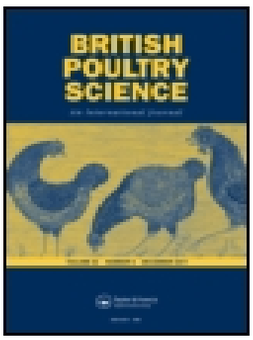

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Effect of gender on breast and thigh turkey meat quality

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Abstract

1. The influence of gender on chemical composition, physicochemical parameters, fatty acid profile, amino acid and mineral composition of turkey breast and thigh meat was studied in order to assess nutrient requirements.

2. Chemical composition showed that only intramuscular fat in breast meat was significantly affected by gender ($P<0.05$). The results showed a higher percentage of intramuscular fat in male samples, almost double the amount found in females (0.73% *vs.* 0.38%).

3.For meat colour parameters, only a* showed different results between sexes, with male samples (breast: $P<0.01$; thigh: $P<0.001$) having the highest values.

4. Fatty acid profiles showed that medium chain unsaturated fatty acids were the most abundant. The significant differences ($P<0.05$) found in both breast and thigh muscle could be linked to a difference in metabolism between males and females.

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5.There were higher levels of C16:1n7 in female s (breast: $P<0.001$; tight: $P<0.01$) compared with male muscle sample (5.05 *vs.* 2.67 g/100 g in breast and 4.95 *vs.* 3.27 g/100 g in thigh). Nutritional indices (n6/n3 and thrombogenic index) were more favourable in female samples demonstrating that female turkeys had better fatty acid profile than the others.

6. Turkey meat is an important source of dietary amino acids, and female samples had the highest contents both of essential and non-essential amino acids. Furthermore, gender had a numeric effect ($P>0.05$) on amino acid composition.

7. Mineral composition showed that Na, Zn and Fe were the minerals most affected by turkey gender.

Keywords: Amino acids; chemical composition; fatty acids; mineral composition; nutritional value; turkey; meat quality

Introduction

High consumption and demand for meat for human consumption makes the development of new tools to assess meat quality necessary. Meat quality is related to sensory quality, processing and shelf life, and is linked to other aspects of production, including animal welfare, breed, feeding regimes, pre-slaughter conditions and slaughter methods. Meat is an important dietary source of protein, B vitamins, amino acids, proteins and minerals for human consumers (Lombardi-Boccia *et al.*, 2005; Lorenzo *et al.*, 2014).

Cholesterol, fat content and fat composition of meat are important health issues for consumers because they are associated with obesity, hypercholesterolaemia and cancer (Chizzolini *et al.*, 1999). Polyunsaturated fatty acids (PUFA), are considered essential for humans because they are not synthesised in the body (Oliveira *et al.*, 2011), and hence, health organisations recommend reductions in saturated fatty acid (SFA) intake and increasing ratios

in PUFA/SFA (Briggs *et al.*, 2017). Intramuscular fat is an important meat characteristic because it is related to palatability, the primary determinant of consumer acceptance (Franco and Lorenzo, 2013).

Turkey meat has gained widespread popularity worldwide and is used in many regional cuisines (Murawska *et al.*, 2015). It is characterised by high protein and mineral content, low fat and good dietetic and flavour traits (Ribarski and Oblakova, 2016). Turkey carcasses are characterised by desirable tissue composition (Havenstein *et al.*, 2007), and rapid development of muscle tissue occurs early in the turkey's life (Moore *et al.*, 2005). Breast and leg muscles are considered most valuable, accounting for 72% (males) and 74% (females) of total meat weight (Murawska *et al.*, 2015).

The high-quality protein is provided by the main essential amino acids and the meat is rich in minerals. This makes it a desirable and valuable source of nutrients for human consumers who wish to eat healthy food.

Sparse information is available about the impact of the sex of the turkey on chemical and nutritional composition of meat. Hence, the main objective of the following experiment was to evaluate the effect of turkey sex on certain meat characteristics including proximate composition, colour, mineral content, fatty acid and amino acid profiles in breast and thigh meat. The study will contribute to a description of the chemical and nutritional composition of turkey meat.

Material and methods

Animals Management and sampling procedures

Twenty turkeys (10 females and 10 males) of Hybrid Optima breed (Hendrix Genetics Company) were used. Animals were reared in an intensive farming system with programmable lights and climate control, automated electric heating and forced ventilation,

and a density of 5.5 birds m^2. The birds were fed *ad libitum* standard commercial diets (Table 1). Males were raised to 19 weeks of age, and females to 14 weeks of age, and were kept separately. After this period, animals were transported to an accredited abattoir (Centro de Procesado Avícola, COREN, Ourense, Spain), with a journey time of approximately two hours. The average final live weight was 16.47 kg and 7.72 kg, for males and females, respectively. They were slaughtered by electrical stunning followed by cutting the jugular vein after 12 h feed withdrawal. To facilitate manual plucking, carcasses were scalded in hot water. Following the removal of the head (between the occipital condyle and the atlas) and feet (at the carpal joint), carcasses were eviscerated. The average carcass weight was 12.65 kg and 5.73 kg, for males and females, respectively. Immediately after slaughter, carcasses were chilled at 4°C in a cold chamber for 24 h. At this point, the breast samples (*pectoralis profundus* muscle) and thigh samples (*biceps femoris*, *semitendinosus* and *semimembranosus* muscles) were extracted from the right side of each carcass.

Table 1. Chemical composition of the diet.

Nutrient	Commercial compound
Chemical composition (%)	
Protein	18.2
Ash	5.6
Fat	9.4
Fibre	2.3
Mineral mix	
Ca (g/kg)	9.0
Na (g/kg)	1.5
Fe (mg/kg)	45.0
Cu (mg/kg)	10.8
Se (mg/kg)	0.23
Zn (mg/kg)	81.0
Se (mg/kg)	0.16
Vitamin mix	
Vitamin A (IU kg^{-1})	9000
Vitamin D_3 (IU kg^{-1})	3600
Vitamin E (mg kg^{-1})	100

Amino acids	
Lysine (g/kg)	11.2
Methionine (g/kg)	4.7

Commercial compound ingredients (in unknown proportions): corn; wheat; soybean meal; animal fat; beans; calcium carbonate; calcium phosphate; sodium chloride; sodium bicarbonate.

Physicochemical and Proximate Composition Analysis

The pH of the samples was measured using a digital portable pH-meter (Hanna Instruments, Eibar, Spain) equipped with a penetration probe. Colour parameters were measured using a portable colorimeter (Konica Minolta CM-600d, Osaka, Japan) with pulsed xenon arc lamp filtered to illuminant D65 lighting conditions, 0° viewing angle geometry and 8 mm aperture size, to estimate colour in the CIELAB space: lightness, (L*); redness, (a*); yellowness, (b*). The colour was measured at three different points of each meat sample. Before each series of measurements, the instrument was adjusted using a white ceramic tile. Protein, moisture and ash were quantified according to the ISO recommended standards (ISO 937:1978; ISO 1442:1997; ISO 936:1998,), while intramuscular fat (IMF) was extracted and quantified according to the AOCS Official Procedure Am 5-04 (AOCS, 2005). For determination of total cholesterol, 2 g of each meat sample was saponified with potassium hydroxide in ethanolic solution and cholesterol was extracted with n-hexane and separated and identified by normal phase-HPLC technique following the procedure described by Domínguez *et al.* (2015a). The total cholesterol in turkey meat was calculated in duplicate for each muscle sample, based on the external standard technique, from a standard curve of peak area *vs.* concentration. Results were expressed as mg cholesterol/100 g of meat.

Fatty acid methyl esters analysis

Total fat was extracted from 10 g of sample, according to the procedure published by Bligh and Dyer (1959). A total of 50 mg of fat was used to determine the fatty acid profile. Total fatty acids were transesterified according to the procedure described by Domínguez *et al.*

(2015b). Separation and quantification of the fatty acid methyl esters (FAMEs) was carried out using a gas chromatograph (GC-Agilent 6890N; Agilent Technologies Spain, S.L., Madrid, Spain) equipped with a flame ionisation detector following the chromatographic conditions described by Domínguez *et al.* (2018). Data regarding FAME composition were expressed as g/100 g of fatty acids.

The atherogenic index (AI) and thrombogenic index (TI) were calculated according to Ulbricht and Southgate (1991) according to the following equations:

$$AI=[C12:0+(4*C14:0)+C16:0]/[(\Sigma PUFA)+(\Sigma MUFA)];$$

$$TI=[C14:0+C16:0+C18:0]/[(0.5*\Sigma MUFA)+(0.5*n6)+(3*n3)+(n3/n6)]$$

The hypocholesterolemic/hypercholesterolemic ratio (h/H) was calculated according to Fernández *et al.* (2007) whereby:

h/H = [(sum of C18:1cn9, C18:1n7, C18:2n6, C18:3n6, C18:3n3, C20:3n6, C20:4n6, C20:5n3, C22:4n6, C22:5n3 and C22:6n3)/(sum of C14:0 and C16:0)]

Protein amino acid profile

The hydrolysis of protein, derivatisation, and identification of hydrolysed amino acids were carried out following the procedure described by Domínguez *et al.* (2015b). Data regarding amino acid composition were expressed in mg/100 g of meat.

Mineral composition

The quantification of mineral elements (Ca, Fe, K, Mg, Na, P and Zn) was performed using inductively coupled plasma-optical emission spectroscopy (ICP-OES), according to the method described by Lorenzo *et al.* (2015). The final value for each element was obtained by

calculating the average of three determinations. The results were expressed as mg/100 g of meat.

Statistical analysis

A total of 40 samples (ten turkeys x two locations x two sexes) were analysed for the various parameters. The effect of sex on pH, colour, chemical composition, fatty acids, amino acids and mineral composition was analysed using a one-way ANOVA, where these parameters was set as dependent variables and sex as fixed effect. Values were expressed as mean values plus standard error (SEM). All statistical analyses were performed using IBM SPSS Statistics 24 software (IBM Corporation, 2017).

Results and discussion

Chemical composition and colour characteristics

The analysis carried out in breast and thigh samples showed that gender had no significant effect on pH values (Table 2). Unlike the results reported by other authors (Abdullah and Matarneh, 2010; López *et al.*, 2011; Schneider *et al.*, 2012), pH values in females were numerically higher than the values obtained in males. Breast meat had lower pH values than thigh samples (6.03 *vs.* 6.29 for breast and thigh samples, respectively). The lower pH values found in breast meat could be due to the different activity of each muscle, in this way the muscles that had lower pH values could be related to the higher concentration of glycogen and lower activity in the muscle (Lorenzo *et al.*, 2013). In all cases, pH values were within the acceptable range for poultry meat (5.7-6.4; Van Laack *et al.*, 2000; Franco *et al.*, 2012a).

Table 2. Effect of turkey gender on chemical composition and colour parameters of breast and thigh meat.

Trait	Breast				Thigh			
	Male	**Female**	**SEM**	**Sig.**	**Male**	**Female**	**SEM**	**Sig.**
pH	5.95	6.11	0.06	ns	6.24	6.33	0.05	Ns
Chemical composition (%)								
Moisture	74.7	75.4	0.58	ns	74.8	74.6	0.66	Ns
IMF	0.73	0.38	0.08	*	3.46	4.24	0.25	Ns
Protein	24.0	24.3	0.13	ns	20.1	20.6	0.20	Ns
Ash	1.27	1.27	0.04	ns	1.10	1.15	0.02	Ns
Cholesterol (mg /100g)	41.9	39.7	0.60	ns	45.4	40.9	1.16	Ns
Colour parameters								
L*	53.0	54.4	0.57	ns	46.8	48.0	0.53	Ns
a*	0.10	-1.08	0.20	**	10.9	8.86	0.34	***
b*	7.76	7.11	0.29	ns	13.0	12.5	0.36	Ns

Sig.: Significance: * (P<0.05), ** (P<0.01), *** (P<0.001), ns (not significant); SEM: Standard error of the mean.

Gender had no effect on the main chemical components of meat from either breast or thigh samples. This outcome is in agreement with data reported by other authors (Damaziak *et al.*, 2013; Ribarski and Oblakova, 2016) for turkey meat. Mean values of 74.9% were found for moisture, whereas protein was above 20%. Although these were not significant, the results were slightly higher in females than in males (Table 2). As expected, protein was higher in breast than in thigh samples (24.2% *vs.* 20.4% respectively), which is in accordance with Wattanachant *et al.* (2004). Regarding IMF, results were different depending on the meat type evaluated. Sex effect was observed in breast samples, since the values found in males were almost double than those in female samples (0.73% *vs.* 0.38% respectively). On the contrary, no significant differences (P>0.05) were found in thigh samples, being in this case higher in female than in male samples (4.24% *vs.* 3.46% for female and male samples, respectively). Moreover, breast samples showed lower IMF contents than thigh samples

(Table 2). This could be related to the type of muscle and its composition, as thigh meat is formed from several muscles with a higher proportion of red fibres with greater lipid content than white fibres from breast meat (Cassens and Cooper, 1971). These values were similar to those found by Ribarski and Oblakova (2016) in breast and thigh from turkey meat. However, these results were lower than those reported by Sarica *et al.* (2011) in turkey meat.

Sex had no influence on cholesterol contents, although the highest values were observed in male samples (43.7 *vs.* 40.3 mg/100 g for males and females, respectively). These values were within typical values found in poultry meat (27 to 90 mg/100 g; Chizzolini *et al.*, 1999; Franco *et al.,* 2013). These results were interesting from a nutritional point of view because cholesterol content is important in making nutritional decisions. The levels from the current trial were below the maximum daily recommendations for cholesterol intake for humans, a one hundred-gram portion of chicken drumstick meat without skin represents 14% of the upper limit of daily cholesterol intake (300 mg per day; American Heart Association, 2008). These contents were lower than the values found in chicken and rooster meat (Komprda *et al.*, 2003; Franco *et al.*, 2012b). The IMF is one of the parameters that can affect the amount of cholesterol, since meat types with high IMF present proportionately less membrane polar lipids and therefore lower amounts of the cholesterol associated with these membranes (Alasnier *et al.*, 1996). However, in the present study, the mean values of cholesterol obtained for thigh were higher than the values found in breast samples (43.2 *vs.* 40.8 mg/100 g, for thigh and breast samples, respectively), despite having more IMF (3.85 *vs.* 0.56%, for thigh and breast samples, respectively).

Colour is considered as important quality indicator and has an impact on consumer acceptability (Gonzalo *et al.*, 2015), that can be influenced by several factors, among which is gender (Jaturasitha *et al.*, 2008). However, in the present study only redness (a*) was significantly ($P<0.001$) affected by sex (Table 2). Meat from males showed a slightly higher

a* values (0.10 and 10.9, for breast and thigh samples, respectively) than meat from females (-1.08 and 8.86, for breast and thigh samples, respectively), which was in agreement with other studies (López *et al.*, 2011; Franco *et al.*, 2016). The values found in breast samples were outside the range of normal a* values observed in breast samples (1.2-2.2; Van Laack *et al.*, 2000). The same was found for yellowness values (b*), while lightness values (L*) were inside the range of normal values for breast samples (Franco *et al.*, 2016).

Nowadays, the concern for obtaining high quality poultry meat has led to focus on the detection and prevention of PSE meat. Is known that pH and colour parameters are related to PSE conditions (Barbut, 1998). As expected, a significant correlation ($P<0.05$) was found between pH and colour parameters L*($r = -0.36$) and a* ($r = 0.38$) values.

Fatty Acid Composition

The fatty acid composition of turkey breast and thigh samples is summarised in Table 3 and is an important factor in assessing its nutritional quality (Lorenzo, 2013). Gender had an effect in intramuscular fatty acid profile in both locations. In fact, twelve out of twenty-five fatty acids in breast and fifteen out of twenty-five fatty acids in thigh were significantly ($P<0.05$) influenced by sex. These results agree with those reported by other authors, who observed differences in meat fatty acids profile between sexes in turkeys (Komprda *et al.*, 2002a; Ribarski and Oblakova, 2016) and in chickens (Powerslam *et al.*, 2010a,b). In contrast, Geldenhuys *et al.* (2015) did not observe any significant difference in the fatty acid profile of goose meat between males and females. In the present study, both locations showed the prevalence of monounsaturated fatty acids (MUFA) (37.4-40.5 and 39.2-42.8 g/100 g of FAME in breast and thigh, respectively) followed by saturated fatty acids (SFA) (34.8-35.6 and 35.1-36.4 g/100 g of FAME in breast and thigh, respectively) and polyunsaturated fatty acids (PUFA) (24.7-27.5 and 22.3-24.4 g/100 g of FAME in breast and thigh, respectively). The fatty acid profiles of these cuts were similar to those reported by Komprda *et al.* (2001)

and Lorenzo *et al.* (2011) in turkey meat and by Komprda *et al.* (1999, 2001) and Amorim *et al.* (2016) in chicken. This, however, is in disagreement with data reported by other authors (Komprda *et al.*, 2002b; Zhao *et al.*, 2011; Kuttappan *et al.*, 2012; Geldenhuys *et al.*, 2013) who observed that the PUFA were the major fatty acids in breast meat from turkey, goose and broilers, followed by SFA and finally MUFA. Finally, Ribarski and Oblakova (2016) found that SFA were the most abundant fatty acids, followed by MUFA and finally PUFA in turkey breast.

Males presented higher amounts of SFA than females in both cuts, and these differences were mainly due to males having the highest ($P<0.001$) values of C18:0 (11.0 *vs.* 9.41 g/100 g of FAME for breast and 10.9 *vs.* 9.0 g/100 g of FAME for thigh samples) and, to a lesser extent, the values of C14:0 and C17:0. This result varies from data reported by Komprda *et al.* (2002a,b) who did not observe significant differences in SFA content between sexes in turkey meat samples, while Poureslami *et al.* (2010a) reported higher amounts of SFA in females broiler chicken than in males. In the present study, the values of C16:0 were higher in females (23.6 *vs.* 22.3 g/100 g of FAME for breast and 23.9 *vs.* 23.0 g/100 g of FAME for thigh samples) than in males. This agrees with the results obtained by Poureslami *et al.* (2010a) in chicken and Ribarski and Oblakova (2016) in turkey samples, who observed higher amounts of C16:0 in females than in males. The MUFA content presented the highest values in female breast (40.5 *vs.* 37.4 g/100 g of FAME, for female and male samples, respectively) and thigh (42.8 *vs.*39.2 g/100 g of FAME, for female and male samples, respectively). These results are in agreement with those obtained by Poureslami *et al.* (2010a) in broiler chicken and by Komprda *et al.* (2002a) in turkey samples. Despite these differences in outcomes, C18:1n9c contents did not show significant differences between sexes, although sex affected the amounts of C14:1n5, C16:1n7, C17:1n7 (only in thigh meat) and C18:1n11t. The most notable differences were observed in C16:1n7, as females presented the highest

values (5.05 *vs.* 2.67 g/100 g of FAME, for male and female samples, respectively) in breast and (4.95 *vs.* 3.27 g/100 g of FAME, for male and female samples, respectively) in thigh.

As occurs in SFA content, males had higher values of PUFA (27.5 *vs.* 24.7 g/100 g of FAME for males and females, respectively) in breast samples and 24.4 *vs.* 22.3 g/100 g of FAME for males and females, respectively) in thigh samples than females. The total n3 PUFA did not show significant differences between sexes, while the total n6 PUFA of males were higher ($P<0.05$) (24.5 and 22.4 g/100 g of FAME, for breast and thigh samples, respectively) than in females (24.5 and 22.4 g/100 g of FAME, for breast and thigh samples, respectively). These differences were mainly due to the content of C18:2n6c and C20:4n6. The individual n3 PUFA did not display differences in breast samples. However, males had lower ($P<0.05$) amounts of C22:5n3 (1.12 *vs.* 1.22 g/100 g of FAME, for male and female samples, respectively) and higher ($P<0.05$) amounts of C18:3n3 (0.28 *vs.* 0.19 g/100 g of FAME, for male and female samples, respectively) than females.

Table 3. Effect of turkey gender on fatty acids profile (g/100 g of total fatty acids) of breast and thigh meat.

Fatty acid	Breast				Thigh			
	Male	**Female**	**SEM**	**Sig.**	**Male**	**Female**	**SEM**	**Sig.**
C14:0	1.40	1.18	0.04	**	1.57	1.39	0.03	**
C14:1n5	0.26	0.32	0.01	**	0.24	0.29	0.01	*
C15:0	0.22	0.18	0.01	***	0.24	0.22	0.01	ns
C16:0	22.3	23.6	0.21	***	23.0	23.9	0.15	**
C16:1n7	2.67	5.05	0.32	***	3.27	4.95	0.29	**
C17:0	0.45	0.33	0.02	***	0.48	0.40	0.01	**
C17:1n7	0.53	0.55	0.02	ns	0.35	0.32	0.01	*
C18:0	11.0	9.41	0.26	***	10.9	9.0	0.30	***
C18:1n11t	1.01	0.75	0.06	*	1.12	0.93	0.04	*
C18:1n9c	30.4	31.4	0.46	ns	31.9	33.4	0.44	ns
C18:1n7c	2.22	2.34	0.03	ns	1.96	2.04	0.03	ns
C18:2n6c	19.9	18.6	0.31	*	19.7	18.8	0.31	*
C20:0	0.07	0.05	0.00	**	0.08	0.07	0.01	ns
C18:3n6	0.06	0.05	0.00	*	0.07	0.06	0.00	ns
C20:1n9	0.29	0.27	0.01	ns	0.34	0.31	0.01	**
C18:3n3	0.98	0.90	0.03	ns	1.12	1.22	0.02	*

9c,11t-CLA	0.16	0.18	0.01	ns	0.18	0.19	0.00	ns
C20:2n6	0.25	0.24	0.01	ns	0.22	0.20	0.01	**
C22:0	0.19	0.16	0.01	ns	0.12	0.09	0.01	*
C20:3n6	0.30	0.35	0.02	ns	0.18	0.17	0.01	ns
C20:3n3	0.05	0.04	0.00	ns	0.04	0.04	0.00	ns
C20:4n6	3.82	2.83	0.23	*	2.18	1.36	0.16	**
C20:5n3	0.20	0.21	0.02	ns	0.10	0.11	0.01	ns
C22:5n3	0.62	0.46	0.05	ns	0.28	0.19	0.02	*
C22:6n3	0.93	0.85	0.08	ns	0.29	0.33	0.02	ns
SFA	35.6	34.8	0.25	*	36.4	35.1	0.28	**
MUFA	37.4	40.5	0.69	*	39.2	42.8	0.70	**
PUFA	27.5	24.7	0.57	**	24.4	22.3	0.46	*
n3	2.88	2.65	0.10	ns	1.83	1.89	0.04	ns
n6	24.5	22.4	0.46	*	22.4	20.6	0.43	*
n6/n3	8.91	8.88	0.29	ns	12.3	10.9	0.20	***
AI	0.43	0.43	0.00	ns	0.46	0.45	0.00	ns
TI	0.89	0.88	0.01	ns	0.98	0.92	0.01	**
h/H	2.50	2.34	0.03	**	2.35	2.28	0.02	ns

Sig.: Significance: * (P<0.05), ** (P<0.01), *** (P<0.001), ns (not significant); SEM: Standard error of the mean; SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids; AI: Atherogenic index; TI: Thrombogenic index; h/H: Hypocholesterolemic/hypercholesterolemic ratio.

Results reported in the literature about the effect of gender on fatty acids showed that the most important differences between sexes in fatty acid composition were caused by a difference in metabolism between females and males (Domínguez *et al.*, 2014). For example, Domínguez *et al.* (2014) observed different Δ5 desturase activity between males and females in pig muscle.

In order to evaluate the nutritional value of intramuscular fat, n6/n3 ratio, atherogenic index (AI), thrombogenic index (TI) and h/H ratio were calculated. In breast samples, only h/H was affected by sex, whereby males had higher values of this ratio than females (Table 3). The IMF of thigh from females had the best n6/n3 ratio values (10.9 *vs.* 12.3, for female and male samples, respectively). Despite these differences, both locations had higher values than the nutritional recommendations for human diet (n6/n3<4). The n6/n3 ratio was in accordance with diets containing high proportions of C18:2n6c (Prado *et al.*, 2014). The values of n6/n3

ratio found in the present study were higher than those obtained by Komprda *et al.* (2002a), who described ratios around 4 and 6 in breast and thigh samples, respectively. In addition, females also presented the best values of TI in thigh samples (0.92 *vs.* 0.95, for females and males, respectively). These differences in nutritional indices were related with the differences in fatty acids contents discussed above.

Amino acids composition

Lean poultry is an important source of dietary amino acids for human to sustain adequate protein nutrition and health (Pereira and Vicente, 2013). In fact, meat contains high amounts of protein and balanced proportions of all amino acids relative to human requirements (Lorenzo and Pateiro, 2013). The amino acid composition of breast and thigh turkey samples is shown in Table 4. Both locations exhibited the following profile: the major amino acid was glutamic acid (around 3400 mg/100 g of meat; around 15% of total amino acids [TAA]), followed by aspartic acid and lysine with similar values (around 2100 mg/100 g of meat [10% TAA]), leucine (around 1900 mg/100 g of meat [9% TAA]) and arginine (around 1800 mg/100 g of meat [8% TAA]). Arginine was included with the essential amino acids, as done by Hoffman *et al.* (2005), because arginine is considered to be conditionally essential (Arienti, 2003). The amino acid profile obtained in this research agreed with those reported in different cuts of chicken (Zhao *et al.*, 2011; Fu *et al.*, 2016), turkey (Ribarski and Oblakova, 2016), goose (Geldenhuys *et al.*, 2015), beef (Franco *et al.*, 2010; Wu *et al.*, 2016), and foal (Polidori *et al.*, 2009; Franco and Lorenzo, 2014).

Table 4. Effect of turkey gender on amino acids composition (mg/100 g of meat) of breast and thigh meat.

Amino acid	Breast				Thigh			
	Male	Female	SEM	Sig.	Male	Female	SEM	Sig.
Non-essential								

Aspartic acid	2145	2213	35.5	ns	2059	2105	41.3	ns
Serine	964	903	29.3	ns	1030	1047	34.3	ns
Glutamic acid	3388	3535	51.8	ns	3357	3568	72.7	ns
Glycine	1005	973	18.2	ns	1134	1051	52.5	ns
Alanine	1329	1375	34.3	ns	1382	1367	41.8	ns
Proline	798	909	26.3	*	863	986	37.8	ns
Tyrosine	853	832	12.7	ns	828	883	33.8	ns
Total non-essentials	10730	11010	188	ns	11293	11555	285	ns
Essential								
Histidine	897	903	11.8	ns	650	767	33.0	ns
Arginine	1791	1845	38.9	ns	1767	1828	45.4	ns
Threonine	1060	1075	25.7	ns	1059	1100	33.9	ns
Cysteine	208	242	9.2	ns	208	265	12.2	*
Valine	1123	1167	18.3	ns	1076	1170	36.4	ns
Methionine	393	415	20.1	ns	234	314	20.5	*
Lysine	2107	2197	41.7	ns	2064	2236	43.9	*
Isoleucine	1150	1205	18.1	ns	1062	1180	27.9	*
Leucine	1901	1990	31.0	ns	1795	1949	48.4	ns
Phenylalanine	935	963	10.8	ns	885	988	32.5	ns
Total essential	11357	11759	176	ns	10642	11532	244	ns
Essential/Non-essential	1.06	1.07	0.01	ns	0.96	0.97	0.02	ns

Sig.: Significance: * (P<0.05), ns (not significant); SEM: Standard error of the mean.

Regarding the essential amino acid fraction, lysine was the most abundant followed by leucine and arginine, representing together about 52% of total essential amino acids, while, methionine and cysteine presented the lowest values (between 208 and 415 mg/100 g of meat; representing around 2-3% of total essential amino acids). Glutamic acid, aspartic acid and alanine were the most abundant of the non-essential fraction, representing together around 61% of the total non-essential amino acids, whereas the lowest values were observed for tyrosine, proline (between 798 and 986 mg/100 g of meat) and serine (between 903 and 1047 mg/100 g of meat), representing around 8-9% of total non-essential amino acids.

Analysis of amino acid composition in breast and thigh samples showed no great difference between sexes. In fact, in breast samples, only the content of proline was affected by sex. In this case, females presented higher (P<0.05) values (909 *vs.* 798 mg/100 g of meat, for female and males, respectively). The remaining individual amino acids and the total essential

and non-essential amino acids did not show differences between genders. In thigh, the sum of total essential, sum of total non-essential and individual non-essential amino acids showed no significant differences. However, individual essential amino acids displayed differences between sexes. Females had higher ($P<0.05$) amounts of lysine (2236 *vs.* 2064 mg/100 g of meat, for female and male samples, respectively), isoleucine (1180 *vs.* 1062 mg/100 g of meat, for female and male samples, respectively), methionine (314 *vs.* 234 mg/100 g of meat, for female and male samples, respectively) and cysteine (265 *vs.* 208 mg/100 g of meat, for female and male samples, respectively). Finally, the values of essential/non-essential ratio were around 1.06 and 0.97 for breast and thigh samples, respectively.

Despite these differences, gender slightly affected the amino acids content. In this regard, Geldenhuys *et al.* (2015) obtained similar results in breast samples of Egyptian geese, where sex only affected the methionine amounts, whereas Ribarski and Oblakova (2016) did not find significant differences between sexes in the amino acid amounts of turkey breast muscle.

Mineral composition

The concentration of minerals of breast and thigh samples from turkey is presented in Table 5. The most abundant macroelement was potassium (K), followed by phosphorous (P), sodium (Na), magnesium (Mg), calcium (Ca), zinc (Zn) and iron (Fe). This is in agreement with data reported by Tasoniero *et al.* (2016) in breast samples from broiler. In contrast, Geldenhuys *et al.* (2013, 2015) found that P was the most abundant mineral, followed by K, Mg and Na in goose meat.

Table 5. Effect of turkey gender on mineral composition (mg/100 g of meat) of breast and thigh meat.

Mineral	*Breast*				*Thigh*			
	Male	**Female**	**SEM**	**Sig.**	**Male**	**Female**	**SEM**	**Sig.**
Ca	7.07	6.60	0.15	ns	7.70	7.15	0.15	ns

Fe	0.60	0.50	0.04	ns	1.23	0.91	0.05	***
K	405	437	16.3	ns	354	353	14.3	ns
Mg	32.2	39.3	2.13	ns	29.3	25.7	1.80	ns
Na	84.9	66.7	2.99	***	100	83.9	3.18	**
P	221	228	2.14	ns	201	196	3.50	ns
Zn	1.28	1.01	0.10	ns	3.46	2.59	0.15	**

Sig.: significance: ** (P<0.01), *** (P<0.001), ns (not significant); SEM: Standard error of the mean.

Statistical analysis showed that the amounts of Na in breast samples and Na, Fe and Zn in thigh samples was influenced by sex. The amount of Na in male breast samples (84.9 *vs.* 66.7 mg/100 g of meat, for male and female samples, respectively) was higher (P<0.001) than those observed in females. Similarly, the content of Na (P<0.01) (100 *vs.* 83.9 mg/100 g), Fe (P<0.001) (1.23 *vs.* 0.91 mg/100 g) and Zn (*P*<0.01) (3.46 *vs.* 2.59 mg/100 g of meat, for male and female samples, respectively) in thigh samples were higher in males. In contrast to these findings, Ribarski and Oblakova (2016) did not find differences in mineral levels between sexes for turkey meat, while Geldenhuys *et al.* (2015) observed that females had slightly different levels of boron than males in goose meat. However, they did not find significant differences between sexes in any other minerals. The amounts of K and Na obtained in the present study (353-437 mg/100 g of meat, and 66-100 mg/100 g of meat, for K and Na, respectively) were higher than those for broilers (around 200 mg/100 g of meat and 20-50 mg/100 g of meat, for K and Na, respectively; Geldenhuys *et al.*, 2013; Tasoniero *et al.*, 2016) and in goose meat (Geldenhuys *et al.*, 2013, 2015). With regard to P and Mg amounts, the values obtained (196-228 mg/100 g of meat and 25-40 mg/100 g of meat, for P and Mg, respectively) were similar to those reported in broiler breast (around 200 mg/100 g of meat and about 30 mg/100 g of meat, for P and Mg, respectively) (Geldenhuys *et al.*, 2013; Tasoniero *et al.*, 2016).

Meat is considered to be a good source of Fe compared with inorganic Fe because 50-60% is in the haem form and is therefore more readily adsorbed (Luciano, 2009). The values of Fe

from the present study were lower than those reported by Geldenhuys *et al.* (2013, 2015) in goose meat (5.3-7.5 mg/100 g of dry basis), and slightly higher than those obtained in turkey (Ribarski and Oblakova, 2016) and in broilers (Geldenhuys *et al.*, 2013).

These differences obtained in Fe amounts between trials could be due to the differences in myoglobin content. The high level of Fe in goose meat has been attributed to elevated myoglobin content because the breast muscle of this bird endures a high level of physical activity on a regular basis. Therefore, the metabolic capacity and fibre composition of the breast muscle may be the main factor that affects the amount of Fe (Geldenhuys *et al.*, 2013). According to Geldenhuys *et al.* (2015), the *pectoralis* muscle in volant birds mainly consists in type IIA fibres, with are aerobic and have a higher myoglobin content for oxygen supply.

Conclusions

Consumer attitudes influence desired meat quality characteristics, particularly in turkey meat and from the results of this experiment it can be concluded that sex had a slightly effect on the meat parameters studied. Only breast meat showed significant differences between sexes for IMF content, being higher in males than females. Despite not being significant, the thigh of females had the highest values. However, the fatty acid profiles were significantly different between sexes in both muscles studied. These differences could be linked to IMF content, metabolism rates or the effect of sex hormones on fatty acid incorporation. Nutritional indices were more favourable in female meat samples, which had better fatty acid profiles (lowest SFA amounts, lower n6/n3 ratio, lower arachidonic contents) than male samples. The values obtained for amino acids and mineral composition showed that these represented an important source for adequate human nutrition and health. The small differences found in these profiles could be due to the fact that this is relatively well conserved in muscle tissue. For minerals, only Na, Fe and Zn were affected by gender. The

levels of K, Na and Fe were higher than those found in other poultry meats. As a general conclusion, this research provided more accurate nutritional and meat quality information regarding to turkey meat.

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