n7), ∑ SFA, ∑ OFA, thrombogenic index (TI), and atherogenic index (AI) were found to be higher (P < 0.05) in leg meat than in breast meat. However, the results demonstrated the highest content of arachidonic acid (C20:0), erucic acid (C22:1n9), ∑ PUFA, ∑ UFA, ∑ DFA, ∑ UFA/∑ SFA ratio, and ∑ PUFA/∑ SFA ratio in breast meat when compared to leg meat. In females, the concentration of arachidonic acid (C20:0), and erucic acid (C22:1n9) was higher (P < 0.05) in breast meat than in leg meat. Convensely, leg meat was characterized by a higher (P < 0.05) proportion of palmitic acid (C16:0), oleic acid (C18:1n9c), and ∑ MUFA than breast meat. Palmitic acid (C16:0), oleic acid (C18:1n9c), and linoleic acid (C18:2n-6c) were the most abundant SFA, MUFA, and PUFA, respectively.

1.4.5. Sensory attributes

The results of the sensory attributes of breast and leg meat from native Mexican guajolotes are presented in Table 6. The panelists evaluated the chewiness of breast meat from males with higher (P < 0.05) scores that breast meat from females. In both genders, colour intensity of leg meat had higher (P < 0.001) scores than in breast meat. Aroma, flavor, tenderness, juiciness and overall acceptance were not influenced by gender or muscle type (P > 0.05).

1.5. DISCUSSION

1.5.1. Carcass characteristics

The current study compared carcass composition and physicochemical, fatty acid and sensory attributes in breast and leg meat from native Mexican guajolotes as influenced by gender. Slaughter weight and carcass characteristics were affected by gender due to the sexual dimorphism that characterizes most domestic birds (Yamak et al., 2016; Uhlířová et al., 2018; Cygan-Szczegielniak et al., 2019). Slaughter weight was almost 50% greater in males than in females, and as expected, the hot and cold carcass weights were higher in males than in females. Also, males had a higher dressing than females. The dressing percentages obtained in male (65.4%) and female (59.9%) native guajolotes were lower than the dressing percentages (71.2 to 82.7%) reported in turkeys from commercial lines (İşgüzar, 2003; Majumdar et al., 2005; Loyra et al., 2013; Chartrin et al., 2019). These differences are common in poultry due to metabolic rate differences among native and commercial genotypes (Rajkumar et al., 2016; Khan et al., 2019). Likewise, selection progress in meat-type poultry, such as turkeys, has contributed to an increase in their body weight, improved carcass composition, and a substantial rise in carcass dressing percentage (Murawska, 2017). In contrast, the lack of selection pressure on growth and yield in guajolotes is likely the reason why the latter are smaller than turkeys. Age, feeding and environmental factors also might account for this variation.

On the other hand, all carcass parts weights exhibited sexual dimorphism, and were higher in males than in females. However, the carcass parts yields were similar between genders, except for drumstick and wings yields, which were higher in females than in males. An important gender effect on carcass parts weights was also reported by other authors (İşgüzar, 2003; Murawska et al.,2015; Tůmová et al., 2020), who found that male turkeys presented heavier carcass parts than females. This is due to the fact that the turkey is characterized by a strong sexual dimorphism on body weight resulting in a higher carcass weight and cut pieces in males than in females (Chartrin et al., 2019). Particularly, breast weight difference between males and females is due to the hypertrophy of the muscle fibers and to a more and/or longer muscle fibers (Chartrin et al., 2019). Breast constituted the heaviest carcass component followed by back with ribs, thighs, drumsticks and wings, regardless of the gender. Consistent trends were observed in carcass parts yields in both males and females. In meat-type birds, breast and leg weight is an important economic consideration (Murawska et al., 2015). Similar findings were reported in previous studies (İşgüzar, 2003; Majumdar et al., 2005; Murawska et al., 2015) where carcass composition in turkeys from commercial lines is based mainly on breast, back, thigh and drumsticks yields. The cited authors also observed significant age-related changes in tissue composition of carcass parts. According to Murawska et al. (2015), in turkeys, selection for enlarged breast muscles is due to the fact that consumers generally prefer meat of this muscle.

In the present study, heart and liver were heavier in males than in females, while gizzard weight did not vary among both genders. However, females had higher abdominal fat content than their male counterparts. In this regard, Jİşgüzar (2003) reported that Bronze and White 18-weeks-old male turkeys showed higher heart and liver weights than females. Another study reported that liver, gizzard and heart weights were similar in males and females of BUT9 hybrid in the early part of the growth period but they diverged from 35 days of age for the gizzard, 56 days for the liver and 77 days for the heart. However, the allometric coefficients describing the growth of each of these internal organs in relation to the increase in body weight were the same for males and females (Tůmová et al., 2020). Also, Murawska (2017) reported that in BIG 6 turkeys, growth rates of individual organs vary with age. The higher fat content in females than in males could be explained by differences in fat deposition. In addition, it has been observed that in poultry, the fat content in females increases at a faster rate than in males as the birds mature (Tůmová et al., 2020; El-Tarabany et al., 2022). Regarding the non-carcass components, these also varied due to the sexual dimorphism of guajolotes. Neck, head, and feet were heavier in males than in females. Similar findings were also reported in other poultry species (Murawska, 2017; Kokoszyński et al., 2020; Biesek et al., 2021).

1.5.2. Physical characteristics

According to Semwogerere et al. (2019), the physical characteristics of meat are of paramount importance as they determine the functional properties of meat, which are key during meat processing. Also, physical characteristics are the primary determinants of consumers’ willingness to purchase the meat. Particularly, meat quality is closely associated to the decrease in muscle pH post-mortem, which in turn is related to the glycolytic enzyme´s activity immediately after death. The ultimate pH is shaped by the initial muscle glycogen levels, and is of importance when considering meat preservation and stability. A high muscle pH affects shelf life and sensorial quality by its undesirable effect on bacterial growth and meat moistness; conversely, a low pH is associated with poor water-holding capacity and meat colour (Cygan-Szczegielniak et al., 2019). The pH values (ranging from 5.75–6.00) obtained in this study varied within the pH range accepted for commercial poultry meat (5.7-6.4) (Gálvez et al., 2018). On one hand, gender did not affect the pH value measured at 24 h post mortem. On the other hand, in females, the pH values differed among muscles types. The highest pH value was observed in leg meat. These pH differences are probably due to the differences in muscle type and glycogen content, which change according to the proportion of the muscle fibers that are responsible for different patterns of muscle metabolism (Khan et al., 2019). The results of the present study are consistent with the study of Gálvez et al. (2018) who found that gender had no significant effect on pH values of breast and thigh meat in Hybrid turkeys. Likewise, breast meat had lower pH values than thigh meat (6.03 vs. 6.29, respectively). On the contrary, Chartrin et al. (2019) reported that male breeder turkeys from the Grademaker line slaughtered at older ages presented a lower pH in breast and thigh muscles than pH measured in females, indicating higher glycogen reserves.

Meat colour is another important attribute used to assess the freshness and quality of meat by consumers and is closely related to the ultimate pH (Uhlířová et al., 2018; Cygan-Szczegielniak et al., 2019). In the present study, breast meat of females was darker (lower L^* value) and yellower (high b^* value), while leg meat was greener (lower a^* value) than that of males. According to Khan et al. (2019), meat colour may be influenced by the heme pigments, genetics and feeding. For example, the consumption of vegetation in the outdoor space could contribute to increased meat yellowness because plant material contains abundant carotenoid pigments (Cygan-Szczegielniak et al., 2019). Moreover, Semwogerere et al. (2019) suggested that meat colour variation also be attributed to the effect of water temperature during the defeathering process. Similar to the present study, Sarica et al. (2011) reported that colour characteristics of breast meat were different between genders from different turkey genotypes; the breast meat of females had lower *L** values (55.55 vs 56.12) and higher *a** (6.71 vs 6.37), and *b** (1.93 vs 1.48) values than those of males. In this regard, Gálvez et al. (2018) found that only *a** value was affected by gender in Hybrid turkeys; breast and thigh meat from males was redder than meat from females.

Water-holding capacity is an important attribute of meat quality, and if it is low, meat will lack juiciness. This means that more water could be released during storage and processing of meat resulting in weight losses in the final product as well as economic losses (Cygan-Szczegielniak et al., 2019; Onk et al., 2019). Our results showed that male leg meat had higher water-holding capacity than that of females. Whereas, breast meat from females had higher drip loss values. Specifically, breast meat from both genders was characterised by high values of water-holding capacity when compared to leg meat. In relation to this, Onk et al. (2019) explained that the discrepancy regarding the ability of meat to retain moisture might be attributed to the extent of pH decline postmortem. Sarica et al. (2011) investigated the effects of gender on some meat quality traits of different turkey genotypes and reported that breast meat of females had higher water-holding capacity values than those of the males. Another study in Hybrid turkeys reported that males had breast muscles displaying higher drip loss during storage and higher cooking loss, resulting in a lower technological yield than that of females (Chartrin et al., 2019).

1.5.3. Proximate composition

Poultry meat is considered an excellent food for human consumption because of its quality and quantity of protein contents that plays a vital role in meat quality assessment (Sabow, 2020). In this study, it was found that gender had a significant effect on proximate composition of Guajolote meat. Especially breast meat from males had higher moisture (73.95% vs 72.98%) and crude protein contents (24.19% vs 22.62%), but lower ash content (1.09% vs 1.12%) than those of females. In addition, protein and ash contents in breast meat was significantly higher than that in leg meat regardless of gender. However, leg meat from both genders had higher moisture and fat contents. This observation is supported by a study from Majumdar et al. (2005) who demonstrated that, irrespective of the age of the turkeys, breast meat contained more crude protein and less fat than leg meat. According to Gálvez et al. (2018), this could be related to muscle type composition, as leg and thigh meat is formed from several muscles with a higher proportion of red fibres and greater lipid content than breast meat. In this regard, Sarica et al. (2011) found that dry matter, crude protein, and fat contents of breast meat and the crude protein and fat contents of thigh meat were affected by gender in commercial turkeys. Females presented higher contents of dry matter in breast muscle, and fat in breast and thigh muscles, but lower crude protein in breast and thigh muscles than those recorded in males. On the contrary, Gálvez et al. (2018) reported that gender had no effect on the chemical components of meat from either breast or thigh samples in turkeys. These authors found a mean value of 74.9% for moisture, whereas that of protein was above 20%; these values were slightly higher in females than in males, also, protein was higher in breast than in thigh samples (24.2% vs 20.4%). Selamat et al. (2022) stated that the higher protein content of village chicken was related to the feed provided and the outdoor system that contributes to muscle development and led to higher protein. In general, Guajolote meat is comparable in terms of proximal composition to the majority of turkey meat that is considered a significant resource of protein.

1.5.4. Fatty acid profile

Fatty acid profile is an important factor determining the quality of animal products (Skiepko et al., 2016). Lipid and fatty acids in muscle are among the major factors that influence meat quality, particularly palatability and nutritional value (Sabow, 2020). In our experiment, when the proportions of individual fatty acids in the breast and leg meat of native guajolotes were considered, arachidonic (C20:0) and erucic acids (C22:1n9) varied according to gender. Also, Gálvez et al. (2018) reported that gender had an effect in 12 out of 25 fatty acids in breast and 15 out of 25 fatty acids in thigh of commercial turkeys. These results agree with those reported by other authors, who observed differences in meat fatty acid profile between genders in chickens (Suchy et al., 2016), turkeys (Skiepko et al., 2016), and ducks (Onk et al., 2019). As expected, palmitic (C16:0), oleic (C18:1n9c), and linoleic acids (C18:2n-6c) were the predominant fatty acids found in breast and leg meat from native guajolotes. Similar results regarding predominance order of these fatty acids have also been found in roosters (Amorin et al., 2016), local Polish goose (Wołoszyn et al., 2020), Japanese quail (Sabow, 2020), as well as broilers and hens (El-Tarabany et al., 2022).

In the current study, the breast and leg meat from native guajolotes was characterized by the prevalence of ∑ MUFA (35.18–41.51 g/100 g of fat), followed by ∑ SFA (24.46–34.95 g/100 g of fat), and ∑ PUFA (23.85–34.87 g/100 g of fat). Females had greater concentrations of ∑ SFA in the breast and leg muscles as compared to males. However, males had a higher proportion of ∑ MUFA in breast meat compared to females. The different compositions of MUFAs and PUFAs in the muscle of different growth rates with the same diet may also be due to different dietary habits of the birds (Nur Mahiza et al., 2021). Dal Bosco et al. (2012) suggested that the low MUFAs levels observed in chickens from pure breed reared under organic system can be attributed to the higher intake of pasture with respect to feed, and to the different intramuscular fat content of birds. In the current study, the dominant MUFA in the meat was oleic acid (C18:1n9c). These results are consistent with those obtained previously in commercial Chinese chickens (Chen et al., 2016) and local Polish goose varieties (Wołoszyn et al., 2020). Similarly, Chartrin et al. (2019) demonstrated that gender had effects on the fatty acids composition of turkeys meat; females had a higher SFA content than males. In this regard, Wołoszyn et al., 2020 described that for preventing cardiovascular disease it is advantageous to consume food enriched with MUFAs, which has favorable influence on the blood lipid profile. Palmitic acid (C16:0) was the most abundant SFA (24.46–34.95%), followed mainly by stearic (C18:0) (9.08–12.01%), myristic (C14:0) (0.95–3.22%), and lauric (C12:0) (0.60–5.05%) acids. According to Wołoszyn et al. (2020), these fatty acids occur naturally in all animal fat and are major products of the fatty acid synthase system; accordingly lauric and myristic acids were detected at low concentrations, thus demonstrating a positive factor in their consumption, because they promote hypercholesteremia. While, stearic acid is neutral in the body as it is directly metabolized into oleic acid (Skiepko et al., 2016).

It was found that breast and leg meat from males contained the highest amount of ∑ UFA (75.48 and 69.78 g/100 g of fat, respectively) and ∑ DFA (84.57 and 81.65 g/100 g of fat, respectively), and the lowest amount of ∑ OFA (13.15 and 16.68 g/100 g of fat, respectively) compared to those observed in females. In a study, Gálvez et al. (2018)

found that male turkeys presented higher amounts of ∑SFA than females in breast and thigh muscles, and these differences were mainly due to males having the highest values of stearic acid (C18:0), and to a lesser extent, to the values of myristic (C14:0) and heptadecanoic (C17:0) acids. The UFAs are classified as essential, meaning that the organism is unable to generate them and therefore they must be provided in the feed. These substances exert significant effects on many aspects of the organism health. They favourably affect prognosis in cardiovascular diseases, are highly beneficial for the brain and quality of vision, and, in addition, strengthen immunity and help to cure eczema, acne and psoriasis (Suchy et al., 2016). Therefore, poultry meat with high UFAs content is preferable for customers due to its low cholesterol (hypocholesterolemic index) and lower atherogenic index (Attia et al., 2017). In relation to this, Nur Mahiza et al. (2021) affirmed that slow-growing birds, as village chickens, might be better sources of desirable fatty acids than the commercial broiler.

The ∑ UFA/∑ SFA and ∑ PUFA/∑ SFA ratios are commonly used parameters to judge meat nutritional value and healthiness of intramuscular fat for human consumption. In general, a ratio of ∑ PUFA/∑ SFA greater than 0.45 is recommended in human diets to prevent the development of cardiovascular diseases and some chronic diseases (Wołoszyn et al., 2020). In this study, ∑ UFA/∑ SFA and ∑ PUFA/∑ SFA ratios ranged from 1.92 to 3.09, and 0.71 to 1.43, respectively, and were significant higher in breast meat of males than of females. In general, the ∑ PUFA/∑ SFA ratios found were consistent with the recommended values, which indicate improved balance of fatty acids in analyzed tissues (Wołoszyn et al., 2020). The values obtained in the present study for ∑ UFA/∑ SFA and ∑ PUFA/∑ SFA ratios were consistent with those found in duck (Onk et al., 2019), laying hens (Semwogerere et al., 2019), and local Polish goose (Wołoszyn et al., 2020).

On the other hand, for a better understanding and nutritional evaluation of fat the use of health indices based on the functional effects of the fatty acids is essential. The thrombogenic (TI) and atherogenic (AI) indexes should be maintained as low as possible in a healthy heart diet (Semwogerere et al., 2019). Thus, the smaller the TI and AI values, the greater the protective potential for coronary artery disease. In terms of human health, the TI and AI, which are less than 0.5 and 1.0, respectively, in the diet, are recommended (Wołoszyn et al., 2020). The TI, AI, and NVI obtained in the present study ranged from 0.16 to 0.42, 0.21 to 0.50, and 2.68 to 2.87, respectively, but did not significantly differ between genders, except, the AI that had a higher value in leg meat of females than males. The TI and AI values found in the present study were lower than those obtained by Gálvez et al. (2018), who described values of TI= 0.89 to 0.88 and 0.98 0.92, and AI= 0.43 to 0.43 and 0.46 to 0.45 in breast and thigh muscles from commercial turkeys, respectively. They also reported that females presented the best TI values in thigh samples (0.92 vs. 0.95, for females and males, respectively). Similar values have been reported by Semwogerere et al. (2019) in breast meat from laying hens (TI= 0.60-0.80 and AI= 0.40-0.50), by Onk et al. (2019) in breast meat from ducks (TI= 0.34-0.36, AI= 0.29-0.31, and NVI= 2.38-2.61), and by Wołoszyn et al. (2020) in breast muscles from local Polish goose (TI= 0.66-0.74, AI= 0.36-0.37, and NVI= 1.88-2.17). In general, the breast and leg meat of native Guajolote studied in the present study showed TI and AI lower than the recommended values; therefore, this is very desirable from a human health point of view.

1.5.5. Sensory attributes

Sensory evaluation is a useful tool for quality assessment of the various foods, such as meat (Uhlířová et al., 2018). Flavor is a combination of taste and aroma, and together with texture forms the core of the sensory profile of meat and meat products. The afore mentioned attributes are correlated to the physicochemical characteristics of meat and meat products (Semwogerere et al., 2019). In the current study, the mean score for all sensory attributes evaluated varied between values 3 to 6 for both genders and muscle types of native guajolotes. However, aroma, flavor, tenderness, juiciness and overall acceptance of meat were not influenced by the evaluated factors. On the other hand, breast meat of males received higher chewiness scores than those of females. Also, according to the panelist evaluations, leg meat of both genders was judged more colored than that of breast meat. This can be explained by the intense colour of red muscle fibres in contrast with the whitish fat of breast meat (Remm et al., 2011). In addition, it is known that the thigh meat color may be influenced also by species, diet and exercise of animals

(Khan et al., 2019). These findings are confirmed by Chartrin et al. (2019), who observed that turkey male thighs were judged more colored, juicier, and stringier than those of females. Whereas, male breasts were less tender, stringier, and less sticky than the breasts of females. Their global flavor was lower, and they were less appreciated than those of females.

1.6. CONCLUSIONS

This study demonstrated a effect of the gender on the weight and dressing percentage of guajolote carcasses, as well as carcass parts weights, which is attributed to natural differences resulting from sexual dimorphism in favor of males. Moreover, the quality of breast and leg meat varied between genders. Breast meat from males was characterized by higher lightness, water-holding capacity, moisture content, crude protein, MUFAs, UFAs, DFAs, UFA/SFA ratio, PUFA/SFA ratio, and chewiness scores. Thus, from a nutritional point of view, the meat from male guajolotes were preferable to those of meat from females. Therefore, guajolote meat is a healthy food that can be ideally incorporated into the human diet.

1.7. ACKNOWLEDGEMENTS

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Table 1. Means (±standard error) of carcass characteristics, internal organs and non-carcass components of native Mexican Guajolote as influenced by gender.

Item	Male	Female	*P*-value
Carcass characteristics			
Slaughter weight (g)	5688.75 ± 250.11	2913.13 ± 189.73	<0.001
Hot carcass weight (g)	3740.63 ± 224.88	1743.13 ± 104.80	<0.001
Cold carcass weight (g)	3719.38 ± 223.91	1733.75 ± 104.20	<0.001
Dressing porcentaje[1] (%)	65.43 ± 1.24	59.97 ± 0.61	0.001
Breast (g)	1285.63 ± 107.77	516.90 ± 38.57	<0.001
Thigh (g)	678.12 ± 19.52	322.50 ± 20.89	<0.001
Drumstick (g)	556.87 ± 19.01	298.75 ± 14.41	<0.001
Wings (g)	423.75 ± 8.16	249.38 ± 9.65	<0.001
Back (g)	745.62 ± 83.57	345.63 ± 27.09	0.001
Breast (%)[2]	34.20 ± 1.02	29.65 ± 0.53	0.001
Thigh (%)[2]	18.60 ± 0.99	18.57 ± 0.15	0.977
Drumstick (%)[2]	15.17 ± 0.52	17.36 ± 0.65	0.020
Wings (%)[2]	11.62 ± 0.58	14.50 ± 0.33	0.001
Back (%)[2]	19.66 ± 1.07	19.85 ± 0.72	0.885
Internal organs			
Heart (g)	26.00 ± 1.45	13.00 ± 1.18	<0.001
Liver (g)	81.37 ± 5.52	52.25 ± 3.43	0.001
Gizzard (g)	75.75 ± 5.54	75.37 ± 4.53	0.959
Abdominal fat (g)	61.71 ± 7.03	175.31 ± 23.74	0.001
Non-carcass components			
Neck (g)	293.75 ± 27.30	106.88 ± 8.50	<0.001
Head (g)	157.50 ± 11.45	89.38 ± 3.19	<0.001
Feet (g)	177.50 ± 4.81	96.25 ± 2.05	<0.001

[1]Cold carcass weight/slaughter weight × 100

[2]Calculated as a percentage of the cold carcass weight.

Table 2. Means (±standard error) of physical characteristics in native Mexican Guajolote meat as influenced by gender and muscle type.

Item	Muscle	Gender		*P*-value
		Male	Female	
pH_{24h}	Breast	5.81 ± 0.03	5.75 ± 0.03	0.301
	Leg	5.90 ± 0.03	6.00 ± 0.03	0.054
	P-value	0.078	0.001	
$Colour_{24h}$				
*L**	Breast	39.57 ± 1.84	27.54 ± 2.85	0.003
	Leg	28.13 ± 1.73	28.73 ± 1.97	0.824
	P-value	0.001	0.738	
*a**	Breast	1.49 ± 0.38	1.55 ± 0.21	0.894
	Leg	9.65 ± 0.37	8.07 ± 0.64	0.048
	P-value	<0.001	<0.001	
*b**	Breast	4.89 ± 0.59	9.00 ± 1.12	0.005
	Leg	8.36 ± 0.91	9.65 ± 0.55	0.264
	P-value	0.006	0.611	
Water-holding capacity (%)	Breast	64.62 ± 2.29	56.25 ± 4.21	0.102
	Leg	55.33 ± 2.94	42.75 ± 2.03	0.003
	P-value	0.026	0.012	
Cooking loss (%)	Breast	21.48 ± 1.40	21.12 ± 0.76	0.824
	Leg	21.72 ± 2.21	22.07 ± 1.78	0.904
	P-value	0.929	0.633	
Drip loss (%)	Breast	2.70 ± 0.40	3.96 ± 0.20	0.014
	Leg	2.81 ± 0.25	2.82 ± 0.21	0.970
	P-value	0.817	0.001	

Table 3. Means (±standard error) of chemical composition in native Mexican Guajolote meat as influenced by gender and muscle type.

Item	Muscle	Gender		*P*-value
		Male	Female	
Moisture content (%)	Breast	73.95 ± 0.16	72.98 ± 0.24	0.005
	Leg	74.98 ± 0.14	74.45 ± 0.24	0.080
	P-value	0.001	0.001	
Crude protein (%)	Breast	24.19 ± 0.24	22.62 ± 0.22	0.003
	Leg	20.42 ± 0.14	20.31 ± 0.07	0.512
	P-value	<0.001	<0.001	
Fat (%)	Breast	0.97 ± 0.13	1.51 ± 0.25	0.079
	Leg	2.01 ± 0.09	3.06 ± 0.15	<0.001
	P-value	<0.001	0.001	
Ash (%)	Breast	1.09 ± 0.00	1.12 ± 0.00	0.015
	Leg	1.12 ± 0.01	1.08 ± 0.01	0.016
	P-value	0.073	0.003	

Table 4. Means (±standard error) of fatty acids (g/100 g of fat) in native Mexican Guajolote meat as influenced by gender and muscle type.

Item	Muscle	Gender		*P*-value
		Male	Female	
Lauric acid (C12:0)	Breast	0.60 ± 0.00	3.70 ± 1.60	0.467
	Leg	0.60 ± 0.10	5.05 ± 1.58	0.175
	P-value	1.000	0.582	
Myristic acid (C14:0)	Breast	0.95 ± 0.04	3.22 ± 1.55	0.165
	Leg	1.52 ± 0.09	2.50 ± 0.43	0.061
	P-value	<0.001	0.660	
Palmitic acid (C16:0)	Breast	12.20 ± 0.24	13.03 ± 0.74	0.302
	Leg	15.35 ± 0.43	16.40 ± 0.64	0.196
	P-value	<0.001	0.004	
Palmitoleic acid (C16:1n7)	Breast	5.96 ± 0.46	6.51 ± 1.15	0.665
	Leg	7.33 ± 0.29	7.40 ± 0.39	0.901
	P-value	0.024	0.480	
Stearic acid (C18:0)	Breast	9.08 ± 0.28	12.01 ± 2.90	0.332
	Leg	11.86 ± 0.47	11.12 ± 0.58	0.343
	P-value	0.001	0.768	
Oleic acid (C18:1n9c)	Breast	25.53 ± 0.44	23.35 ± 2.93	0.472
	Leg	31.33 ± 0.77	32.78 ± 1.34	0.366
	P-value	<0.001	0.011	
Linoleic acid (C18:2n-6c)	Breast	34.87 ± 0.74	31.13 ± 4.54	0.430
	Leg	28.27 ± 1.07	23.85 ± 2.01	0.073
	P-value	0.001	0.164	
Arachidonic acid (C20:0)	Breast	1.00 ± 0.11	2.83 ± 0.39	0.001
	Leg	0.56 ± 0.04	1.40 ± 0.30	0.021
	P-value	0.008	0.018	
Erucic acid (C22:1n9)	Breast	9.11 ± 1.25	5.32 ± 0.88	0.027
	Leg	3.78 ± 0.25	1.95 ± 0.67	0.018
	P-value	0.003	0.032	
Lignoceric acid (C24:0)	Breast	1.15 ± 0.43	0.70 ± 0.05	0.560
	Leg	1.50 ± 0.62	0.35 ± 0.25	0.356
	P-value	0.645	0.179	

Table 5. Means (±standard error) of nutritional indices of the lipids in native Mexican Guajolote meat as influenced by gender and muscle type.

Item	Muscle	Gender		*P*-value
		Male	Female	
∑ SFA	Breast	24.46 ± 0.54	33.72 ± 4.17	0.045
	Leg	30.25 ± 0.79	34.95 ± 1.97	0.044
	P-value	<0.001	0.794	
∑ MUFA	Breast	40.61 ± 0.87	35.18 ± 1.93	0.022
	Leg	41.51 ± 1.06	41.16 ± 1.50	0.852
	P-value	0.523	0.028	
∑ PUFA	Breast	34.87 ± 0.74	31.13 ± 4.54	0.430
	Leg	28.27 ± 1.07	23.85 ± 2.01	0.073
	P-value	0.001	0.164	
∑ UFA	Breast	75.48 ± 0.55	66.32 ± 4.18	0.047
	Leg	69.78 ± 0.80	65.01 ± 1.96	0.040
	P-value	<0.001	0.780	
∑ DFA	Breast	84.57 ± 0.64	78.33 ± 1.92	0.008
	Leg	81.65 ± 0.55	76.13 ± 1.84	0.012
	P-value	0.004	0.423	
∑ OFA	Breast	13.15 ± 0.28	16.26 ± 1.38	0.045
	Leg	16.68 ± 0.44	18.90 ± 0.85	0.037
	P-value	<0.001	0.127	
∑ UFA/∑ SFA	Breast	3.09 ± 0.08	2.19 ± 0.26	0.005
	Leg	2.32 ± 0.09	1.92 ± 0.17	0.063
	P-value	<0.001	0.425	
∑ PUFA/∑ SFA	Breast	1.43 ± 0.04	1.06 ± 0.16	0.049
	Leg	0.94 ± 0.05	0.71 ± 0.09	0.059
	P-value	<0.001	0.093	
TI	Breast	0.16 ± 0.00	0.42 ± 0.25	0.308
	Leg	0.23 ± 0.01	0.29 ± 0.02	0.082
	P-value	<0.001	0.618	
AI	Breast	0.21 ± 0.00	0.50 ± 0.18	0.127
	Leg	0.29 ± 0.01	0.47 ± 0.06	0.018
	P-value	<0.001	0.883	
NVI	Breast	2.84 ± 0.05	2.87 ± 0.50	0.949
	Leg	2.82 ± 0.07	2.68 ± 0.07	0.238
	P-value	0.820	0.713	

Table 6. Means (±standard error) of sensory attributes in native Mexican Guajolote meat as influenced by gender and muscle type.

Item	Muscle	Gender		*P*-value
		Male	Female	
Aroma	Breast	5.30 ± 0.29	4.93 ± 0.37	0.444
	Leg	5.13 ± 0.30	4.83 ± 0.29	0.484
	P-value	0.696	0.833	
Flavor	Breast	5.13 ± 0.27	4.66 ± 0.37	0.322
	Leg	4.53 ± 0.42	4.40 ± 0.34	0.809
	P-value	0.244	0.606	
Tenderness	Breast	5.53 ± 0.27	5.00 ± 0.27	0.181
	Leg	4.80 ± 0.39	4.93 ± 0.34	0.800
	P-value	0.136	0.881	
Chewiness	Breast	6.00 ± 0.29	4.96 ± 0.31	0.023
	Leg	5.06 ± 0.39	5.43 ± 0.38	0.509
	P-value	0.068	0.354	
Juiciness	Breast	4.60 ± 0.34	4.66 ± 0.37	0.897
	Leg	5.10 ± 0.32	4.40 ± 0.30	0.127
	P-value	0.303	0.585	
Colour	Breast	3.80 ± 0.27	3.33 ± 0.37	0.325
	Leg	5.26 ± 0.20	5.00 ± 0.23	0.405
	P-value	0.001	0.001	
Overall	Breast	5.46 ± 0.23	5.00 ± 0.31	0.243
acceptance	Leg	5.00 ± 0.27	5.10 ± 0.33	0.817
	P-value	0.205	0.827	

CHAPTER II. EFFECTS OF SLAUGHTER AGE AND GENDER ON CARCASS CHARACTERISTICS AND MEAT QUALITY OF NATIVE MEXICAN TURKEY (*M. g. gallopavo*) REARED UNDER AN EXTENSIVE PRODUCTION SYSTEM

2.1. ABSTRACT

The study aimed to investigate the effects of slaughter age and gender on carcass characteristics and meat quality of native Mexican turkeys raised under an extensive production system. Forty-five native turkeys (36 males and 9 females) were used. They were sacrificed at 24, 32, and 40 weeks of age. Slaughter age significantly affected slaughter weight (SW), hot carcass weight (HCW) and cold carcass weight (CCW). Also, dressing percentages, non-carcass components, internal organs, abdominal fat, and most carcass parts and proportions were affected. Gender significantly affected SW, HCW and CCW, non-carcass components, internal organs, and carcass parts weights. Regarding the physical properties of breast and leg meat, pH values and color parameters taken at 45 min and 24 h *post-mortem*, as well as the water-holding capacity (WHC), cooking (CL), and drip loss (DL), were significantly affected by slaughter age, except CL in leg meat. Meanwhile, gender influenced L^*_{45min}, b^*_{24h}, the pH_{24h} values, and CL in breast meat. Concerning the chemical composition of the meat, slaughter age had a significant effect on ether extract (EE) content of breast meat and on dry matter (DM), crude protein (CP), EE, ash, and energy contents of leg meat. Gender significantly affected the DM, CP, and energy contents of breast meat and DM, EE, and energy contents of leg meat. These results indicate that the carcass weight and yield, and its components, as well as meat quality were better in older male turkeys than in adult females.

Keywords: Carcass composition; meat quality; native Mexican turkeys; poultry genetic resource; slaughter age

2.2. INTRODUCTION

Currently, poultry meat is one of the most consumed foods of animal origin worldwide since it provides proteins, vitamins, and minerals of high biological value, essential nutrients in the human diet (Marangoni et al. 2015). Thus, poultry meat contributes to the nutrition and food security of the population, especially in developing countries (Mottet and Tempio 2017). In recent years, a trend has been observed in the consumption of poultry meat produced from ecological or organic production systems, as they provide a good image for the product and environmental sustainability, improved animal welfare and meat quality (Cobanoglu et al. 2014; Uhlířová et al. 2018; Özbek et al. 2020; Aksoy et al. 2021; Dal Bosco et al. 2021). In these production systems, poultry must have access to an abundance of fresh air, daylight, and outdoor space. Specifically, every effort has to be made to allow chickens to live as natural a life as possible (Dal Bosco et al. 2021). Likewise, greater use of local and native poultry genotypes has also been promoted as an alternative to commercial genotypes because they produce meat with high nutritional value with more protein and less fat (Dalle Zotte et al. 2019). In addition, its production is cheap since it requires fewer inputs and less labor than intensively farmed poultry (Uhlířová et al. 2018; Boz et al. 2019; Onk et al. 2019; Kokoszyński et al. 2020).

Turkeys (*Meleagris gallopavo gallopavo*) are poultry native to Mexico with interesting biological and productive characteristics for ecological or organic poultry production systems (Portillo-Salgado et al. 2022). They show slow growth because they have been kept unselected over the years; however, they are characterized by their excellent muscle development and little carcass fat (Juárez-Caratachea 2004). In addition, native turkeys are incredibly resilient. They have good adaptability and natural resistance against some common poultry diseases due to their ability to develop antibodies, allowing them to thrive under various climatic conditions (Camacho-Escobar et al. 2008).

The raising of native turkeys has a long tradition in Mexico and other Central American countries (Ramírez-Rivera et al. 2012). It is a crucial poultry activity for small and medium producers since it allows them to obtain meat for self-consumption and sale, contributing to families' food and economic sustenance (García-Flores and Guzmán-Gómez 2016). This poultry is traditionally bred in extensive conditions and grazed in open spaces, cultivated areas, or backyards to diversify and complement their diet through herbs, grasses, fruits, seeds, worms, and insects (Portillo-Salgado et al. 2018). At the same time, this production system generates an environment of well-being and improves the birds' physical condition (Cigarroa et al. 2017).

In poultry, carcass characteristics and meat quality properties are affected by numerous factors, including age at slaughter, gender, genotype, diet, production system, environment, and procedures before and after slaughter (Baéza et al. 2021). Therefore, it is crucial to evaluate these factors to regulate and optimize their production and allocate added value based on the quality of the product (Onk et al. 2019). In particular, the meat of native turkeys is considered one of the healthiest meats since it contains low cholesterol and fat levels (Gallardo-Nieto et al. 2007). In addition, it has a good flavor and aroma, which are attractive sensory attributes for consumers (Ramírez-Rivera et al. 2012). These qualities contribute to the acceptance of native turkeys' meat, which facilitates its adoption. However, there is not enough scientific data on the characteristics of the carcass and the technological and nutritional value of native turkey meat (López et al. 2011). The influence of age at slaughter and gender on these parameters has not been evaluated.

Therefore, the purpose of this study was to evaluate the effects of slaughter age and gender on carcass characteristics, physical properties, and chemical composition of breast and leg meat from native Mexican turkey raised under a system of extensive production. This information is essential for the sustainable use of this native poultry resource raised under a production model that represents a potential source in the supply of organic products to meet the demands of the current poultry market.

2.3. MATERIAL AND METHODS

2.3.1. Ethics statement

All the experimental procedures used in this study were approved by the Animal Welfare Committee (COBIAN) of the Colegio de Postgraduados. They complied with the standards for regulating the use and care of animals used for research (Approval number: COBIAN 002/21).

2.3.2. Birds and design of the experiment

The experiment was carried out in a poultry production unit in Sihochac, Champotón, Campeche, Mexico (19.49° 21' N, 90.58° 20' W; 24 m.a.s.l.). The area is characterized by a warm sub-humid climate with summer rainfall A(w), temperatures that oscillate between 18 and 30 °C, and total annual precipitation of 1600 mm (INEGI 2009).

The study period was from June to December 2021. The experimental material consisted of a total of 45 native turkeys, comprising of 36 males and 9 females, with an age of 12 weeks and a mean initial body weight of 2238.13 ± 485.45 g and 1825.00 ± 268.48 g, respectively. The birds were randomly collected in different poultry production units from rural communities in Champotón, Campeche, where they are traditionally raised under extensive production systems (Portillo-Salgado et al. 2018). All birds were dewormed and vaccinated upon arrival, and an adaptation period of 15 d was given. Animals had outdoor access during the day (7:00 to 18:00 h) and were kept at night in a poultry house with walls and floor made of concrete. The floor was covered with a 10 cm thick wood chip bed. Feeders and drinkers were installed.

The feeding of the birds consisted of domestic organic waste, such as tortillas, bread, and vegetables; tomato (*Solanum lycopersicum*), lettuce (*Lactuca sativa* L.), potato (*Solanum tuberosum*), cabbage (*Brassica oleracea*), and onion (*Allium cepa*). They also had access to fruits such as papaya (*Carica papaya*), avocado (*Persea americana*), sapote (*Manilkara zapota*), mamey (*Pouteria sapota*), mango (*Mangifera indica*), and carambola (*Averrhoa carambola*). The grazing areas were covered with the grass(es) *Cynodon dactylon*, *Urochloa brizantha cv. Marandu*, and *Pennisetum purpureum*. Additionally, the birds received a mixed diet that included: 60% corn, 20% wheat bran, and 20% soybean meal that contained 17% crude protein (CP) and 11.90 MJ of metabolizable energy (ME/kg) (NRC 1994). Feed and water were available *ad libitum*.

2.3.3. Slaughter and carcass characteristics

Fifteen turkeys (12 males and 3 females) were humanely killed at different slaughter ages (24, 32, and 40 weeks). Slaughter weight (SW) was recorded after 10 h of fasting with free access to clean water. The birds were humanely slaughtered by exsanguination following the Official Mexican Standards (NOM-008-ZOO-1994, NOM-009-ZOO-1994, and NOM-033-ZOO-1995) established for the humane slaughter of animals intended for meat production. Later, the carcasses were scalded in hot water (60-65 °C) for 2 min to facilitate manual plucking. Head, feet, internal organs (edible and non-edible), and abdominal fat were removed and weighed. Subsequently, the carcasses were weighed to obtain the hot carcass weight (HCW), and they were stored at +4 °C for 24 h to obtain the cold carcass weight (CCW). The percentages of hot and cold dressing were determined relative to the SW. Carcass dissection was performed as described by Hahn and Spindler (2002). Carcass parts weights and their percentages relative to the CCW were determined (Yamak et al. 2018).

2.3.4. Evaluation of meat physical properties

The physical properties of breast (*Pectoralis major*) and leg (thigh and drumstick) meat without skin were analyzed. Meat color was measured at 45 min and 24 h *post-mortem* using a colorimeter (Model CR-400, Konica Minolta®, Tokyo, Japan), recording the lightness (L*), redness (a*), and yellowness (b*) values recommended by the manufacturer (CIE 1986). Three replicate measurements were made of these variables and their average was recorded for each sample. The pH values were taken at the same sampling points using a portable pH meter (Model HI 99161, Hanna Instruments®, USA) equipped with a glass electrode, which was introduced to a depth of one cm in the cross-section of the muscle (Uhlířová et al. 2018). The pH meter was previously calibrated using two calibration buffers (pH 4.0 and 7.0).

The water-holding capacity (WHC) of the meat was determined by the filter paper press method (Grau and Hamm 1953) modified by Biesek et al. (2021). Ground meat samples (3 g) were placed between two sheets of filter paper (Whatman® Grade No. 1), and a load of 2 kg was applied for 5 min. The samples were then removed from the filter paper and weighed. WHC was calculated as the difference between the initial sample weight and the final weight and expressed as a percentage. Cooking loss (CL) was determined by placing ground meat samples (20 g) on absorbent gauze inside sealed plastic bags and cooking in a water bath at 85 °C for 10 min (Kokoszyński et al. 2020). Cooked meat samples were chilled at +4°C for 30 min and dried with paper towels. The CL was expressed as the ratio between the weight before and after cooking. Drip loss (DL) was determined by placing ground meat samples (20 g) in two sealable bags (one of the bags was perforated to allow dripping) and storing them at +4 °C for 24 h (Kokoszyński et al. 2020). The LD was expressed as the percentage of weight loss of the sample concerning its weight recorded before the refrigeration period. WHC, DL, and CL measurements were performed in triplicate and the average was calculated.

2.3.5. Chemical composition of meat

The chemical composition analysis of breast (*Pectoralis major*) and leg (thigh and drumstick) meat without skin was carried out according to the methods approved by the AOAC (1990). Dry matter (DM) content (%) was calculated by freeze-drying the sample using a freeze-dryer (LABCONCO®). Crude protein (CP) (%) was determined by combustion according to the Dumas method (AOAC 2005; method 990.03). The ether extract content (%) was determined with diethyl ether using the Soxtec method or immersion method (Thiex et al. 2003), approved by the AOAC (2000; method 991.36). Ash content (%) was determined by incineration at 600 °C for 2 h (AOAC 1995; method 942.05), whereas gross energy content by combustion using calorimetric equipment (IKA® C200 BASIC).

2.3.6. Statistical analysis

Data analysis was performed using the SAS ver. 9.4 statistical package (SAS Institute Inc., Cary, NC 2016). A Shapiro–Wilk test was performed to evaluate the normality of data. The results of the carcass characteristics, physical properties and chemical composition of meat were analyzed by a two-way ANOVA that considered slaughter age (A) and gender (G) as fixed effects (PROC GLM). A × G interaction was also analyzed. The model used was:

$Y_{ijk} = \mu + A_i + G_j + (A \times G)_{ij} + e_{ijk}$

where: Y_{ijk} = is the response variable (carcass characteristics, physical properties, and chemical composition of meat); μ = is the overall mean common to all observations; A_i = is the effect of the age (24, 32, and 40 weeks); G_j = is the effect of the gender (male and female); $(A \times G)_{ij}$ = is an interaction of age with gender; e_{ijk},= is the random error with mean 0 and variance σ2. Bonferroni's test assessed significant differences among means. Differences were considered significant at $p < .05$. For statistical analyses, the individual bird was the experimental unit.

2.4. RESULTS AND DISCUSSION

2.4.1. Slaughter weight and carcass characteristics

Until now, this is the first study to explore the effects of age at slaughter and gender on carcass characteristics and meat quality of native Mexican turkeys raised under extensive production system. The SW and carcass characteristics of native Mexican turkeys are presented in Table 1. SW, HCW, and CCW were affected by slaughter age ($p < .001$); however, the mean values of these traits were significantly different ($p < .05$) only in males, they were higher at 32 and 40 weeks of age. Old males had 33% more SW and 40% more HCW and CCW than young males. In females, SW, HCW and CCW increased with age, only 23%, 10% and 10%, respectively. Gender had a significant effect ($p < .001$) on SW, HC, and CCW, with higher values in males than females, except at 24 weeks, where HCW and CCW did not vary significantly ($p > .05$) between genders.

In the present study, poor weight gain was observed in males and females between 32 and 40 weeks of age. This result could be due to puberty, which in this poultry species is reached between 6 and 9 months of age (Portillo-Salgado et al. 2022). During puberty, male turkeys display aggressive behavior to demonstrate dominance within the flock, while female turkeys begin laying, which affects feed intake, reducing weight gain rates (Uicab-Sonda 2019). Similar findings were reported by Zawacka et al. (2017) in Green-legged Partridge chickens because during sexual maturity; cockerels show an aversive behavior to establish hierarchies within the flock, which negatively influences their productive parameters. In hens, the growth curve flattens when they start laying eggs. On the other hand, the differences between male and female turkeys regarding slaughter weight and hot and cold carcass weights could be attributed to the variation in growth patterns due to the effect of sexual dimorphism that characterizes the species (Pérez-Lara et al. 2013b).

The percentages of hot and cold dressing of the native turkeys ranged between 55.1 and 62.9% and 54.6 and 62.2%, respectively. Slaughter age had a significant effect ($p <$

.05) on these traits. The native turkeys at 32 and 40 weeks presented significantly higher percentages of hot and cold dressing than those of the native turkeys at 24 weeks. The percentages of dressing recorded in this study were lower than those reported by Juárez-Caratachea (2004) in male native turkeys of 26-week-old kept under confinement (78.9% and 75.9% for hot and cold dressing, respectively). These differences could be attributed to the higher slaughter weight recorded in that study (7.93 kg). In addition, some authors (Sarica et al. 2009; Yamak et al. 2018; Boz et al. 2019) reported that poultry raised under extensive conditions showed lower carcass yield than those raised under controlled conditions. These results could be related to physical activity and higher energy expenditure of birds raised outdoors, as well as to the inherently variable factors (temperature, photoperiod and light intensity) that characterize production systems with outdoor access (Sarica et al. 2009). The effect of slaughter age × gender interaction was significant for HCW and CCW, as well as for dressing percentages ($p < .05$, $p < .01$).

The effects of slaughter age and gender on the non-carcass components, internal organs, and abdominal fat weights of native Mexican turkeys are given in Table 2. Head and foot weights were significantly affected by the factors studied ($p < .01$, $p < .001$). Thirty-two and 40-week-old males had heavy heads. The weight of their feet was similar to that of 24-week-old males and 32-week-old females. These results indicate a more significant growth of the head and feet until week 32, after which the weight of these non-carcass components decreases with age. In the study by Musundire et al. (2018), the weight of the head and feet of chickens and guinea fowl decreased with age; in this case, the authors suggest that it is due to the allometric growth of the birds during maturity.

In the present study, the effect of slaughter age was significant ($p < .05$, $p < .001$) for liver, heart, spleen, intestines, and abdominal fat weights. The mean values of these variables increased with age, except for total intestinal weight, which did not vary significantly ($p > .05$) among age groups. In contrast, Sarica et al. (2009) showed that the weights and proportions of edible and inedible internal organs of Big-6 turkeys decreased with age. In poultry, internal organs develop at different rates depending on their functions (Murawska 2013). For example, the development of the heart, liver, gizzard and intestines are completed in the first stages of life, so the proportion of these organs with regards to body weight decreases with age (Yamak et al. 2016; Sarica et al. 2019). Gender had a significant effect ($p < .05$, $p < .001$) on the weight of internal organs and abdominal fat, except for the weight of the liver and intestines ($p > .05$). Male turkeys had heavier internal organs than females due to its larger size and high body weight. Abdominal fat weight was significantly higher ($p < .05$) in females of all ages. Male turkeys had less abdominal fat in their carcasses than female turkeys, and probably because of differences in metabolic rate and fat accumulation capabilities (Nikolova et al. 2007). Murawska (2013) found that female commercial turkeys develop belly fat at 8 weeks and males at 10 weeks of age, respectively; however, at the time of slaughter, male and female turkeys showed a fat proportion of 2.3 and 1.5%, respectively. Several authors (Sarica et al. 2009; Yamak et al. 2016; Uhlířová et al. 2018. Musundire et al. 2018; Boz et al. 2019) reported that the gender has a significant effect on abdominal fat in poultry. The slaughter age × gender interaction had a significant effect ($p < .001$) on abdominal fat weight.

Carcass parts weights and proportions of native Mexican turkeys are presented in Table 3. Slaughter age showed a significant effect ($p < .001$) on breast, drumstick, back, neck, and wing weights, with mean values increasing with age. Also, the back and neck proportions increased with age ($p < .01$, $p < .001$); on the contrary, the proportion of the thigh decreased. Musundire et al. (2018) reported that the decrease in weights and proportions of some carcass parts with increasing age is due to the allometric growth of poultry. In this study, gender had a significant effect ($p < .05$, $p < .001$) on carcass parts weights and proportions, except for thigh and wing proportions ($p > .05$). Males had significantly higher ($p < .05$) carcass parts weights than females. That might be due to the variation in the metabolic processes of each gender. Also, the growth rates of the tissue particles lead to changes in the distribution of the tissue components in the carcass parts (Bochno et al. 2005). The breast was the component with the highest weight and proportion in the carcass. In male turkeys of 24 and 40-week-old, breast weight increased from 615.0 to 1073.6 g, while its percentage increased from 27.5 to 34.1%. In female turkeys, breast weight increased from 493.3 to 546.7 g, but breast proportion decreased from 29.4 to 29.1%. Case et al. (2010) mention that the breast increment is due to an accelerated increase in the depth of the muscle. That might be due to the length and width of the breast that remains constant, increasing the bird's body size. The breast ratios observed in this study were higher than those reported by Safiyu et al. (2019) in local Nigerian turkeys (17.6 to 18.92%), but lower than those reported by Werner et al. (2008), Damaziak et al. (2013) and Murawska et al. (2015) in different lines of commercial turkeys (28.5 to 38.8%). Such differences are explained by the greater muscle deposition of commercial turkeys in the breast compared to local genotypes, such as native turkeys, which have not been subjected to selective breeding programs. The effect of the slaughter age × gender interaction was significant ($p < .05$, $p < .01$) for weight and proportion of the breast and the proportion of wings.

2.4.2. Meat physical quality properties

The effects of slaughter age and gender on color parameters and pH values of breast and leg meat from native Mexican turkeys are shown in Table 4. Slaughter age had a significant effect ($p < .05$, $p < .001$) on breast and leg meat color parameters taken at 45 min and 24 h *post-mortem*. Breast and leg meat from young turkeys had higher L* and b* values; however, breast and leg meat from old turkeys had significantly ($p < .05$) higher a* values than young turkeys. The dark red color of meat was probably due to the predominance of myoglobin. On the other hand, gender significantly ($p < .05$) affected the L* and b* values of breast meat recorded at 45 min and 24 h, respectively, with mean values higher in males than in females. The effect of slaughter age × gender interaction was significant ($p < .05$) for the b* value of breast meat recorded at 24 h *post-mortem*. In poultry, meat color is one of the most valued characteristics by consumers, as it is associated with freshness and suitability for specific culinary purposes (Kokoszyński et al. 2019). The results of the present study are in line with those reported in other poultry (Yamak et al. 2016; Musundire et al. 2017), which reported that the meat presents a greater redness with increasing age while the level of lightness decreases, resulting in a darker color of the meat. The poultry meat color was influenced by meat pH, myoglobin content, and the redox state of the myoglobin, that is related to species, animal age, and muscle type (Baéza et al. 2021; Panpipat et al. 2022).

Meanwhile, the yellowness color of the meat is associated with the total lipid content and with the pigments that birds obtain through forage consumption (Musundire et al. 2017). Galvez et al. (2018) found that the a* value of breast and thigh meat from Hybrid

Optima turkeys was significantly affected by gender, with higher values in males than in females. Damaziak et al. (2013) found higher values of the a* parameter and lower values of the b* and L* parameters in the breast and leg meat of male Big-6 turkeys compared to females.

Another trait of importance to consumers and meat processors is pH, as it determines the shelf life of meat. The decreased pH causes less bacterial growth in the meat; therefore, the shelf life of meats with a high pH is shorter (Boz et al. 2019). In the current study, slaughter age had a significant effect ($p < .001$) on breast and leg meat pH values recorded at 24 h *post-mortem*, which decreased with age (Table 4). Likewise, slaughter age influenced significantly ($p < .001$) the pH value of leg meat taken at 45 min *post-mortem*, with higher mean values for old turkeys. In this regard, the glycogen content in muscle is predominantly affected by the proportional changes in muscle fibers where the patterns of muscle metabolism may differ. For instance, the breast and leg of older birds tended to have increased glycogen storage, thereby reducing the *post-mortem* pH (Panpipat et al. 2022). The effect of gender was significant ($p < .05$) only for the pH value of the breast recorded at 24 h *post-mortem*. In general, the pH values obtained in the present study were not in the intervals which would cause an adverse effect such as pale, soft, exudative meat (Onk et al. 2019). Slaughter age × gender interaction was not significant ($p > .05$) for pH values. In the study by Sarica et al. (2011), the pH values of breast and thigh meat from Bronze and Hybrid turkeys, and their crosses, were affected by slaughter age, with old turkeys having a lower pH than young turkeys. In another study, Gálvez et al. (2018) found that gender did not significantly influence the pH values of commercial turkeys' breast and thigh muscles. The cited authors also reported that breast muscle had lower pH values than thigh muscle. Similarly, in our study, the pH in breast meat was lower than in leg meat; this is because, usually, breast meat consists of type IIB fibers which has high glycogen content. This characteristic of breast meat is related with higher lactic acid accumulation *post-mortem* than thigh meat (Panpipat et al. 2022).

Water-holding capacity (WHC) is an essential technological attribute of meat quality that determines its ability to retain juice when applying external forces, such as cutting, heating, grinding or pressing, and can be assessed through water loss, cooking or dripping (Sarica et al. 2011). If WHC is low, more water could be released during raw meat storage, processing and storing after meat processing resulting in weight losses in the final product as well as in economic losses (Onk et al. 2019). The effects of slaughter age and gender on WHC, CL, and DL of breast and leg meat from native Mexican turkeys are given in Table 5. Slaughter age had a significant effect ($p < .05$, $p < .001$) on WHC, CL, and DL of breast meat, as well as on WHC and DL of leg meat, with mean values that increased with age. In contrast, Sarica et al. (2011) reported that thigh meat from commercial turkeys of 21-week-old had a lower WHC than thigh meat from turkeys of 17-week-old (40% vs. 47%). In the same experiment, no significant effect of slaughter age was observed on the WHC of breast meat. Higher WHC values might be attributed to slaughter age influence as well as higher pH values. Also, muscle proteins might be denatured at higher pH values and so WHC is decreased (Onk et al. 2019). In our study, the effect of gender was significant ($p < .05$) for CL in breast meat, with males showing significantly higher values than females. Damaziak et al. (2013) reported that breast and leg meat from hybrid and local male turkeys had higher WHC and CL values than meat from female turkeys. For their part, Sarica et al. (2011) reported that the breast meat of female commercial turkeys had a higher WHC than that of males. These authors also observed a significant effect of the genotype × gender interaction on the WHC of thigh meat. Differences in cooking losses with respect to slaughter age and gender might be attributed to different proteins solubility (especially collagen) and to different fat content. Cooking temperature and ultimate pH could also play a role (Uhlířová et al. 2018). The variation in the experimental methodologies used in each study could also influence the results obtained. There was no effect of slaughter age × gender interaction on WHC, CL, and DL of breast and leg meat.

2.4.3. Chemical composition of meat

The effects of slaughter age and gender on the chemical composition of the breast and leg meat of native Mexican turkeys are shown in Table 6. The slaughter age had a significant effect ($p < .05$) on the content of ether extract of the breast meat, as well as the contents of dry matter, crude protein, ether extract, ash, and energy of the leg meat ($p < .001$). Young turkeys had a higher percentage of ether extract (2.4-2.2%) in the breast meat; in contrast, old turkeys had high percentages of dry matter (28.9-25.1%), crude protein (20.6-20.2%), ether extract (6.0-2.3%) and energy (1692.5-1231.3 cal g^{-1}), but low percentages of ash content (1.1-0.9%) in leg meat. On the other hand, the dry matter, crude protein, and energy content of breast meat and the dry matter, ether extract and energy content of leg meat were significantly ($p < .05$, $p < .001$) affected by gender (Table 6). The breast meat of the females had higher contents of dry matter (28.0-26.8% vs. 26.5-25.7%), crude protein (23.2-22.9% vs. 22.9-21.5%), and energy (1406.9-1314.4 cal g^{-1} vs. 1322.6 -1241.6 cal g^{-1}) than those observed in males. Likewise, the leg meat of females exhibited higher values of dry matter content (28.9-25.6% vs 25.1-23.9%), ether extract (6.0-2.5% vs 2.3-1.2%) and energy (1692.5-1196.6 cal g^{-1} vs 1231.3-1169.6 cal g^{-1}), than that of leg meat from males. Similar results were reported by López et al. (2011), who found that the breast, thigh, and leg meat of female native turkeys were characterized by higher contents of dry matter (25.5-21.9%) and crude protein (22.7-18.7%). On the other hand, the breast, thigh, and leg meat of male turkeys had a higher ash content (0.65-0.64%). In Bronze and Hybrid turkeys, and their crosses, Sarica et al. (2011) reported that slaughter age affected breast meat's protein and fat contents, as well as the dry matter, protein, and ash contents of thigh meat. These authors also found that the gender of the birds affected the dry matter, protein and fat content of breast meat and the protein and fat content of thigh meat. However, Galvez et al. (2018) found no significant effect of gender on breast and thigh muscle water, protein, and fat content in commercial hybrid turkeys. Another study (Damaziak et al. 2013) found that breast and leg meat from Big-6 male turkeys had higher water, protein, and fat contents than in females. This study also reported that breast meat from a local strain of male turkeys had higher protein content but lower water and fat contents, while leg meat had lower water content and higher protein and fat contents than females; fat content compared to that of their female counterparts. The differences observed regarding the chemical composition of the meat between Mexican native turkeys and turkeys from improved lines may be due to the genotype and the type of feeding, which are factors that affect the quality of the meat (López et al. 2011). For example, the lower fat content in native turkeys might be caused by the lipid metabolism in indigenous poultry occurring to a greater extent than that in commercial turkeys. Slaughter age × gender interaction was significant ($p > .001$) on leg muscle's dry matter, ether extract, and energy contents.

2.5. CONCLUSIONS

In conclusion, native Mexican turkeys raised traditionally under extensive conditions can achieve relatively high carcass weights and yields, particularly in adult males, making them preferable for meat production. Although females present acceptable carcass yields and meat of better nutritional quality in terms of crude protein and energy, they tend to deposit higher fat content in the carcass and the meat, even more so in the leg muscle. It is recommended that native male turkeys be slaughtered at 40 weeks of age for better carcass yields and more edible, high nutritional value meat. In the future, it is essential to manage genetic improvement programs for the native turkeys through genetic selection oriented towards the betterment of carcass and meat quality traits to take advantage of its production potential and guarantee better quality meat products.

2.6. ACKNOWLEDGMENTS

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Table 1. Effects of slaughter age and gender on slaughter weight and carcass characteristics of native Mexican turkeys.

Slaughter age (weeks)	Gender	Slaughter weight (g)	Hot carcass weight (g)	Cold carcass weight (g)	Hot dressing percentage (%)	Cold dressing percentage (%)
24	♂	3802.1[b]	2245.4[b]	2225.8[b]	58.9[ab]	58.5[ab]
	♀	2816.7[c]	1683.4[b]	1675.0[b]	59.8[ab]	59.5[ab]
32	♂	4806.7[a]	2957.5[a]	2900.0[a]	61.4[a]	60.2[a]
	♀	3401.7b[c]	2141.7[b]	2120.0[b]	62.9[a]	62.2[a]
40	♂	5064.1[a]	3174.1[a]	3150.4[a]	62.6[a]	62.1[a]
	♀	3440.0[bc]	1893.4[b]	1878.3[b]	55.1[b]	54.6[b]
RMSE		342.12	281.19	274.71	2.41	2.37
			Effects			
Age		<0.001	<0.001	<0.001	0.011	0.031
Gender		<0.001	<0.001	<0.001	0.059	0.101
Age × gender		0.131	0.026	0.021	0.000	0.000

RMSE: root mean square error.

[abc] Means within columns with no common superscript letter differ significantly ($p < 0.05$).

Table 2. Effects of slaughter age and gender on non-carcass components, internal organs and abdominal fat weights of native Mexican turkeys.

Slaughter age (weeks)	Gender	Head weight (g)	Feet weight (g)	Gizzard weight (g)	Liver weight (g)	Heart weight (g)	Lungs weight (g)	Kidney weight (g)	Spleen weight (g)	Total intestinal weight (g)	Abdominal fat weight (g)
24	♂	118.1[b]	149.1[a]	95.4[b]	64.4[bc]	15.8[c]	23.3[a]	16.5[a]	4.9[ab]	202.5[a]	6.9[c]
	♀	73.6[c]	79.7[b]	86.1[b]	53.7[c]	11.4[d]	17.6[a]	13.2[a]	3.1[b]	206.6[a]	20.9[bc]
32	♂	144.9[a]	158.7[a]	104.5[ab]	77.9[a]	20.0[b]	27.4[a]	18.4[a]	6.8[a]	185.3[a]	7.7[c]
	♀	87.9[c]	101.6[a]	81.0[b]	70.8[abc]	14.2[cd]	15.6[a]	13.3[a]	4.9[ab]	136.6[a]	31.3[b]
40	♂	140.0[a]	160.4[a]	112.1[a]	77.1[ab]	23.5[a]	18.9[a]	13.9[a]	5.4[ab]	164.1[a]	27.7[b]
	♀	83.3[c]	91.6[b]	81.7[b]	72.6[abc]	15.1[cd]	16.7[a]	13.2[a]	4.4[ab]	150.0[a]	81.4[a]
RMSE		14.04	10.86	11.85	10.36	1.91	5.87	3.10	1.44	28.08	8.41
					Effects						
Age		0.007	0.008	0.518	0.002	<0.001	0.353	0.298	0.024	0.000	<0.001
Gender		<0.001	<0.001	<0.001	0.062	<0.001	0.003	0.013	0.006	0.070	<0.001
Age × gender		0.542	0.386	0.155	0.807	0.077	0.223	0.318	0.769	0.125	<0.001

RMSE: root mean square error.

[abc] Means within columns with no common superscript letter differ significantly ($p < 0.05$).

Table 3. Effects of slaughter age and gender on carcass part weights and ratios of native Mexican turkeys.

Slaughter age (weeks)	Gender	Breast weight (g)	Breast ratio (%)	Thigh weight (g)	Thigh ratio (%)	Drumstick weight (g)	Drumstick ratio (%)	Back weight (g)	Back ratio (%)	Neck weight (g)	Neck ratio (%)	Wing weight (g)	Wing ratio (%)
24	♂	615.0^{b}	27.5^{b}	449.6^{b}	20.2^{a}	248.3^{c}	18.0^{a}	232.1^{c}	10.4^{c}	210.0^{bc}	9.4^{ab}	332.9^{b}	15.0^{a}
	♀	493.3^{b}	29.4^{ab}	335.0^{c}	20.1^{a}	400.0^{b}	14.8^{b}	190.0^{c}	11.2^{c}	116.6^{c}	7.0^{ab}	225.0^{c}	13.4^{b}
32	♂	945.8^{a}	32.3^{a}	479.6^{ab}	16.6^{b}	470.0^{a}	16.3^{b}	397.5^{b}	13.7^{c}	280.0^{ab}	9.6^{ab}	400.8^{a}	13.9^{ab}
	♀	600.0^{b}	28.2^{ab}	323.3^{c}	15.2^{b}	305.0^{c}	14.4^{b}	355.0^{b}	16.8^{ab}	131.6^{c}	6.3^{b}	293.3^{bc}	13.9^{ab}
40	♂	1073.6^{a}	34.1^{a}	516.4^{a}	16.3^{b}	506.8^{a}	16.1^{b}	500.9^{a}	15.9^{b}	346.8^{a}	11.1^{a}	397.3^{a}	12.6^{c}
	♀	546.7^{b}	29.1^{ab}	313.3^{c}	16.7^{b}	283.3^{c}	15.1^{b}	355.0^{b}	18.9^{a}	208.3^{bc}	11.0^{ab}	278.3^{bc}	14.8^{ab}
RMSE		144.28	3.05	41.57	1.21	40.73	1.04	54.28	1.42	60.96	2.12	27.65	1.08
Effects													
Age		0.000	0.094	0.499	<0.001	0.000	0.073	<0.001	<0.001	0.000	0.004	<0.001	0.601
Gender		<0.001	0.040	<0.001	0.390	<0.001	<0.001	0.000	0.000	<0.001	0.020	<0.001	0.672
Age × gender		0.014	0.037	0.080	0.278	0.138	0.101	0.068	0.168	0.578	0.233	0.878	0.002

RMSE: root mean square error.

[abc] Means within columns with no common superscript letter differ significantly ($p < 0.05$).

Table 4. Effects of slaughter age and gender on pH values and colour parameters in breast and leg meat measured at 45 min and 24 h *post-mortem*.

Slaughter age (weeks)	Gender	Breast meat								Leg meat							
		pH_{45min}	$Colour_{45min}$			pH_{24h}	$Colour_{24h}$			pH_{45min}	$Colour_{45min}$			pH_{24h}	$Colour_{24h}$		
			L*	a*	b*		L*	a*	b*		L*	a*	b*		L*	a*	b*
24	♂	5.8^{a}	47.6^{ab}	1.1^{b}	3.7^{a}	5.9^{a}	46.2^{ab}	1.5^{a}	3.2^{a}	5.8^{b}	44.6^{abc}	2.3^{b}	4.3^{a}	5.9^{a}	45.9^{a}	3.2^{c}	4.9^{a}
	♀	5.8^{a}	45.9^{bc}	1.2^{ab}	2.1^{ab}	5.9^{a}	45.1^{ab}	1.1^{a}	1.5^{b}	5.8^{b}	45.3^{abc}	2.2^{b}	3.8^{a}	5.8^{ab}	45.1^{ab}	2.2^{c}	4.8^{a}
32	♂	5.7^{a}	54.5^{a}	2.2^{ab}	1.1^{b}	5.4^{b}	49.5^{a}	2.6^{a}	1.1^{b}	5.9^{b}	49.1^{a}	4.5^{b}	2.3^{a}	5.6^{b}	45.0^{ab}	6.4^{b}	1.8^{b}
	♀	5.6^{a}	47.3^{abc}	2.2^{ab}	0.4^{b}	5.6^{b}	46.2^{ab}	2.9^{a}	1.3^{b}	6.1^{ab}	47.5^{ab}	4.6^{b}	1.6^{a}	5.7^{b}	39.9^{abc}	8.7^{ab}	3.9^{ab}
40	♂	5.8^{a}	40.2^{c}	2.6^{a}	2.2^{ab}	5.6^{b}	40.7^{b}	1.4^{a}	0.9^{b}	6.3^{a}	36.7^{c}	9.3^{a}	3.4^{a}	5.6^{b}	34.7^{c}	8.8^{a}	1.4^{b}
	♀	5.8^{a}	38.8^{c}	2.7^{a}	2.7^{ab}	5.5^{b}	41.7^{b}	1.1^{a}	0.7^{b}	6.2^{ab}	37.6^{bc}	9.4^{a}	4.6^{a}	5.6^{b}	36.8^{bc}	9.9^{a}	2.7^{ab}
RMSE		0.178	4.152	0.755	1.142	0.102	3.613	0.881	0.756	0.153	4.929	1.774	1.754	0.119	4.008	1.632	1.392
Effects																	
Age		0.124	<0.001	0.000	0.000	<0.001	0.001	0.000	0.000	<0.001	<0.001	<0.001	0.017	0.000	<0.001	<0.001	0.000
Gender		0.736	0.034	0.712	0.150	0.016	0.413	0.702	0.040	0.605	0.992	0.917	0.985	0.969	0.403	0.193	0.051
Age × gender		0.594	0.234	0.989	0.150	0.189	0.449	0.695	0.018	0.157	0.820	0.984	0.455	0.980	0.162	0.106	0.233

RMSE: root mean square error.

[abc] Means within columns with no common superscript letter differ significantly ($p < 0.05$).

Table 5. Effects of slaughter age and gender on water-holding capacity, cooking loss and drip loss in breast and leg meat.

Slaughter age (weeks)	Gender	Breast meat			Leg meat		
		Water-holding capacity (%)	Cooking loss (%)	Drip loss (%)	Water-holding capacity (%)	Cooking loss (%)	Drip loss (%)
24	♂	47.5^{b}	21.1^{b}	1.6^{b}	33.3^{bc}	23.6^{a}	2.3^{b}
	♀	43.3^{b}	19.1^{b}	2.3^{ab}	20.0^{c}	26.5^{a}	3.3^{ab}
32	♂	76.0^{a}	30.4^{a}	4.2^{a}	50.0^{a}	32.2^{a}	3.4^{ab}
	♀	63.3^{ab}	26.3^{ab}	4.0^{a}	46.6^{ab}	26.3^{a}	4.6^{a}
40	♂	70.0^{ab}	24.8^{ab}	3.8^{a}	50.0^{a}	25.2^{a}	4.2^{a}
	♀	73.3^{ab}	19.6^{b}	3.0^{ab}	46.6^{ab}	22.3^{a}	3.6^{ab}
RMSE		13.183	3.704	1.011	9.380	5.353	1.053
Effects							
Age		0.000	0.000	0.000	<0.001	0.132	0.041
Gender		0.408	0.017	0.751	0.092	0.377	0.178
Age × gender		0.510	0.666	0.328	0.447	0.245	0.208

RMSE: root mean square error.

[abc] Means within columns with no common superscript letter differ significantly ($p < 0.05$).

Table 6. Effects of slaughter age and gender on chemical composition of breast and leg meat.

Slaughter age (weeks)	Gender	Breast meat					Leg meat				
		Dry Matter (%)	Crude protein (%)	Ether extract (%)	Crude ash (%)	Energy content (cal/g)	Dry Matter (%)	Crude protein (%)	Ether extract (%)	Crude ash (%)	Energy content (cal/g)
24	♂	26.5^{ba}	21.5^{a}	2.4^{a}	1.0^{a}	1322.6^{a}	24.9^{cb}	19.5^{b}	2.3^{b}	1.1^{a}	1197.7^{b}
	♀	28.0^{a}	23.0^{a}	2.2^{a}	1.0^{a}	1406.9^{a}	25.6^{cb}	19.8^{ba}	2.5^{b}	1.1^{a}	1196.6^{b}
32	♂	25.7^{b}	22.9^{a}	0.56^{b}	1.1^{a}	1241.6^{a}	23.9^{c}	20.6^{ba}	1.2^{b}	1.0^{ba}	1169.6^{b}
	♀	27.2^{ba}	22.9^{a}	2.1b^{a}	1.0^{a}	1346.7^{a}	25.8^{b}	21.3^{a}	2.5^{b}	1.0^{ba}	1319.1^{b}
40	♂	26.3^{ba}	22.7^{a}	1.5b^{a}	1.1^{a}	1309.0^{a}	25.1^{cb}	20.2^{ba}	2.3^{b}	0.9^{b}	1231.3^{b}
	♀	26.8^{ba}	23.2^{a}	1.6^{ba}	1.1^{a}	1314.4^{a}	28.9^{a}	20.6^{ba}	6.0^{a}	1.0^{ba}	1692.5^{a}
RMSE		0.780	0.733	0.675	0.067	67.703	0.726	0.622	0.550	0.050	67.666
Effects											
Age		0.135	0.129	0.025	0.292	0.138	<0.001	0.002	<0.001	0.001	<0.001
Gender		0.001	0.028	0.090	0.944	0.035	<0.001	0.111	<0.001	0.050	<0.001
Age × gender		0.363	0.163	0.054	0.309	0.344	0.001	0.860	<0.001	0.653	<0.001

RMSE: root mean square error.

[abc] Means within columns with no common superscript letter differ significantly ($p < 0.05$)

CHAPTER III. PREDICTIVE EQUATIONS OF CARCASS CHARACTERISTICS AND PRIMAL CUT WEIGHTS OF NATIVE MEXICAN GUAJOLOTES USING BODY MEASUREMENTS

3.1 ABSTRACT

This study was conducted to develop predictive equations for carcass characteristics and primal cut weights of native Mexican guajolotes using body measurements (BM). For this study, a total of 36 clinically-healthy male guajolotes, aged 6 to 10 months, and mean slaughter body weight (SBW) of 4543.14 ± 656.60 g, were used. The following BMs were recorded 24 h before slaughter: thoracic perimeter (TP), body circumference (BC), body length (BL), wing length (WL), keel length (KL), shank length (SL) and shank diameter (SD). After slaughter, hot carcass weight (HCW), cold carcass weight (CCW), hot dressing percentage (HDP), cold dressing percentage (CDP), organs and viscera weight (VIS) and abdominal fat weight (AFW) were recorded. The carcasses were dissected into five primal cut (breast, thigh, drumstick, back and wing). The SBW and BMs showed moderate to high positive correlations ($p < 0.01$; $0.34 \leq r < 0.97$) with carcass characteristics and primal cut weights. In the equations generated to predict HCW, CCW, HDP, CDP, VIS and AFW, the R^2 ranged from 0.40 to 0.96, and the predictor variables were SBW, KL, BC, WL and SL. Regarding the equations developed to predict the primal cut weights, R^2 ranged from 0.58 to 0.91. In these models, SBW, BC, SD, WL and KL explained most of the observed variation. Our results indicated that SBW together with the BMs could accurately and precisely be used as a practical tool for predicting carcass characteristics and primal cut weights of native Mexican guajolotes.

Keywords: Body measurements, carcass characteristics, mathematical equations, native guajolotes, primal cut weights.

3.2. INTRODUCTION

In today's poultry production, carcass composition is an economically important factor due to the increasing demand for specific cuts of meat (Faridi et al., 2012). The weights and proportions of meat in the carcass, which are quantified by traits such as the retail product, are indicators of the quality of the carcasses based on the quantity of product to be marketed (Silva et al., 2012). Therefore, the emphasis in meat poultry production is on the quality and yield of the main parts of the carcass (Faridi et al., 2012).

The most accurate standard method for determining carcass tissue composition in meat species is physical separation of the tissues or by dissection (Lorenzo et al., 2018). However, it is an expensive, laborious procedure, and requires a lot of time and specialized labor (Faridi et al., 2012). In addition, it promotes a significant waste of meat (Lin et al., 2018; Batista et al., 2021). Therefore, some indirect methods have been proposed to estimate the yield and tissue composition of the carcass of farm animals, such as digital image analysis (Bozkurt et al., 2008; Lorenzo et al., 2018; Batista et al., 2021), X-ray computed tomography (Navajas et al., 2010), and real-time ultrasonography (Melo et al., 2003; Teixeira et al., 2008). Although these techniques are promising for the subjective evaluation of carcass composition, their use is limited to laboratory conditions and the required equipment is expensive, which represents a challenge for developing countries. On the other hand, several authors (Bochno et al., 2000; Kleczek et al., 2006; Yakubu et al., 2009; Tyasi et al., 2018; Costa et al., 2020; Gomes et al., 2021) showed that the development of regression equations using some body measurements represents an indirect, accurate and non-invasive method to predict carcass components. Additionally, this technique allows information to be collected from animals in vivo, without the need for sacrifice, so it can be useful for selective breeding and genetic improvement (Banerjee, 2011; Erensoy et al., 2020).

The Guajolote is a poultry native to Mexico that has an acceptable productive yield, high rusticity and resistance to diseases, as well as a good capacity for adaptation that allows it to thrive in various adverse climatic conditions (Portillo-Salgado et al., 2022). Male guajolotes are characterized by their ability to produce meat as they have good muscle development and produce little fat in the carcass (Juárez-Caratachea, 2004). Instead, female guajolotes are used only for the incubation of eggs, their own or those of Creole hens, due to their excellent maternal ability in protecting their chicks in outdoor conditions (Portillo-Salgado et al., 2020). The Guajolote production is an important poultry activity in suburban and rural communities because it contributes to the nutritional and economic sustenance of families. The birds are raised in semi-technified, extensive or backyard conditions (Portillo-Salgado et al., 2022). The consumption of Guajolote meat has a long tradition in Mexico and other Central American countries. Although this meat is mostly consumed during the december season, throughout the year it is used in the preparation of typical regional dishes that are offered in social and family festivities because it has a desirable flavor and aroma (Ramírez-Rivera et al., 2012). In native guajolotes, the most important primal carcass cuts are the breast, drumsticks and thighs, and represent approximately 30% of total muscle mass of the bird (Juárez-Caratachea, 2004). However, other components of the carcass are also used, such as the back and wings.

Therefore, the hypothesis of this study was that body measurements taken *in vivo* could be used to predict carcass characteristics and primal cut weights in native Mexican guajolotes. Since there is little scientific literature on the use of body measurements to estimate carcass composition of native Mexican guajolotes, the objective of this study was to develop predictive equations for carcass characteristics and primal cut weights using body measurements of native Mexican guajolotes.

3.3. MATERIALS AND METHODS

3.3.1. Experimental site and animals

The animals included in this study were handled in accordance with the guidelines and ethical standards for the use and care of animals intended for research established by the Animal Welfare Committee (Comité de Bienestar Animal (COBIAN)) of the Colegio de Postgraduados (Approval number: 002/21). The experiment was carried out in an experimental poultry unit (19° 29' N, 90° 32' W; 24 masl), located in the locality of Sihochac, Campeche, Mexico.

In the experiment, a total of 36 clinically-healthy male guajolotes, aged 6 to 10 months, and mean slaughter body weight (SBW) of 4543.14 ± 656.60 g, were used. Birds were kept under traditional extensive conditions (Portillo-Salgado et al., 2018). They had access to the outside during the day (7:00 to 18:00 h), while at night they were confined in a roofed pen, with concrete walls and floor, the latter was covered with 10 cm thick wood chip bed. Feeders and drinkers were provided in the pen. The feed, provided in mash form, consisted of a mixed diet that included: 60% corn, 20% wheat bran, and 20% soybean meal, and had 17% crude protein (CP) and 11.90 MJ metabolizable energy (ME/kg) (NRC, 1994). The grazing areas were covered with the grasses *Cynodon dactylon*, *Urochloa brizantha* cv. Marandu, and *Pennisetum purpureum*. Feed and water were available ad libitum.

3.3.2. Body measurements

Body measurements (BM) were taken *in vivo* on each guajolote 24 h before slaughter using a plastic measuring tape graduated in cm and a millimeter digital vernier (TRUPER®). Birds were placed upright on a flat surface. BMs were taken as previously described by Cigarroa-Vázquez et al. (2013), these were: thoracic perimeter (TP), body circumference (BC), body length (BL), wing length (WL), keel length (KL), shank length (SL) and shank diameter (SD). All measurements were made by the same person for consistency purposes and to avoid undesirable measurement errors.

3.3.3. Slaughter of animals

All birds were sacrificed on the same day after a 12 h fasting period, during which they received only clean water. The slaughter was carried out in accordance with the Official Mexican Standards (NOM-008-ZOO-1994, NOM-009-ZOO-1994 and NOM-033-ZOO-1995) established for the humane slaughter of animals intended for meat production. Before slaughter, the body weight (SBW) of the birds was recorded using a precision digital scale (±1 g). The birds were humanely killed by exsanguination, and the carcasses were then scalded in hot water (60-65 °C) for 2 min to facilitate manual plucking. The head and legs were cut off, and the viscera and internal organs (VIS), comprising blood, liver, empty gizzard, heart, kidneys, lungs, intestines, gallbladder, and spleen, were collected and weighed. Likewise, the weight of abdominal fat (AFW) attached to the carcass was recorded. Subsequently, the carcasses were weighed to obtain the hot carcass weight (HCW), and they were stored at +4 °C for 24 h to obtain the cold carcass weight (CCW). The percentages (%) of hot (HDP) and cold (CDP) dressing were determined in relation to the SBW. Carcass dissection was performed as described by

Hahn & Spindler (2002). The primal cuts selected were the breast, thigh, drumstick, back and wing.

3.3.4. Statistical analysis

Initially, the descriptive statistics of the variables were obtained using the MEANS procedure of the SAS statistical program, ver. 9.4 (SAS Inst. Inc., Cary, NC). For exploratory analysis of relationships between dependent (carcass characteristics and primal cut weights) independent variables (body measurements), Pearson correlation coefficients (r) were obtained using the CORR procedure of SAS. Simple and multiple linear regressions were developed to estimate functional relationships between variables using the REG procedure of SAS. The STEPWISE and Mallow's Cp options were used in the REG procedure to determine the significant variables ($P < 0.05$) that were included in the statistical models. The STEPWISE process added and removed explanatory variables in the models to strike a balance between model simplicity (parsimony) and predictive performance. The goodness of fit of the models was determined using the determination coefficient (R^2), root mean square error (RMSE), Akaikés Information Criterion (AIC) and Bayesian Information Criterion (BIC). Models with the lowest RMSE, AIC and BIC, and highest R^2 were defined as the best models (Rivera-Alegría et al., 2022).

3.4. RESULTS AND DISCUSSION

To date, this is the first study conducted to evaluate the use of body measurements as an indirect, practical, and non-invasive method to predict carcass characteristics and primal cut weights of native Mexican guajolotes. The mathematical models developed in this type of study, in addition to estimating the tissue composition of the carcass in poultry of different breeds and sexes, also contribute to establishing the optimal market age (Faridi et al., 2012).

The results of the descriptive analysis of the variables are shown in Table 1. The mean SBW was 4543.14 ± 656.60 g, with a CV of 14.45% among birds. The observed variability is related to the susceptibility of this variable to external factors; however, a diversified database is desirable for better accuracy (Gomes et al., 2021). Regarding HCW and

CCW, they showed mean values of 2781.43 ± 496.91 g and 2747.57 ± 487.51 g, respectively, both with a CV > 17%. Based on these results, the HDP and CDP were estimated, which in turn had values of around 60%, with a CV of 4.70% for both parameters. Previously, Juárez-Caratachea (2004) reported higher percentages of hot and cold dressing (78.94 and 75.91%, respectively), which were related to the higher slaughter body weight of the native guajolotes used in that study (7.93 ± 0.69 kg). In poultry production, the dressing percentage is an important criterion for the evaluation of slaughter value of the carcass (Mueller et al., 2018; Nematbakhsh et al., 2021). Overall, carcass characteristics showed moderate variability (< 25%), except AFW which had a CV of 92.11% among birds. In this regard, Nematbakhsh et al. (2021) found that variation in body fat content in broilers can be explained by breed, slaughter age and maturity stage of the birds. On the other hand, the primal cut weights extracted from the carcass showed moderate variability (10.59-33.39%). The greatest variation was observed in back and breast weights, which showed a CV of 33.39% and 28.30%, respectively. This variability may be associated with the lack of genetic improvement practices due to the fact that these native poultry have remained unselected over the years since they are raised in extensive or backyard conditions (Juárez-Caratachea et al., 2019). However, Juárez-Caratachea (2004) suggests that variability among native guajolotes with respect to a particular trait represents an advantage in the systematic selection of the best individuals for the purpose of improving this characteristic. Finally, the BMs showed low variability (4.20-10.15%), which is consistent with that reported in other studies (Ríos et al., 2016; Portillo-Salgado et al., 2020), which reported moderate or low morphological variability in the populations of native guajolotes reared in rural regions of Mexico.

The results of the Pearson correlation coefficients (r) are shown in Table 2. The SBW and BMs showed moderate to high positive correlations ($p < 0.01$; $0.34 \leq r < 0.97$) with carcass characteristics and primal cut weights, except for WL, which had a positive correlation ($p < 0.01$) only with BRW ($r = 0.35$). However, SL presented a negative correlation ($p < 0.01$) with AFW ($r = -0.56$) and BAW ($r = -0.33$). This means that birds with shorter shanks have a greater weight of abdominal fat and back, and vice versa. Juárez-Caratachea (2004) reported, in native male guajolotes, that SBW presented moderate to high positive correlations ($0.38 \leq r < 0.90$) with carcass characteristics and breast, leg and thigh weights. The strong relationship between body weight and the breast and thigh weights is due to the fact that in these parts of the carcass there is greater deposition of muscle tissue (Ogah, 2011). Other studies in chickens (Melo et al., 2003; Yang et al., 2006; Mendeş & Akkartal, 2009; Yakubu et al., 2009; Erensoy et al., 2020), ducks (Bochno et al., 2000; Kleczek et al., 2006; Kokoszyňski et al., 2019), and guinea fowl (Ogah, 2011) also reported high and significant correlations between body weight and body measurements with carcass characteristics and primal cut weights. This suggests that body weight and body measurements could be used as reliable predictors of carcass composition.

The regression equations developed to predict carcass characteristics and primal cut weights are presented in Table 3. For HCW, two equations explained ($p < 0.001$) between 95 [Eq.1] and 96% [Eq. 2] of the observed variation. Of these, Equation [2], which included SBW and KL as predictors, was the best model to predict HCW because it had lower values of RMSE (98.84), AIC (324.41), and BIC (326.95). Instead, for CCW, the SBW explained ($p < 0.001$) by itself a 95% of the variation observed in the model [Eq. 3], with RMSE, AIC and BIC values of 104.40, 327.32 and 329.55, respectively. It was observed that the SBW contributed a high percentage of the variation for HCW and CCW. These findings are consistent with previous studies in poultry (Bochno et al., 2000; Raji et al., 2010; Banerjee, 2011), which reported that body weight accounted for a high proportion of the variation in carcass weight. However, the inclusion of body measurements in the models, such as chest circumference, breast width, body length, wing length and keel length, improves their accuracy (Yakubu et al., 2009; Ogah, 2011; Behiry et al., 2019). In the same way, the models to predict HDP [Eqs. 4 and 5] were fitted using the SBW and KL as predictor variables. However, Equation [5], compared to Equation [4], had the best goodness of fit due to its lower values of RMSE (2.09 vs 2.14), AIC (54.75 vs 55.28) and BIC (57.39 vs 57.32), as well as the highest prediction capacity ($R^2 = 0.49$). For the prediction of CDP, a single Equation [6] was fitted, with $R^2 = 0.40$; in this case, only SBW was included as a predictor. The equations developed to predict VIS [7-10] showed an R^2 that ranged between 0.62 and 0.79. In these models, SBW, BC, WL and KL were included as predictor variables, with Equation [10] having the best goodness of fit (RMSE = 60.96, AIC = 292.33 and BIC = 295.94), and explained 79% of the variation observed in the model. Regarding the prediction of AFW, the variables that were included in the models [Eqs. 11 and 12] were SBW and SL, providing an increase in R^2 from 0.44 to 0.61. However, Equation [12] which included both variables presented lower RMSE (7.50), AIC (143.98) and BIC (146.52) values. In broilers, Melo et al. (2003) reported that abdominal fat weight can be predicted with good accuracy (R^2 = 0.74) using a regression equation that included live weight and abdominal fat surface. In another study (Raji et al., 2010), using the same type of poultry, a prediction model was developed for fat weight that presented an R^2 of 0.86, using the chest girth, chest depth, chest width, live weight and wing length, as predictor variables. Similarly, Kleczek et al. (2006) reported that carcass fat weight of male Muscovy ducks can be estimated from a regression model that included body weight, humerus length and chest depth. The high precision of the model developed in the study was confirmed with the coefficients of multiple correlation (r = 0.87) and determination (R^2 = 0.75). Recently, Lin et al. (2018) fitted an equation to predict abdominal fat weight in Pekin ducks using live weight, skin fat thickness, chest width and neck length, showing a r = 0.58 and R^2 = 34.65%.

In the prediction of BRW, in addition to the SBW, two body measurements (BC and SD) were added to the models [Eqs. 13-15]. Equation [13], using SBW as the only predictor, explained 87% of the variation observed in the model. However, the inclusion of body measurements provided a light increase in R^2 of 4%, reaching a precision of 91% and lower values of RMSE (77.51), AIC (308.28) and BIC (311.28). Previously, Rymkiewicz & Bochno (1998) suggested the use of live weight and thickness of breast muscles, in a practical and accurate model (R^2 = 0.972) for the prediction of breast meat weight in broilers. Similarly, Melo et al. (2003) reported that the best model for the prediction of breast weight in broilers was the simple regression of live weight because it had an R^2 of 0.85, with a residual standard error of 32.34 g. In male Muscovy ducks, Kleczek et al. (2006) proposed a regression equation that included body weight, breast-bone crest length and chest girth to estimate breast muscle weight. The model showed a multiple correlation coefficient between the dependent variable and the set of independent variables of 0.77, while the R^2 was 59.29%. For female ducks, the cited authors suggested an equation that included body weight, breast-bone crest length, and breast muscle thickness. The developed model presented higher values of the multiple correlation coefficient (0.80) and of R^2 (64.16%), than the equation based on data for males. For the estimation of THW, SBW was the only independent variable that was included in the prediction model [Eq. 16], which had an R^2 of 0.58. Raji et al. (2010) found that thigh weight of male broilers was predicted with high accuracy ($r = 0.91$; $R^2 = 0.83$) based on live weight, chest width and chest girth, while for females the independent variables were chest girth, chest width, live weight and chest depth ($r = 0.94$; $R^2 = 0.88$). Regarding the DRW prediction, the variables that were included in the models were SBW and SD [Eqs. 17 and 18]. It was observed that the SBW alone can explain 78% of the variation of the dependent variable, but with the inclusion of SD in Equation [18], the precision had a light increase ($R^2 = 0.81$) and the model showed a best fit (RMSE = 27.41, AIC = 234.64, BIC = 237.18). Three equations were generated to predict BAW [Eqs. 19-21], which showed an R^2 ranging between 0.79 and 0.83. In this case, SBW associated with WL and SD were selected as predictor variables. Finally, the models developed to predict WIW [Eqs. 22-25] explained from 64 to 80% of its variation, being the model of Equation [25] the one that had a slightly better goodness of fit (RMSE = 20.16, AIC = 214.88 and BIC = 218.49). Although both back and wings are considered low-value carcass cuts, it is known that in poultry up to 32% of total lean meat is found in these body parts, as well as in the neck (Bochno et al., 2003; 2005).

3.5. CONCLUSIONS

In conclusion, our results suggest that slaughter body weight can be used together with the body measurements as predictive variables of carcass characteristics and primal cut weight of native Mexican guajolotes. The prediction equations obtained in the study had moderate to high accuracy ($R^2 > 0.40 \leq$ and ≤ 0.96); therefore, they can be used by researchers, technicians and poultry producers to obtain information on the carcass composition of native guajolotes. Further studies should evaluate the use of these equations under different production conditions.

3.6. ACKNOWLEDGEMENTS

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Table 1. Descriptive analysis of the body measurements, carcass characteristics and primal cut weights in native Mexican guajolotes (*n* = 36).

Variable	Description	Mean ± SD	Minimum	Maximum	CV (%)
Body measurements					
SBW	Slaughter body weight (g)	4543.14 ± 656.60	3465.00	5655.00	14.45
TP	Thoracic perimeter (cm)	47.04 ± 4.45	37.80	55.60	9.47
BC	Body circumference (cm)	46.04 ± 3.27	39.40	51.50	7.11
BL	Body length (cm)	40.33 ± 4.09	31.80	48.30	10.15
WL	Wing length (cm)	33.28 ± 1.40	30.40	39.60	4.20
KL	Keel length (cm)	16.29 ± 0.90	14.80	18.50	5.52
SL	Shank length (cm)	13.21 ± 0.65	11.80	14.30	4.92
SD	Shank diameter (cm)	1.86 ± 0.12	1.70	2.20	6.52
Carcass characteristics and primal cut weights					
HCW	Hot carcass weight (g)	2781.43 ± 496.91	1960.00	3675.00	17.86
CCW	Cold carcass weight (g)	2747.57 ± 487.51	1940.00	3640.00	17.74
HDP	Hot dressing percentage (%)	60.94 ± 2.86	55.60	67.43	4.70
CDP	Cold dressing percentage (%)	60.22 ± 2.83	54.72	66.79	4.70
VIS	Organs and viscera weight (g)	589.05 ± 126.05	378.20	819.40	21.39
AFW	Abdominal fat weight (g)	12.74 ± 11.73	6.50	36.00	92.11
BRW	Breast weight (g)	872.57 ± 246.96	510.00	1300.00	28.30
THW	Thigh weight (g)	480.85 ± 50.92	355.00	570.00	10.59
DRW	Drumstick weight (g)	457.57 ± 61.83	360.00	595.00	13.51
BAW	Back weight (g)	373.28 ± 125.04	190.00	585.00	33.39
WIW	Wing weight (g)	376.42 ± 42.90	295.00	460.00	11.39

Table 2. Pearson correlation coefficients (r) among the variables used in the development of the equations.

	SBW	TP	BC	BL	WL	KL	SL	SD
HCW	0.97^{***}	0.69^{***}	0.84^{***}	0.61^{***}	0.24^{ns}	0.55^{***}	-0.22^{ns}	0.37^{**}
CCW	0.97^{***}	0.70^{***}	0.85^{***}	0.61^{***}	0.25^{ns}	0.55^{***}	-0.24^{ns}	0.38^{**}
HDP	0.67^{***}	0.49^{***}	0.57^{***}	0.40^{**}	0.15^{ns}	0.26^{ns}	-0.12^{ns}	0.29^{ns}
CDP	0.64^{***}	0.51^{***}	0.58^{***}	0.40^{**}	0.15^{ns}	0.24^{ns}	-0.19^{ns}	0.30^{ns}
VIS	0.79^{***}	0.40^{**}	0.53^{***}	0.41^{**}	-0.00^{ns}	0.30^{ns}	-0.08^{ns}	0.24^{ns}
AFW	0.66^{***}	0.50^{***}	0.61^{***}	0.47^{***}	-0.00^{ns}	0.46^{***}	-0.56^{***}	0.15^{ns}
BRW	0.93^{***}	0.75^{***}	0.87^{***}	0.68^{***}	0.35^{**}	0.58^{***}	-0.33^{ns}	0.26^{ns}
THW	0.76^{***}	0.49^{***}	0.59^{***}	0.40^{**}	0.09^{ns}	0.43^{***}	-0.24^{ns}	0.34^{**}
DRW	0.88^{***}	0.62^{***}	0.75^{***}	0.52^{***}	0.16^{ns}	0.45^{***}	-0.18^{ns}	0.49^{***}
BAW	0.89^{***}	0.53^{***}	0.70^{***}	0.53^{***}	0.09^{ns}	0.58^{***}	-0.33^{**}	0.23^{ns}
WIW	0.80^{***}	0.47^{***}	0.68^{***}	0.31^{ns}	0.18^{ns}	0.24^{ns}	0.03^{ns}	0.47^{***}

HCW = Hot carcass weight; CCW = Cold carcass weight; HDP = Hot dressing percentage; CDP = Cold dressing percentage; VIS = Organs and viscera weight; AFW = Abdominal fat weight; BRW = Breast weight; THW = Thigh weight; DRW = Drumstick weight; BAW = Back weight; WIW = Wing weight; SBW = Slaughter body weight; TP = Thoracic perimeter; BC = Body circumference; BL = Body length; WL = Wing length; KL = Keel length; SL = Shank length; SD = Shank diameter;

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < .001$; ^{ns} non-significant.

Table 3. Regressions equations to predict the carcass characteristics using body measurements in native Mexican guajolotes (*n* = 36).

Eq. No.	Equations	R^2	RMSE	AIC	BIC	*p*-value
Hot carcass weight (g)						
[1]	HCW = –587.08 (±121.11***) + 0.74 (±0.02***) × SBW	0.95	101.04	325.03	327.26	<0.0001
[2]	HCW = –118.14 (±319.97ns) + 0.77 (±0.03***) × SBW – 37.60 (±23.83^{ns}) × KL	0.96	98.84	324.41	326.95	<0.0001
Cold carcass weight (g)						
[3]	CCW = –549.65 (±125.14***) + 0.72 (±0.02***) × SBW	0.95	104.40	327.32	329.55	<0.0001
Hot dressing percentage (%)						
[4]	HDP = 47.50 (±2.56***) + 0.002 (±0.000***) × SBW	0.45	2.14	55.28	57.32	<0.0001
[5]	HDP = 57.28 (±6.79***) + 0.003 (±0.000***) × SBW – 0.78 (±0.50^{ns}) × KL	0.49	2.09	54.75	57.29	<0.0001
Cold dressing percentage (%)						
[6]	CDP = 47.66 (±2.64***) + 0.002 (±0.000***) × SBW	0.40	2.20	57.44	59.68	<0.0001
Organs and viscera weight (g)						
[7]	VIS = –100.22 (±93.96^{ns}) + 0.15 (±0.02***) × SBW	0.62	78.39	307.26	307.57	<0.0001
[8]	VIS = 473.30 (±211.43*) + 0.24 (±0.03***) × SBW – 21.65 (±7.31**) × BC	0.70	70.53	300.79	301.63	<0.0001
[9]	VIS = 954.39 (±273.20**) + 0.27 (±0.03***) × SBW – 21.11 (±6.77**) × BC – 39.73 (±15.74*) × KL	0.75	65.27	296.25	298.13	<0.0001
[10]	VIS = 1515.53 (±349.27***) + 0.27 (±0.03***) × SBW – 18.26 (±6.44**) × BC – 18.65 (±7.92*) × WL – 44.66 (±14.85**) × KL	0.79	60.96	292.33	295.94	<0.0001
Abdominal fat weight (g)						
[11]	AFW = –41.23 (±10.66**) + 0.01 (±0.002***) × SBW	0.44	8.89	154.95	155.85	<0.0001
[12]	AFW = 69.66 (±30.61*) + 0.009 (±0.002***) × SBW – 7.73 (±2.04**) × SL	0.61	7.50	143.98	146.52	<0.0001

R^2 = Determination coefficient; RMSE = Root mean square error; AIC = Akaikés Information Criterion; BIC = Bayesian Information Criterion; SBW = Slaughter body weight; TP = Thoracic perimeter; BC = Body circumference; BL = Body length; WL = Wing length; KL = Keel length; SL = Shank length; SD = Shank diameter. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < .001$; ^{ns}: non-significant.

Table 4. Regressions equations to predict the primal cuts weights using body measurements in native Mexican guajolotes (*n* = 36).

Eq. No.	Equations	R^2	RMSE	AIC	BIC	*p*-value
Breast weight (g)						
[13]	BRW = –723.72 (±107.20**) + 0.35 (±0.02***) × SBW	0.87	89.44	316.49	317.58	<0.0001
[14]	BRW = –1278.50 (±250.36***) + 0.26 (±0.04***) × SBW + 20.94 (±8.66*) × BC	0.89	83.52	312.62	314.26	<0.0001
[15]	BRW = –960.94 (±265.25**) + 0.25 (±0.04***) × SBW + 26.80 (±8.37**) × BC - 305.03 (±122.92*) × SD	0.91	77.51	308.28	311.28	<0.0001
Thigh weight (g)						
[16]	THW = 210.39 (±39.71**) + 0.05 (±0.008***) × SBW	0.58	33.13	246.97	249.20	<0.0001
Drumstick weight (g)						
[17]	DRW = 78.40 (±34.86*) + 0.08 (±0.007***) × SBW	0.78	29.08	237.85	239.61	<0.0001
[18]	DRW = –68.09 (±72.50^{ns}) + 0.07 (±0.007***) × SBW + 94.57 (±0.41.72*) × SD	0.81	27.41	234.64	237.18	<0.0001
Back weight (g)						
[19]	BAW = –399.22 (±68.51***) + 0.17 (±0.01***) × SBW	0.79	57.15	285.14	287.38	<0.0001
[20]	BAW = 2.38 (±224.99^{ns}) + 0.17 (±0.01***) × SBW – 13.03 (±6.97^{ns}) × WL	0.81	55.11	283.52	286.07	<0.0001
[21]	BAW = 410.24 (±289.08^{ns}) + 0.19 (±0.01***) × SBW - 17.44 (±6.96*) × WL – 175.49 (±83.66*) × SD	0.83	52.40	280.88	283.88	<0.0001
Wings weight (g)						
[22]	WIW = 138.37 (±31.17***) + 0.05 (±0.006***) × SBW	0.64	26.01	230.04	232.27	<0.0001
[23]	WIW = 368.97 (±73.39***) + 0.06 (±0.007***) × SBW – 18.49 (±5.46**) × KL	0.73	22.67	221.34	223.89	<0.0001
[24]	WIW = 398.78 (±70.24***) + 0.07 (±0.008***) × SBW – 2.69 (±1.18*) × BL – 16.06 (±5.24**) × KL	0.77	21.31	217.92	220.92	<0.0001
[25]	WIW = 291.01 (±83.14**) + 0.07 (±0.007***) × SBW – 2.54 (±1.12*) × BL – 15.93 (±4.96**) × KL + 66.32 (±30.76*) × SD	0.80	20.16	214.88	218.49	<0.0001

CONCLUSIONES GENERALES

El GNM criado tradicionalmente en condiciones extensivas puede alcanzar pesos y rendimientos de la canal relativamente altos a las 40 semanas de edad, particularmente los machos debido a las diferencias naturales por el dimorfismo sexual, lo que los hace preferibles para la producción de carne.

La calidad de la carne del GNM varia entre géneros. La carne de la pechuga de los machos tuvo mayor valor nutricional en términos de proteína y acidos acidos grasos saludables, así como mejor masticabilidad. La carne de la pierna de las hembras presentó mayor contenido de grasa. Por lo tanto, desde el punto de vista nutricional, la carne de los guajolotes machos fue preferible en comparación a la carne de las hembras. En general, la carne del GNM es un alimento saludable que se puede incorporar idealmente a la dieta humana.

Las ecuaciones de predicción de las características de la canal y el peso de cortes primarios del GNM usando el peso corporal junto con algunas medidas biométricas como variables predictoras, tuvieron una precisión de moderada a alta ($0.40 \leq R^2 \leq 0.96$). Por lo tanto, pueden ser utilizadas por avicultores y técnicos para obtener información sobre la composición de la canal de guajolotes nativos.

En el futuro, es fundamental gestionar programas de mejora genética del GNM a través de la selección orientada al mejoramiento de los rasgos de la canal y calidad de la carne para aprovechar su potencial productivo y garantizar productos cárnicos de mejor calidad, que puedan competir con los producidos en la industría del pavo comercial.

LITERATURA CITADA

AOAC. 1990. Official Methods of Analysis of the Association of Official Analytical Chemists, 15th edn., Association of Official Analytical Chemists, Washington, p. 1228.

AOAC. 1995. Official Methods of Analysis. 16th ed. AOAC (method 942.05). International, North Frederic Avenue USA.

AOAC. 2005. Official methods of analysis. Dumas method (990.03). 15th ed., Association of Official Analytical Chemists Washington, DC, USA.

Aksoy, T., Narinç, D., Önenç, A., Ilaslan Çürek, D. 2021. Effects of season, genotype and rearing system on some meat quality traits for broilers raised in semi-intensive systems. *Tropical Animal Health and Production*, 53(3): 352. https://doi.org/10.1007/s11250-021-02791-3

Amorin, A., Rodrigues, S., Pereira, E., Teixeira, A. 2016. Physicochemical composition and sensory quality evaluation of capon and rooster meat. *Poultry Science*, 95, 1211–1219. https://doi:10.3382/ps/pev448

Ángel-Hernández, A., Morales-Flores, S., Carrillo-Rodríguez, J.C., Rodríguez-Ortíz, G., Villegas-Aparicio, Y., Jerez-Salas, M.P. 2014. Historia, domesticación y situación actual del guajolote (*Meleagris gallopavo gallopavo*) en México. *Revista Mexicana de Agroecosistemas*, 1(2): 132–143.

Attia, Y.A., Al-Harthi, M.A., Korish, M.A., Shiboob, M.M. 2017. Fatty acid and cholesterol profiles, hypocholesterolemic, atherogenic, and thrombogenic indices of broiler meat in the retail market. Lipids in Health and Disease, 16: 40. https://doi:10.1186/s12944-017-0423-8

Baéza, E., Guillier, L., Petracci, M. 2021. Review: Production factors affecting poultry carcass and meat quality attributes. *Animal*, 16(Suppl.1): 100331. https://doi.org/10.1016/j.animal.2021.100331

Banerjee, S. 2011. Prediction of carcass cuts using some non-invasive predictors on broiler ducks reared in hot and humid climate of Eastern India. *World Applied Sciences Journal*, 12: 642–651.

Batista, A.C., Santos, V., Afonso, J., Guedes, C., Azevedo, J., Teixeira, A., Silva, S. 2021. Evaluation of an image analysis approach to predicting primal cuts and lean in light lamb carcasses. *Animals*, 11: 1368. https://doi.org/10.3390/ani11051368

Bautista-Díaz, E., Mezo-Solis, J.A., Herrera-Camacho, J., Cruz-Hernández, A., Gomez-Vazquez, A., Tedeschi, L.O., Lee-Rangel, H.A., Vargas-Bello-Pérez, E., Chay-Canul, A.J. 2020. Prediction of carcass traits of Hair sheep lambs using body measurements. *Animals*, 10: 1276. https://doi.org/10.3390/ani10081276

Behiry, F.M., Hassanin, M.N.F., Ali, A.E.A., El-Kamash, E.M., Bahnas, M.M. 2019. Using some body measurements as predictors of live body weight and carcass traits in four broilers straits. *Egyptian Poultry Science Journal*, 39: 835–849. https://dx.doi.org/10.21608/epsj.2019.67500

Belhaj, K., Mansouri, F., Benmoumen, A., Sindic, M., Fauconnier, M.L., Boukharta, M., Serghini, C.H., Elamrani, A. 2020. Fatty acids, health lipid indices, and cholesterol content of sheep meat of three breeds from Moroccan pastures. *Archives Animal Breeding*, 63: 471–482. https://doi:10.5194/aab-63-471-2020

Bochno, R., Rymkiewicz, J., Szeremeta, J. 2000. Regression equations for *in vivo* estimation of the meat content of Pekin duck carcases. *British Poultry Science*, 41: 313–317. https://doi.org/10.1080/713654937

Bochno, R., Brzozowski, W., Murawska, D. 2003.Agerelated changes in distribution of meat, fat with skin and bones in broiler chicken carcasses. *Polish Journal of Natural Sciences*, 14: 335–345.

Bochno, R., Brzozowski, W., Murawska, D. 2005. Age-related changes in the distribution of lean, fat with skin and bones in duck carcases. *British Poultry Science*, 46:199–203. https://doi.org/10.1080/00071660500064378

Bozkurt, Y., Aktan, S., Ozkaya, S. 2008. Digital image analysis to predict carcass weight and some carcass characteristics of Beef cattle. *Asian Journal of Animal and Veterinary Advances*, 3:129–137. https://dx.doi.org/10.3923/ajava.2008.129.137

Biesek, J., Banaszak, M., Kuźniacka, J., Adamski, M. 2021. Characteristics of carcass and physicochemical traits of meat from male and female ducks fed a diet based on extruded soybean. *Poultry Science*, 100(7): 101170. https://doi.org/10.1016/j.psj.2021.101170

Boz, M.A., Oz, F., Yamak, U.S., 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(7): 3067–3080. https://doi.org/10.3382/ps/pez125

Camacho-Escobar, M.A., Ramírez-Cancino, L., Lira-Torres, I., Hernández-Sánchez, V. 2008. Phenotypic characterization of the Guajolote (*Meleagris gallopavo gallopavo*) in Mexico. *Animal Genetic Resources Information*, 43: 59–66, https://doi:10.1017/S101423390000273X

Camacho-Escobar, M.A., Arroyo-Ledezma, J., Ramírez-Cancino, L. 2008. Diseases of backyard turkeys in the Mexican tropics. *Annals of the New York Academy of Sciences*, 1149: 368–370. https://doi.org/10.1196/annals.1428.004

Canales, A.M., Camacho, M.E., Beltrán, A.H., Delgado, J.V., Landi, V., Martínez, A.M. 2022. Genetic diversity in 10 populations of domestic turkeys by using microsatellite markers. Poultry Science, https://doi.org/10.1016/j.psj.2022.102311

Case, L.A., Miller, S.P., Wood, B.J. 2010. Factors affecting breast meat yield in turkeys. *World's Poultry Science Journal*, 66(2): 189–202. https://doi.org/10.1017/S0043933910000255

Cendron, F., Mastrangelo, S., Tolone, M., Perini, F., Lasagna, E., Cassandro, M. 2021. Genome-wide analysis reveals the patterns of genetic diversity and population structure of 8 Italian local chicken breeds. *Poultry Science*, 100: 441–451 https://doi.org/10.1016/j.psj.2020.10.023

Chartrin, P., Bordeau, T., Godet, E., Méteau, K., Gicquel, J. C., Drosnet, E., Briére, S., Bourin, M., Baéza, E. 2019. Is meat of breeder turkeys so different from that of standard turkeys?, *Foods*, 8. https://doi:10.3390/foods8010008

Chen, Y., Qiao, Y., Xiao, Y., Chen, H., Zhao, L., Huang, M., Zhou, G. 2016. Differences in physicochemical and nutritional properties of breast and thigh meat from crossbred chickens, commercial broilers and spent hens. *Asian-Australasian Journal of Animal Sciences*, 29: 855–864. https://doi:10.5713/ajas.15.0840

CIE. 1986. Colorimetry. 2th ed. Publication CIE No. 15.2. Vienna: Commission Internationale de l'Eclairage.

Cigarroa-Vázquez, F., Herrera-Haro, J.G., Ruíz-Sesma, B., Cuca-García, J.M., Rojas-Martínez, R.I., Lemus-Flores, C. 2013. Phenotypic characterization of the indigenous turkey (*Meleagris gallopavo*) and production system in the north-central region of Chiapas, México. *Agrociencia*, 47: 579–591.

Cigarroa, V.F.A., Herrera-Haro, J.G., Ruiz-Sesma, B., Ortega-Cerilla, M.E., Cuca-García, J.M., Campo-Chavarri, J.L., Rojas-Martínez, R.I., Lemus-Flores, C. 2017. Evaluation of animal welfare indicators in autochthonous domestic Turkey (*M. gallopavo*) in confinement and free range at Villaflores Chiapas, Mexico. *Agrociencia*, 51:833–847.

Cobanoglu, F., Kucukyilmaz, K., Cinar, M., Bozkurt, M., Catli, A.U., Bintas, E. 2014. Comparing the profitability of organic and conventional broiler production. *Brazilian Journal of Poultry Science*, 16(4): 403–410. https://doi.org/10.1590/1516-635x1604403-410

Costa, R.G., Lima, A.G.V.O., Ribeiro, N.L., Medeiros, A.N., Medeiros, G.R., Gonzaga Neto, S., Oliveira, R.L 2020. Predicting the carcass characteristics of Morada Nova lambs using biometric measurements. *Revista Brasileira de Zootecnia*, 49: e20190179. https://doi.org/10.37496/rbz4920190179

Cuca-García, J.M., Gutiérrez-Arenas, D.A., López-Pérez, E. 2015. La avicultura de traspatio en México: Historia y caracterización. *Agroproductividad*, 8(4): 30–36.

Cygan-Szczegielniak, D., Maiorano, G., Janicki, B., Buzała, M., Stasiak, K., Stanek, M., Roślewska, A., Elminowska-Wenda, G., Bogucka, J., Tavaniello, S. 2019. Influence of rearing system and sex on carcass traits and meat quality of broiler chickens. *Journal of Applied Animal Research*, 47(1): 333–338, https://doi:10.1080/09712119.2019.1634076

Dal Bosco, A., Mattioli, S., Cartoni-Mancinelli, A., Cotozzole, E., Castellini, C. 2021. Extensive rearing systems in poultry production: The right chicken for the right farming system. A review of twenty years of scientific research in Perugia University, Italy. *Animals*, 11(5): 1281. https://doi.org/10.3390/ani11051281

Dal Bosco, A., Mugnai, C., Ruggeri, S., Mattioli, S., Castellini, C. 2012: Fatty acid composition of meat and estimated indices of lipid metabolism in different poultry genotypes reared under organic system. *Poultry Science*, 91: 2039–2045, https://doi:10.3382/ps.2012-02228

Dalle-Zotte, A., Tasoniero, G., Baldan, G., Cullere, M. 2019. Meat quality of male and female Italian Padovana and Polverara slow-growing chicken breeds. *Italian Journal of Animal Science*, 18(1): 398–404. https://doi.org/10.1080/1828051X.2018.1530963

Damaziak, K., Pietrzak, D., Michalczuk, M., Mroczek, J., Niemiec, J. 2013. Effect of genotype and sex on selected quality attributes of turkey meat. *Archiv für Geflügelkunde*, 77(3): 206–214.

El-Tarabany, M.S., Ahmed-Farid, O.A., El-Bahy, S.M., Nassan, M.A., Salah, A.S. 2022. Muscle oxidative stability, fatty acid and amino acid profiles, and carcass traits of broiler chickens in comparison to spent laying hens. *Frontiers in Veterinary Science*, 9: 948357. https://doi: 10.3389/fvets.2022.948357

Erensoy, K., Noubandiguim, M., Cilavdaroglu, E., Sarica, M., Yamak, U.S. 2020. Correlations between breast yield and morphometric traits in broiler pure lines. *Brazilian Journal of Poultry Science*, 22: 001–008. https://doi.org/10.1590/1806-9061-2019-1148

Fanatico, A.C., Pillai, P.B., Emmert, J.L., Owens, C.M. 2007. Meat quality of slow-and fast-growing chicken genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access. *Poultry Science*, 86(10): 2245–2255. https://doi.org/10.1093/ps/86.10.2245

Faridi, A., Sakomura, N.K., Golian, A., Marcato, S.M. 2012. Predicting body and carcass characteristics of 2 broiler chicken strains using support vector regression and neural network models. *Poultry Science*, 91: 3286–3294. https://doi.org/10.3382/ps.2012-02491

Gallardo-Nieto, J.L., Villamar-Angulo, L., Guzmán-Valenzuela, H. 2007. Situación actual y perspectiva de la producción de carne de guajolote (pavo) en México 2006. *Claridades Agropecuarias*, 161:3–37.

Gálvez, F., Domínguez, R., Pateiro, M., Carballo, J., Tomasevic, I., Lorenzo, J.M. 2018. Effect of gender on breast and thigh turkey meat quality. *British Poultry Science*, 59(4): 408–415. https://doi.org/10.1080/00071668.2018.1465177

Gao, Y.S., Jia, X.X., Tang, X., Fan, Y.F., Lu, J.X., Huang, S.H., Tang, M.J. 2017. The genetic diversity of chicken breeds from Jiangxi, assessed with BCDO2 and the complete mitochondrial DNA D-loop region. *PLoS ONE*, 12(3): e0173192. https://doi:10.1371/journal.pone.0173192

García-Flores, A., Guzmán-Gómez, E. 2016. The native turkey, an everyday backyard element in Playa Ventura, Copala, Guerrero, México. *Agricultura, Sociedad y Desarrollo*, 13(1): 1–18.

Gomes, M.B., Neves, M.L.M.W., Barreto, L.M.G., Ferreira, M.A., Monnerat, J.P.S., Carone, G.M., Marais, J.S., Chaves, V.A.S. 2021. Prediction of carcass composition through measurements *in vivo* and measurements of the carcass of growing Santa Inês sheep. *PLoS ONE*,16: e0247950. https://doi.org/10.1371/journal.pone.0247950

González-Ariza, A., Arando-Arbulu, A., Navas-González, F.J.; Nogales-Baena, S., Delgado-Bermejo, J.V., Camacho Vallejo, M.E. 2021. The study of growth and performance in local chicken breeds and varieties: A review of methods and scientific transference. *Animals*, 11: 2492. https://doi.org/10.3390/ani11092492

González-Ariza, A., Navas-González, F.J., Arando-Arbulu, A., León-Jurado, J.M., Delgado-Bermejo, J.V., Camacho-Vallejo, M.E. 2022. Variability of meat and carcass quality from worldwide native chicken breeds. *Foods*, 11: 1700, https://doi:10.3390/foods11121700

Grau, R., Hamm, R. 1953. Eine einfache methode zur bestimmung der wasserbindung im muskel. *Naturwissenschaften*, 40: 29–30. https://doi:10.1007/BF00595734

Hahn, G., Spindler, M. 2002. Method of dissection of turkey carcases. *World's Poultry Science Journal*, 58(2): 179–197. https://doi: 10.1079/WPS20020017

Hortúa-López, L.C., Cerón-Muñoz, M.F., Zaragoza-Martínez, M.L., Angulo-Arizala, J. 2021. Avicultura de traspatio: aportes y oportunidades para la familia campesina. *Agronomía Mesoamericana*, 32(3). https://doi.org/10.15517/am.v32i3.42903

INEGI. 2009. Prontuario de información geográfica municipal de los Estados Unidos Mexicanos; Champotón, Campeche. [accessed 2022 January 20].

İşgüzar, E. 2003. Growth, carcass traits and meat quality of Bronze and White turkeys in Isparta province of Turkey. *Archiv fur Tierzucht*, 46(5): 471–481. https://doi:10.5194/aab-46-471-2003

Itza-Ortiz, M.F., Carrera-Chavéz, J.M., Castillo-Castillo, Y., Ruiz-Barrera, O., Aguilar-Urquiso, E., Sangines-García, J.R. 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.

Juárez-Caratachea, A. 2004. Efecto del peso corporal en el rendimiento de la masa muscular en el pavo nativo mexicano. *Cuban Journal of Agricultural Science*, 38(4): 405–409.

Juárez-Caratachea, A., Delgado-Hurtado, I., Gutiérrez-Vázquez, E., Guillermo-Salas, R., Ortiz-Rodríguez, R., Segura-Correa, J. 2019. Descripción de la curva de crecimiento de pavos locales usando modelos no lineales. *Revista MVZ Cordoba*, 24: 7104–7107. https://doi.org/10.21897/rmvz.1149

Kanakachari, M., Rahman, H., Chatterjee, R.N., Bhattacharya, T.K. 2022. Signature of Indian native chicken breeds: a perspective. *World's Poultry Science Journal*, 78(2): 421–445. https://doi:10.1080/00439339.2022.2026201

Khan, U., Hussain, J., Mahmud, A., Khalique, A., Mehmood, S., Badar, I. H., Usman, M., Jaspal, M.H., Ahmad, S. 2019. Comparative study on carcass traits, meat quality and taste in broiler, broiler breeder and Aseel chickens. *Brazilian Journal of Poultry Science*, 21(1): 001–010. https://doi:10.1590/1806-9061-2018-0770

Kleczek, K., Wawro, K., Wilkiewicz-Wawro, E., Makowski, W. 2006. Multiple regression equations to estimate the content of breast muscles, meat, and fat in Muscovy ducks. *Poultry Science*, 85: 1318–1326. https://doi.org/10.1093/ps/85.7.1318

Kokoszyński, D., Arpášova, H., Hrnčar, C., Zochowska-Kujawska, J., Kotowicz, M., Sobczak, M. 2020. Carcass characteristics, chemical composition, physicochemical properties, texture, and microstructure of meat from spent Pekin ducks. *Poultry Science*, 99: 1232–1240. https://doi:10.1016/j.psj.2019.09.003

Kokoszyński, D., Piwczyński, D., Arpášová, H., Hrnčar, C., Saleh, M., Wasilewski, R. 2019. A comparative study of carcass characteristics and meat quality in genetic resources Pekin ducks and commercial crossbreds. *Asian-Australasian Journal of Animal Sciences*, 32(11): 1753–1762. https://doi.org/10.5713%2Fajas.18.0790

Lin, F.B., Zhu, F., Hao, J.P., Yang, F.X., Hou, Z.C. 2018. *In vivo* prediction of the carcass fatness using live body measurements in Pekin ducks. *Poultry Science*, 97: 2365–2371. https://doi.org/10.3382/ps/pey079

López, P.E., Uriostegui, R.E., López, P.F., Pró, M.A., Hernández, M.O., Guerrero, S.I. 2011. Nutritional quality of breast, thigh and leg of female and male Native Mexican turkeys (*Meleagris gallopavo* L.). *Actas Iberoamericanas de Conservación Animal*, 1: 338–34.

Lorenzo, J.M., Guedes, C.M., Zdolec, N., Sarriés, M.V., Franco, D., De Palo, P., Muchenje, V., Silva, S.R. 2018. Prediction of foal individual primal cuts yield using video image analysis. *South African Journal of Animal Science*, 48: 6. http://dx.doi.org/10.4314/sajas.v48i6.8

Loyra, T.E., Santos, R.R., Sarmiento, F.L., Segura, C.J. 2013. Productive performance and carcass yield of turkey fed feather meal treated with NaOH. *Revista MVZ Córdoba*, 18(2): 3467–3473. https://doi:10.21897/rmvz.169

Majumdar, S., Bhanja, S.K., Singh, R.P., Agarwal, S. K. 2005. Effect of age on the carcass traits and meat quality of turkey poults. *Journal of Applied Animal Research*, 27(2): 85–88. https://doi:10.1080/09712119.2005.9706546

Manyelo, T.G., Selaledi, L., Hassan, Z.M., Mabelebele, M. 2020. Local chicken breeds of Africa: Their description, uses and conservation methods. *Animals*, 10: 2257. https://doi:10.3390/ani10122257

Marangoni, F., Corsello, G., Cricelli, C., Ferrera, N., Ghiselli, A., Lucchin, L., Poli, A. 2015. Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing: an Italian consensus document. *Food & Nutrition Research*, 59: 27606. https://doi.org/10.3402/fnr.v59.27606

Melo, J.E., Motter, M.M., Morao, L.R., Huguet, M.J., Canet, Z., Miquel, M.C. 2003. Use of *in-vivo* measurements to estimate breast and abdominal fat content of a free-range broiler strain. *Animal Science*, 77: 23–31. http://dx.doi.org/10.1017/S1357729800053613

Mendeş, M., Akkartal, E. 2009. Regression tree analysis for predicting slaughter weight in broilers. *Italian Journal of Animal Science*, 8: 615–624. https://doi.org/10.4081/ijas.2009.615

Mengesha, Y., Kebede, E., Getachew, A. 2022. Review of chicken productive and reproductive performance and its challenges in Ethiopia. *All Life*, 15(1): 118–125. https://doi:10.1080/26895293.2021.2024894

Mottet, A., Tempio, G. 2017. Global poultry production: current state and future outlook and challenges. *World's Poultry Science Journal*, 73(2): 245–256. https://doi.org/10.1017/S0043933917000071

Mueller, S., Kreuzer, M., Siegrist, M., Mannale, K., Messikommer, R.E., Gangnat, I.D.M. 2018. Carcass and meat quality of dual-purpose chickens (Lohmann Dual, Belgian Malines, Schweizerhuhn) in comparison to broiler and layer chicken types. *Poultry Science*, 97: 3325–3336. https://doi.org/10.3382/ps/pey172

Murawska, D. 2013. Age-related changes in the percentage content of edible and nonedible components in turkeys. *Poultry Science*, 92(1): 255–264. https://doi.org/10.3382/ps.2012-02611

Murawska, D., Kozlowski, K., Tomaszewska, K., Brzozowski, W., Zawacka, M., Michalik, D. 2015. Age-related changes in the tissue composition of carcass parts and in the distribution of lean meat, fat with skin and bones in turkey carcasses. *European Poultry Science*, 79. https://doi:10.1399/eps.2015.103

Murawska, D. 2017. The effect of age on growth performance and carcass quality parameters in different poultry species, In (Ed.), *Poultry Science, IntechOpen*, https://doi:10.5772/64860

Musundire, M.T., Halimani, T.E., 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*, 58(4): 390–396. https://doi.org/10.1080/00071668.2017.1313961

Musundire, M.T., Halimani, T.E., 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(1): 860–867. https://doi.org/10.1080/09712119.2017.1411266

National Research Council (NRC). 1994. Nutrient requirements of poultry. 9nd ed. Washington (DC): The National Academic Press.

Navajas, E.A., Richarson, R.I., Fisher, A.V., Hyslop, J.J., Ross, D.W., Prieto, N., Simm, G., Roehe, R. 2010. Predicting beef carcass composition using tissue weights of a primal cut assessed by computed tomography. *Animal*, 4: 1810–1817. https://doi.org/10.1017/S1751731110001096

Nematbakhsh, S., Selamat, J., Idris, L.H., Razis, A.F.A. 2021. Chicken authentication and discrimination via live weight, body size, carcass traits, and breast muscle fat content clustering as affected by breed and sex varieties in Malaysia. *Foods*, 10: 1575. https://doi.org/10.3390/foods10071575

Nikolova, N., Pavlovski, Z., Milošević, N., Perić, L. 2007. The quantity of abdominal fat in broiler chicken of different genotypes from fifth to seventh week of age. *Biotechnology in Animal Husbandry*, 23: 331–338.

Nur Mahiza, M.I., Lokman, H.I., Ibitoye, E.B. 2021. Fatty acid profile in the breast and thigh muscles of the slowand fast-growing birds under the same management system. *Tropical Animal Health and Production*, 53: 409, doi:10.1007/s11250-021-02777-1

Ogah, D.M. 2011. *In vivo* prediction of live weight and carcass traits using body measurements in indigenous guinea fowl. *Biotechnology in Animal Husbandry*, 27: 1827–1836.

Onk, K., Yancintan, H., Sari, M., Adiguzel Isik, S., Yakan, A., Ekiz, B. 2019. Effects of genotype and sex on technological properties and fatty acid composition of duck meat. *Poultry Science*, 98: 491–499. http://dx.doi.org/10.3382/ps/pey355

Özbek, M., Petek, M., Ardıçlı, S. 2020. Physical quality characteristics of breast and leg meat of slow- and fast-growing broilers raised in different housing systems. *Archives Animal Breeding*, 63: 337–344. http://doi:10.5194/aab-63-337-2020

Padhi, M.K. 2016. Importance of indigenous breeds of chicken for rural economy and their improvements for higher production performance. *Scientifica (Cairo)*, 2604685. http://doi:10.1155%2F2016%2F2604685

Panpipat, W., Chaijan, M., Karnjanapratum, S., Keawtong, P., Tansakul, P., Panya, A., Phonsatta, N., Aoumtes, K., Quan, T.H., Petcharat, T. 2022. Quality characterization of different parts of broiler and Ligor hybrid chickens. *Foods*, 11: 1929. https://doi.org/10.3390/foods11131929

Pérez-Lara, E., Camacho-Escobar, M.A., García-López, J.C., Machorro-Samano, S., Ávila-Serrano, N.Y., Arroyo-Ledezma, J. 2013. Mathematical modeling of the native Mexican turkey's growth. *Open Journal of Animal Sciences*, 3(4):305–310. http://dx.doi.org/10.4236/ojas.2013.34045

Pius, L.O., Strausz, P., Kusza, S. 2021. Overview of poultry management as a key factor for solving food and nutritional security with a special focus on chicken breeding in East African countries. *Biology*, 10: 810. http://doi:10.3390/ biology10080810

Portillo-Salgado, R., Herrera-Haro, J.G., Bautista-Ortega, J., Ortega-Cerrilla, M.E., Sánchez-Villarreal, A., Bárcena-Gama, J.R. 2018. Descriptive analysis of the local practices for breeding and management of native turkey (*Meleagris gallopavo* L.) in Campeche, Mexico. *Agroproductividad*, 11: 88–94.

Portillo-Salgado, R., Herrera Haro, J. G., Bautista-Ortega, J., Chay-Canul, A. J., Cigarroa Vázquez, F. A. 2022a. Guajolote – A poultry genetic resource native to Mexico, *World's Poultry Science Journal*, 78(2): 467–482. http://doi:10.1080/00439339.2022.2028217

Portillo-Salgado, R., Herrera-Haro, J.G., Bautista-Ortega, J., Sánchez-Villarreal, A., Cigarroa-Vázquez, F. A., Chay-Canul, A. J., Yakubu, A. 2022b. Study of racial profile of the native Guajolote (*Meleagris gallopavo gallopavo*) in two regions of Mexico: morphometric characterization. *Tropical Animal Health and Production*, 54: 93. http://doi:10.1007/s11250-022-03101-1

Raji, A.O., Igwebuike, J.U., Kwari, I.D. 2010. Regression models for estimating breast, thigh and fat weight and yield of broilers from non invasive body measurements. *Agriculture and Biology Journal of North America*, 1: 469–475.

Rajkumar, U., Muthukumar, M., Haunshi, S., Niranjan, M., Raju, M.V.L.N., Rama-Rao, S.V., Chatterjee, R. N. 2016. Comparative evaluation of carcass traits and meat quality in native Aseel chickens and commercial broilers. *British Poultry Science*, 57(3): 339–347. http://doi:10.1080/00071668.2016.1162282

Ramírez-Rivera, E.J., Camacho-Escobar, M.A., García-López, J.C., Reyes-Borques, V., Rodríguez-De la torre, M. 2012. Sensory analysis of Creole turkey meat with flash profile method. *Open Journal of Animal Science*, 2(1): 1–10. http://doi:10.4236/ojas.2012.21001

Remm, K., Langen, M., Nowak, B. 2011. Microbiological quality and sensory evaluation of European unseasoned raw minced turkey meat. *Archiv für Geflügelkunde*, 75(2): 113–119.

Restoux, G., Rognon, X., Vieaud, A., Guemene, D., Petitjean, F., Rouger, R., Brard-Fudulea, S., Lubac-Paye, S., Chiron, G., Tixier-Boichard, M. *Genetics Selection Evolution,* 54: 56. https://doi.org/10.1186/s12711-022-00746-2

Ríos, U.A., Román, P.S.I., Vélez, I.A., Cabrera, T.E., Cantú, C.A., De la Cruz, C.L., Durán, A.M., Maldonado, J.J.A., Martínez, S.F.E., Martínez, V.G., Ruíz, L.F.J., Bagnato, A., Vega, M.V.E. 2016. Analysis of morphological variables in Mexican backyard turkeys (*Meleagris gallopavo gallopavo*). *Revista Mexicana de Ciencias Pecuarias*, 7: 377–389.

Rivera-Alegria, F.M., Ríos-Rincon, F.G., Macias-Cruz, U., García-Herrera, R.A., Herrera-Camacho, J., Benaouda, M., Angeles-Hernández, J.C., Muñoz-Benítez, A.L., Vargas-Bello-Pérez, E., Chay-Canul, A.J. 2022. Prediction of carcase characteristics using neck traits from hair-sheep ewes. *Italian Journal of Animal Science*, 21: 106–112. https://doi.org/10.1080/1828051X.2021.2018363

Romero-López, A.R. 2021. Las funciones de las aves en la producción avícola de pequeña escala: el caso de una comunidad rural en Hidalgo, México. *Revista Mexicana de Ciencias Pecuarias*, 12(1): 217–237. https://doi.org/10.22319/rmcp.v12i1.5088

Rymkiewicz, J., Bochno, R. 1998. Estimation of breast muscle weight in chickens on the basis of live measurements. *Archiv für Geflügelkunde*, 63: 229–233.

Sabow, A.B. 2020. Carcass characteristics, physicochemical attributes, and fatty acid and amino acid compositions of meat obtained from different Japanese quail strains. *Tropical Animal Health and Production*, 52: 131–140. http://doi:10.1007/s11250-019-01991-2

Safiyu, K.K., Sogunle, O.M., Egbeyale, L.T., Shittu, T.A. 2019. An exploratory study on the effects of rearing system and plumage colour on performance, carcass characteristics and meat quality of local turkeys. *International Journal Of Health, Animal Science And Food Safety*, 6: 1–15.

Samaraweera, A.M., Liyanage, R., Ibrahim, M.N., Okeyo, A.M., Han, J., Silva, P. 2021. High genetic diversity but absence of population structure in local chickens of Sri Lanka inferred by microsatellite markers. *Frontiers in Genetics*, 12: 723706. https://doi:10.3389/fgene.2021.723706

Sarica, M., Ocak, N., Karacay, N., Yamak, U., Kop, C., Altop, A. 2009. Growth, slaughter and gastrointestinal tract traits of three turkey genotypes under barn and free-range housing systems. *British Poultry Science*, 50(4):487–494. https://doi.org/10.1080/00071660903110919

Sarica, M., Ocak, N., Turhan, S., Kop, C., Yamak, U.S. 2011. Evaluation of meat quality from 3 turkey genotypes reared with or without outdoor access. *Poultry Science*, 90: 1313–1323. https://doi.org/10.3382/ps.2009-00600

Sarica, M., Boz, M.A., Yamak, U.S., 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(1).

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

Selamat, J., Zaidy, N.A.N.M., Zakaria, N.S., Juhari, N.H., Murugesu, S. 2022. Comparison of physicochemical characteristics and sensory attributes of four different chicken breeds from the genuine and selected local market. *Journal of Food Quality*, 1419937. http://doi:10.1155/2022/1419937

Semwogerere, F., Neethling, J., Muchenje, V., Hoffman, L.C. 2019. Meat quality, fatty acid profile, and sensory attributes of spent laying hens fed expeller press canola meal or a conventional diet. *Poultry Science*, 98: 3557–3570. http://doi:10.3382/ps/pez092

Servicio de Información Agroalimentaria y Pesquera (SIAP). 2021.Población Avícola-Guajolote, 2012-2021. https://www.gob.mx/cms/uploads/attachment/file/744953/Inventario_2021_guajolote.pdf

Skiepko, N., Chwastowska-Siwiecka, I., Kondratowicz, J., Mikulski, D. 2016. Fatty acid profile, total cholesterol, vitamin content, and TBARS value of turkey breast muscle cured with the addition of lycopene. *Poultry Science*, 95(5): 1182–1190. http://doi:10.3382/ps/pew005

Silva, S.J., Urdapilleta, T.J., Sterman, F.J.B., Gomes, R.C., Leme, P.R., Navajas, E.A. 2012. Prediction of retail beef yield, trim fat and proportion of high-valued cuts in Nellore cattle using ultrasound live measurements. *Revista Brasileira de Zootecnia*, 41: 2025–2031. https://doi.org/10.1590/S1516-35982012000900009

Silva, S.J., do Santos, D.G., Neto, J.V.E., Lana, Â.M.Q., da Silva Roberto, F.F., Ribeiro, P.H.C. 2019. Biometric measurements of Santa Inês meat sheep reared on *Brachiaria brizantha* pastures in Northeast Brazil. *PLoS ONE*, 14(7): e0219343. https://doi.org/10.1371/journal.pone.0219343

Sokołowicz, Z., Krawczyk, J., Świątkiewicz, S. 2016. Quality of poultry meat from native chicken breeds-A review. *Annals of Animal Science*, 16(2): 347–368. https://doi.org/10.1515/aoas-2016-0004

Strillacci, M. G., Marelli, S. P., Martínez-Velazquez, G. 2020. Hibrid versus autochthonous turkey populations: homozygous genomic regions occurrences due to artifcial and natural selection. *Animals*, 10: 1318. https://doi.org/10.3390/ani10081318

Tan, F.J., Li, D.C., Kaewkot, C., Wu, H.D.I., Świąder, K., Yu, H.C., Chen, C.F., Chumngoen, W. 2022. Application of principal component analysis with instrumental analysis and sensory evaluation for assessment of chicken breast meat juiciness. *British Poultry Science*, 63(2): 164–170. http://doi:10.1080/00071668.2021.1955330

Teixeira, A., Joy, M., Delfa, R. 2008. *In vivo* estimation of goat carcass composition and body fat partition by real-time ultrasonography. *Journal of Animal Science*, 86: 2369–2376. https://doi.org/10.2527/jas.2007-0367

Thiex, N.J., Anderson, S., Gildemeister, B. 2003. Crude fat, diethyl ether extraction, in feed, cereal grain, and forage (Randall/Soxtec/Submersion Method): collaborative study. *Journal AOAC International*, 86(5): 888–898. http://doi:10.1093/jaoac/86.5.888

Thiex, N., Novotny, L. 2012. Determination of ash in animal feed: AOAC Official Method 942.05. *Journal AOAC International*, 95(5): 1392–1397. http://doi:10.5740/jaoacint.12-129

Toomer, O.T., Livingston, M.L., Wall, B., Sanders, E., Vu, T.C., Malheiros, R.D., Livingston, K.A., Carvalho, L.V., Ferket, P.R. 2019. Meat quality and sensory attributes of meat produced from broiler chickens fed a high oleic peanut diet, *Poultry Science*, 98: 5188–5197. http://doi:10.3382/ps/pez258

Tyasi, T.L., Qin, N., Niu, X., Sun, X., Chen, X., Zhu, H., Zhang, F., Xu, R. 2018. Prediction of carcass weight from body measurement traits of Chinese indigenous Dagu male chickens using path coefficient analysis. *Indian Journal of Animal Sciences*, 88: 744–748. http://dx.doi.org/10.56093/ijans.v88i6.80897

Tůmová, E., Gous, R.M., Chodova, D., Ketta, M. 2020. Differences in growth and carcass composition of growing male and female turkeys. *Czech Journal of Animal Science*, 65(09), 330–336. http://doi:10.17221/180/2020-CJAS

Ulbricht, T.L.V., Southgate, D.A.T. 1991. Coronary heart disease, seven dietary factors. *Lancet*, 338: 982–992. http://doi:10.1016/0140-6736(91)91846-m

Uhlířová, L., Tůmová, E., Chodová, D., Vlčková, J., Ketta, M., Volek, Z., Skřivanová, V. 2018. The effect of age, genotype and sex on carcass traits, meat quality and sensory attributes of geese. *Asian-Australasian Journal of Animal Sciences*, 31(3): 421–428. http://doi:10.5713/ajas.17.0197

Uicab-Sonda, L.A. 2019. Efecto de los niveles de proteina sobre el crecimiento de guajolotes (*Meleagris gallopavo*). Tesis de Maestría. Instituto Tecnológico de Conkal. Tecnológico Nacional de México. 52 p.

Werner, C., Riegel, J., Wicke, M. 2008. Slaughter performance of four different Turkey strains, with special focus on the muscle fiber structure and the meat quality of the breast muscle. *Poultry Science*, 87: 1849–1859. https://doi.org/10.3382/ps.2007-00188

Wołoszyn, J., Haraf, G., Okruszek, A., Wereńska, M., Goluch, Z., Teleszko, M. 2020. Fatty acid profiles and health lipid indices in the breast muscles of local Polish goose varieties. *Poultry Science*, 99: 1216–1224. http://doi:10.1016/j.psj.2019.10.026

Yamak, U.S., Sarica, M., Boz, M.A., Ucar, A. 2016. The effect of production system (barn and free-range), slaughtering age and gender on carcass traits and meat quality of partridges (*Alectoris chukar*). *British Poultry Science*, 57(2): 185–192. http://doi:10.1080/00071668.2016.1144920

Yamak, U.S., Sarica, M., Boz, M.A., Ucar, A. 2018. Effect of production system (barn and free range) and slaughter age on some production traits of guinea fowl. *Poultry Science*, 97(1): 47–53. https://doi.org/10.3382/ps/pex265

Yang, Y., Mekki, D.M., Lv, S.J., Yu, J.H., Wang, L.Y., Wang, J.Y., Xie, K.Z., Dai, G.J. 2006. Canonical correlation analysis of body weight, body measurement and carcass characteristics of Jinghai Yellow chicken. *Journal of Animal and Veterinary Advances*, 5: 980–984.

Yakubu, A., Idahor, K.O., Agade, Y.I. 2009. Using factor scores in multiple linear regression model for predicting the carcass weight of broiler chickens using body measurements. *Revista UDO Agrícola*, 9: 963–967.

Zawacka, M., Murawska, D., Gesek, M. 2017. The effect of age and castration on the growth rate, blood lipid profile, liver histology and feed conversion in Green-legged Partridge cockerels and capons. *Animal*. 11(6): 1017–1026. https://doi.org/10.1017/s1751731116002378