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The fatty acid profile and the quality of breast and leg muscles in female and male pearl gray guinea fowl (*Numida meleagris*)

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ABSTRACT The aim of this study was to evaluate the fatty acid (**FA**) profile and the quality of breast and leg muscles in male and female guinea fowl. In comparison with leg muscles, breast muscles had a higher content of dry matter and total protein, and contained less fat and total collagen ($P \leq 0.05$). Sex had no effect on the chemical composition of the studied muscles or the FA profile of intramuscular fat (**IMF**) ($P > 0.05$). The IMF of breast muscles was characterized by higher proportions of total saturated fatty acids (**SFAs**) and polyunsaturated fatty acids (**PUFAs**), and lower proportions of total unsaturated fatty acids (**UFAs**) and monounsaturated fatty acids (**MUFAs**) ($P \leq 0.05$) than the IMF of leg muscles. The physicochemical properties of guinea fowl meat were significantly influenced by muscle type ($P \leq 0.05$), but not by sex ($P > 0.05$). Leg muscles were characterized by a higher pH, higher cooking loss, lower lightness (L*), lower drip loss, a higher contribution of redness (a*), and a lower contribution of yellowness (b*) than breast muscles ($P \leq 0.05$). The experimental factors had no effect on the sensory attributes or the shear force values of the analyzed muscles ($P > 0.05$). The unique sensory attributes, high protein content, and low fat content of the analyzed muscles indicate that guinea fowl meat can be a dietary supplement and an addition to other types of meat consumed, especially that most guinea fowl are reared in extensive farming systems that contribute to sustainable food production.

Key words: fatty acid profile, guinea fowl, meat quality, muscle type, sex

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INTRODUCTION

Current nutrition trends increase consumer demand for food products with a high nutritional value. These products include the meat of guinea fowl (*Numida meleagris*) which are a market-niche poultry species. The wild guinea fowl is native to Africa, but this bird species has spread to other continents and countries, including Asia, Latin America, the United States, Canada, and Europe (López-Pedrouso et al., 2019) because it easily adapts to various climates and environmental conditions. In addition, guinea fowl are effective foragers that are resistant to common poultry diseases and can be raised in various production systems, including intensive systems. As a result, guinea fowl rearing and breeding can generate substantial profits (Yamak et al., 2018), and in some African countries, guinea fowl are the cheapest source of poultry meat (Sarica et al., 2019).

Guinea fowl meat is nutritious and low in calories due low fat content and a high content of protein and unsaturated fatty acids (**UFAs**) (Das et al., 2021). Guinea fowl can be produced in alternative farming systems, including home farms, that contribute to sustainable food production, which is also an important consideration for many consumers. It is generally believed that low stocking density and better access to natural light in free-range farms improve bird welfare and, consequently, the quality of poultry meat (López-Pedrouso et al., 2019). Guinea fowl have a marginal share of the global intensive poultry production, and this bird species is usually reared in extensive farming systems, including in home farms (Sarica et al., 2019). The meat of free-range guinea fowl has an exceptional aroma and taste, and it is often compared to venison, in particular pheasant meat (Yildirim et al., 2020).

Despite the fact that guinea fowl are farmed around the world, their genetic potential, including the quality of guinea fowl meat, has not been thoroughly researched because in most countries (excluding the USA and France), guinea fowl of different varieties are produced mostly in free-range systems with low and varied levels of agricultural mechanization, and under different environmental conditions (Abdul-Rahman et al., 2019;

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Araújo et al., 2019). According to the small number of studies conducted on this poultry species, the quality of guinea fowl meat can be influenced by the housing and management system (Yamak et al., 2018), variety (Koné et al., 2022), diet (Batkowska et al., 2021), age at slaughter, and sex (Sarica et al., 2019).

Guinea fowl meat may offer an excellent alternative to other types of poultry meat (Araújo et al., 2023). Guinea fowl meat enjoys growing popularity due to its high nutritional value, unique sensory attributes, and health-promoting properties. However, there is a general scarcity of research on guinea fowl produced for meat and the quality of guinea fowl meat (Kgwatalala et al., 2020; Ahiagbe et al., 2021). The relevant information would be highly useful for assessing the processing suitability of guinea fowl meat, and selecting the optimal storage methods and times.

The quality of guinea fowl meat produced in various regions of the world remains insufficiently investigated, and this study was undertaken to fill in this knowledge gap (Koné et al., 2022). Pearl gray guinea fowl were selected for the study as the most widely reared variety of the examined bird species (López-Pedrouso et al., 2019). The present study is a continuation of the authors' previous research which compared the quality of meat from pearl gray and lavender guinea fowl (Śmiecińska et al., 2022). To the best of the authors' knowledge, the quality of the major muscles in guinea fowl carcasses has never been compared in the literature. Therefore, the research hypothesis postulates that breast and leg muscles in male and female guinea fowl differ in fatty acid (**FA**) profile, chemical composition, physicochemical properties, and sensory attributes. The aim of this study was to evaluate the FA profile and the quality parameters of breast muscles (fillets and tenderloins) and leg muscles (thighs and drumsticks) in 16-wk-old male and female pearl gray guinea fowl.

MATERIALS AND METHODS

Materials

Meat samples for the study were obtained from 18 carcasses of 16-wk-old pearl gray guinea fowl (9 males and 9 females) purchased from a farm in north-eastern Poland (Figure 1). The birds were reared in summer/fall in an extensive farming system and had ad libitum access to commercial chicken diets. The administered diets had the following content of crude protein and energy: starter diet (wk 0−6)—19.0% and 12.3 MJ/kg, respectively; grower diet (wk 7−12) —16.5% and 11.6 MJ/kg, respectively; finisher diet (wk >13) —15.08% and 11.5 MJ/kg, respectively. The detailed composition of the diets fed to guinea fowl in different feeding phases was presented by Śmiecińska et al. (2022). The average hot carcass weight was 1,056.56 g in females and 1,037.44 g in males. Carcasses packaged in polyethylene bags were transported to the laboratory and refrigerated at a temperature of 4°C for 24 h. After refrigeration, breast (fillets and tenderloins) and leg (thighs and drumsticks) muscles were removed from the carcasses, separated from the skin and bones, and immediately analyzed in the laboratory of the Department of Commodity Science and Processing of Animal Raw Materials (University of Warmia and Mazury in Olsztyn, Poland).

Figure 1. A female in the foreground and a male in the back (photographer Kamil Kryński).

Methods

Chemical Analyses. The content of dry matter (determined by drying at 105°C to constant weight), total protein (Kjeldahl method, Kjeltec 8400 Auto Distillation Unit, FOSS Analytical, Hilleroed, Denmark), crude fat (Soxhlet extraction with diethyl ether as the solvent, Soxtec 2050 Auto Fat Extraction System, FOSS Analytical, Hilleroed, Denmark), and minerals (crude ash) in muscle samples was determined by standard AOAC methods (AOAC, 2007). The content of collagen in breast and leg muscles was determined based on the concentration of hydroxyproline (ISO 3496, 1994) which was converted to total collagen content with a conversion factor of 7.25.

Fatty Acid Profile. Fatty acid methyl esters were prepared by the method described by Peisker (Żegarska et al., 1991), with some modifications, with the use of a chloroform: methanol: sulfuric acid mixture (100:100:1 v/v). Fatty acid profiles were determined with the Agilent Technologies 6890N (Santa Clara, CA) system with a flame-ionization detector (**FID**). Samples of fatty acid methyl esters were separated on a capillary column (length: 50 m, inner diameter: 0.25 mm, liquid phase-Stabilwax, film thickness: 0.25 μm). The following parameters were applied in the FA analyses of the samples and standards: carrier gas—helium, flow rate—1.2 mL/min, injector temperature—230°C, detector temperature—250°C, column temperature—195°C, split ratio—1:50. The results were expressed as the percentages of saturated (**SFAs**) and unsaturated fatty acids (**UFAs**) in the total FA pool in intramuscular fat (**IMF**).

Meat pH. The values of pH were measured in breast and leg muscle homogenates (1:1 ratio of meat to redistilled water) with a combination Polilyte Lab electrode (Hamilton Bonaduz AG, Bonaduz, Switzerland) and a 340i pH-meter with a TFK 325 temperature sensor

(WTW Wissenschaftlich-Technische Werkstätten, Weilheim, Germany).

Drip Loss. Samples of around 50 g each were cut out from breast and leg muscles. A nylon thread was passed through each sample; the samples were placed in tightly sealed plastic bags and hung at a temperature of 4°C for 48 h. The samples were weighed, and drip loss was determined as the percent change from initial weight (Oeckel Van, 1999).

Cooking Loss. Meat samples weighing around 100 g were cut out from breast and leg muscles after fat and epimysium had been removed. The samples were weighed and placed in water-tight bags in a water bath so as to prevent their contact, at a temperature of 80°C for 60 min. Then the samples were cooled to a temperature of 5°C for 30 min (Honikel, 1998), dried and weighed again. Cooking loss was calculated as the percentage of their initial weight.

Color Analysis. The color parameters of breast and leg muscles were determined in CIELAB space (L*—lightness, a*—redness, and b*—yellowness) by the reflectance method using the HunterLab MiniScan XE Plus spectrophotometer (Hunter Associates Laboratory Inc., Reston, VA). Color parameters were expressed as the mean values of 3 measurements performed at randomly selected points on the ventral side of the left breast and 4 measurements performed at randomly selected points on the ventral side of the left leg (2 on the thigh and 2 on the drumstick). Parameters L*, a*, and b* were used to calculate chroma $C^* = (a^{*2} + b^{*2})^{1/2}$ and the hue angle $h° = \arctan (b^*/a^*)$.

Sensory Analysis. Muscles cubes weighing around 50 g each were cut out from the muscles across the grain. The samples were heated in 0.6% NaCl solution at a temperature of 96°C for 1 h. The sensory analysis was performed under standard conditions, immediately after heat treatment. The analysis involved 6 trained panelists (ISO 8586, 1993) who evaluated the following sensory attributes on a 5-point scale: intensity of aroma and taste: 5 points—highly distinct, 4 points—distinct, 3 points—weakly distinct, 2 points—perceptible, 1 point—imperceptible; desirability of aroma and taste: 5 points—highly desirable, 4 points—desirable, 3 points—neutral, 2 points—somewhat undesirable, 1 point—highly undesirable; juiciness: 5 points—juicy, 4 points—somewhat juicy, 3 points—weakly juicy, 2 points—somewhat dry, 1 point—dry; tenderness: 5 points—very tender, 4 points—tender, 3 points—somewhat tough, 2 points—tough, 1 point—very tough. In order to train the panelists, the tests included in the above-mentioned standard were used. Furthermore, prior to sample evaluation, the panelists participated in orientation sessions to familiarize themselves with the sensory properties of cooked guinea fowl meat.

Shear Force. Shear force was measured in the INSTRON 5542 universal testing machine (Instron, Canton, Massachusetts) equipped with a Warner-Bratzler head (500 N, speed 100 mm/min). Samples of breast and leg muscles were prepared for the analysis according to the method described by Honikel (1998). Cylinder-shaped subsamples (diameter—1.27 cm, height—2 cm) were cut out from muscle samples. The maximum shear force required to cut each subsample across the grain was recorded, and the final result was the arithmetic mean of 5 measurements of the maximum shear force in each sample.

Statistical Analysis. The results were processed statistically in Statistica v. 13.3 (TIBCO Software Inc.). The normality of data distribution was checked by the Shapiro-Wilk test. The effects of the experimental factors (muscle type and sex) on the studied parameters and their interactions were determined by 2-way ANOVA. Significant interactions were not observed between the experimental factors ($P > 0.05$); therefore, the significance of differences between group means was estimated by Tukey's test at $P \leq 0.05$ (Żuk, 1989).

RESULTS AND DISCUSSION

Chemical Composition

The chemical composition of breast and leg muscles sampled from male and female pearl gray guinea fowl is presented in Table 1. Breast muscles were characterized by a higher content (%) of dry matter and total protein than leg muscles ($P < 0.001$). In turn, fat content was 6 times higher and total collagen content was approximately twice higher in leg muscles than in breast muscles ($P < 0.001$). Only the content of minerals (crude ash) was similar in the compared muscles ($P > 0.05$). Sex had no significant effect on the chemical composition of breast and leg muscles ($P > 0.05$). Gender-related differences in the chemical composition of guinea fowl meat have been rarely analyzed in the literature. Similarly to the present study, Musundire et al. (2017) did not report

Table 1. Chemical composition of guinea fowl meat depending on muscle type and sex.

Parameter	Muscle type		Sex		SEM	*P* value	
	Breast	Leg	Female	Male		Muscle type	Sex
Dry matter (%)	26.41 ^{a}	24.71 ^{b}	25.71	25.41	0.171	<0.001	0.376
Total protein (%)	25.26 ^{a}	21.77 ^{b}	23.55	23.47	0.311	<0.001	0.903
Crude fat (%)	0.37 ^{b}	2.26 ^{a}	1.32	1.31	0.197	<0.001	0.972
Crude ash (%)	1.10	1.11	1.11	1.11	0.008	0.237	0.465
Total collagen (%)	0.57 ^{b}	1.31 ^{a}	0.91	0.96	0.071	<0.001	0.732

Values within a row followed by different superscript letters, within experimental factors, are significantly different at $P \leq 0.05$.
SEM, standard error of the mean.

differences in the chemical composition of breast muscles sampled from male and female guinea fowl ($P > 0.05$). In turn, Daszkiewicz and Janiszewski (2020) analyzed the chemical composition of breast muscles from farmed male and female pheasants and found that sex influenced only the total collagen content of breast muscles ($P = 0.030$).

Similarly to the present study, Tejerina et al. (2009) reported significant differences in dry matter, protein, and fat content between breast and thigh muscles ($P \leq 0.05$). Boz et al. (2021) also noted considerable differences in the chemical composition of breast and thigh muscles from 16-wk-old, free-range guinea fowl, although the difference in fat content was only 0.37% (1.89% in the present study). In the current study, the dry matter content of the evaluated muscles was similar, but the content of protein and ash was higher than in the cited studies. In an experiment analyzing the chemical composition of thigh muscles (*quadriceps femoris*) from 16-wk-old indigenous guinea fowl and Galor guinea fowl (Koné et al., 2022), the content of dry matter and lipids was higher than in the present study (dry matter—26.40% and 27.72%, respectively; fat—3.77 and 3.90%, respectively), whereas the content of protein and ash was similar in indigenous guinea fowl (21.60 and 1.02%, respectively) and higher in Galor guinea fowl (22.40 and 1.41%, respectively), compared with the present study.

Guinea fowl meat is a good alternative to other types of poultry meat not only due to low production costs (Araújo et al., 2023), but also on account of its desirable chemical composition. According to Musundire et al. (2017), the breast muscles of guinea fowl contain approximately 3.5% more protein ($P < 0.05$) and less fat ($P < 0.05$) than chicken breast muscles. Fadare et al. (2019) also found that guinea fowl meat had higher protein content and lower fat content ($P < 0.05$) than chicken and duck meat.

The low level of production and consumption of guinea fowl meat in many countries is caused by the lack of tradition of eating this meat and the limited knowledge of consumers about its nutritional and health properties. Meat-oriented production of guinea fowl occurs in Africa, Asia, and Latin America in a free-range system (Araújo et al., 2019). In the intensive production system, it is a viable activity in countries such as the United States and Canada, as well as France and Italy (López-Pedrouso et al., 2019). On the other hand, in most countries there is a large gap in the production, sale and consumption of guinea fowl. It seems that the popularization of guinea fowl farming, the increase in the availability of guinea fowl meat and, above all, the increase in consumer awareness of its nutritional value and consumption values, creates a potential opportunity to increase the consumption of this meat. An opportunity to increase the demand for guinea fowl meat may be the interest of consumers in poultry products from alternative housing systems, m.in. from extensive or organic farming. Improving the availability of this type of meat in wholesale, retail, catering establishments, educating potential buyers about its culinary qualities and its culinary processing, as well as improving knowledge about its health benefits can contribute to increasing the consumption of this type of meat. The consumption of guinea fowl meat may be positively influenced by the trend for a healthy lifestyle. Undoubtedly, the promotion of guinea fowl meat requires emphasizing its high health and culinary values. Many authors emphasize that the products obtained from guinea fowl, including meat, have not yet been fully described, because they are mostly kept in extensive systems. Hence, the slower genetic improvement of this species results (Abdul-Rahman et al., 2019; Araújo et al., 2019; López-Pedrouso et al., 2019).

Guinea fowl meat, in particular meat produced in extensive and organic systems, is often compared to pheasant meat due to similarities in chemical composition and sensory attributes, especially taste and aroma (Costa et al., 2016; Yildirim et al., 2020). In the present study, breast and leg muscles differed considerably in fat content, which corroborates the findings of Franco and Lorenzo (2013). In the cited study, the breast muscles of 10-mo-old pheasants raised in an extensive system were characterized by a higher content of protein ($P = 0.001$), and a lower content of fat ($P = 0.005$), collagen ($P = 0.001$), and ash ($P < 0{,}001$) than drumsticks. In the current study, similar differences were noted in the first 3 parameters. According to Hwang et al. (2010), oxidative muscles, including leg muscles, contain more IMF than glycolytic muscles, such as breast muscles. Similar observations were made by Weng et al. (2022) who found that the breast muscles of broiler chickens contained less fat and more protein than leg muscles ($P < 0.05$).

The results of the present study and literature data indicate that breast and leg muscles in guinea fowl can differ in chemical composition, in particular in the content of dry matter, protein, and fat, which has also been observed in other bird species (Gálvez et al., 2018; López-Pedrouso et al., 2019; Weng et al., 2022). Research has also revealed considerable variations in the chemical composition of the same muscles, which could be attributed to differences in age, production system, and diet. In guinea fowl, the greatest differences have been observed in the protein content of breast muscles, which ranged from 22.8% in 6-mo-old females (Musundire et al., 2017) to 23.48% in 12-wk-old females (Tufarelli and Laudadio, 2015) or even 27.5% in 1-yr-old males (Musundire et al., 2017). The protein content of leg muscles is less varied, ranging from 19.66% in 16-wk-old, free-range guinea fowl and 20.38% in 16-wk-old birds raised in an intensive system (Boz et al., 2021) to 21.26% in 16-wk-old guinea fowl reared indoors (Pudyszak et al., 2005) and 21.89% in 16-wk-old, free-range lavender guinea fowl (Śmiecińska et al., 2022). In turn, the IMF content of breast muscles was determined in the range of 0.21% (Śmiecińska et al., 2022) to 0.84% (Pudyszak et al., 2005) and 2.09% in 12-wk-old guinea fowl broilers fed faba beans (Tufarelli and Laudadio, 2015). Leg muscles contain more fat than breast

Table 2. Percentages of SFAs in the total fatty acid pool in intramuscular fat of guinea fowl meat depending on muscle type and sex.

Parameter	Muscle type		Sex		SEM	*P* value	
	Breast	Leg	Female	Male		Muscle type	Sex
C12:0 (lauric)	0.31 [a]	0.06 [b]	0.09	0.27	0.052	0.015	0.102
C14:0 (myristic)	1.21	1.14	1.14	1.21	0.034	0.259	0.269
C15:0 (pentadecanoic)	0.25	0.22	0.24	0.24	0.007	0.113	0.940
C16:0 (palmitic)	25.91	25.51	26.07	25.35	0.304	0.528	0.244
C17:0 (margaric)	0.43 [a]	0.36 [b]	0.39	0.40	0.010	<0.001	0.582
C18:0 (stearic)	14.13	13.48	13.46	14.15	0.205	0.114	0.092
C20:0 (arachidic)	0.28 [a]	0.22 [b]	0.24	0.27	0.008	0.001	0.072
C22:0 (behenic)	0.41 [a]	0.20 [b]	0.25 [b]	0.37 [a]	0.026	<0.001	0.018
Total SFAs	42.94 [a]	41.23 [b]	41.89	42.25	0.341	0.008	0.598

Values within a row followed by different superscript letters, within experimental factors, are significantly different at $P \leq 0.05$.
SEM, standard error of the mean; SFAs, saturated fatty acids.

muscles, and their fat content was determined at 0.53% in 16-wk-old birds produced in an intensive system, 0.66% in 16-wk-old, free-range guinea fowl, and 5.86% (Pudyszak et al., 2005). The results of this study and the cited research indicate that breast and leg muscles in guinea fowl have a similar content of minerals (ash). Significant differences in the ash content of breast and leg muscles have not been reported in the literature. In turn, the collagen content of guinea fowl meat has not been analyzed to date; therefore, the present results cannot be compared with the findings of other authors. The collagen content of breast muscles in Ross 308 chickens was 0.58% higher than that noted in this study, and nearly identical to that determined in leg muscles (1.32 vs. 1.31%).

Fatty Acid Profile

Breast muscles were characterized by a higher content of total SFAs ($P = 0.008$) as well as a higher content of individual SFAs in IMF ($P \leq 0.05$) than leg muscles (Table 2). Breast muscles were significantly more abundant in lauric acid (C12:0), margaric acid (C17:0), arachidonic acid (C20:0), and behenic acid (C22:0) than leg muscles ($P = 0.015$, $P < 0.001$, $P = 0.001$, and $P < 0.001$, respectively). The content of C22:0 was higher in the muscles of male than female guinea fowl ($P = 0.018$). The content of the remaining SFAs in IMF was not significantly differentiated by sex ($P > 0.05$).

Leg muscles were characterized by higher proportions of total UFAs ($P = 0.008$) and total monounsaturated fatty acids (**MUFAs**) ($P = 0.001$), whereas the content of total polyunsaturated fatty acids (**PUFAs**) was higher ($P = 0.042$) in breast muscles (Table 3). An analysis of individual MUFAs revealed that leg muscles were more abundant in myristoleic acid (C14:1), palmitoleic acid (C18:1), and oleic acid (C18:1) ($P = 0.009$, $P = 0.049$, and $P = 0.001$, respectively). The content of C14:1 and margaroleic acid (C17:1) was higher, whereas the content of gadoleic acid (C20:1) was lower in the muscles of female than male guinea fowl ($P = 0.026$, $P = 0.049$, and $P = 0.021$, respectively). An analysis of individual PUFAs revealed that the IMF of breast muscles was characterized by higher concentrations of eicosatrienoic acid (C20:3 n-6), arachidonic acid (C20:4 n-6), docosapentaenoic acid (C22:5 n-3, DPA), and docosahexaenoic acid (C22:6 n-3, DHA) ($P = 0.042$, $P < 0.001$, $P = 0.001$, and $P < 0.001$, respectively), and lower

Table 3. Percentages of UFAs in the total fatty acid pool in intramuscular fat of guinea fowl meat depending on muscle type and sex.

Parameter	Muscle type		Sex		SEM	*P* value	
	Breast	Leg	Female	Male		Muscle type	Sex
C14:1 (myristoleic)	0.11 [b]	0.15 [a]	0.14 [a]	0.11 [b]	0.008	0.009	0.026
C16:1 (palmitoleic)	2.39 [b]	2.87 [a]	2.82	2.44	0.124	0.049	0.134
C17:1 (margaroleic)	0.14	0.13	0.15 [a]	0.12 [b]	0.005	0.913	0.049
C18:1 (oleic)	21.84 [b]	24.02 [a]	23.10	22.77	0.355	0.001	0.645
C20:1 (gadoleic)	0.62	0.64	0.59 [b]	0.68 [a]	0.020	0.686	0.021
Total MUFAs	25.09 [b]	27.83 [a]	26.79	26.13	0.457	0.001	0.473
C18:2 (linoleic)	18.03 [b]	24.20 [a]	21.98	20.25	0.726	<0.001	0.238
C18:3 n-6 (γ-linolenic)	0.24	0.25	0.23	0.25	0.005	0.244	0.142
C18:3 (linolenic)	0.98 [b]	1.32 [a]	1.25 [a]	1.05 [b]	0.004	<0.001	0.016
C20:2 (eicosadienoic)	0.46	0.41	0.38 [b]	0.49 [a]	0.026	0.382	0.024
C20:3 n-6 (eicosatrienoic)	0.29 [a]	0.23 [b]	0.29 [a]	0.23 [b]	0.014	0.042	0.040
C20:4 n-6 (arachidonic)	10.79 [a]	3.88 [b]	6.14	8.53	0.782	<0.001	0.129
C22:5 n-3 (docosapentaenoic—DPA)	0.47 [a]	0.30 [b]	0.44	0.34	0.027	0.001	0.070
C22:6 n-3 (docosahexaenoic—DHA)	0.69 [a]	0.36 [b]	0.59	0.47	0.043	<0.001	0.176
Total PUFAs	31.96 [a]	30.97 [b]	31.31	31.61	0.611	0.042	0.809
Total UFAs (MUFAs + PUFAs)	57.05 [b]	58.79 [a]	58.11	57.74	0.341	0.008	0.599

Values within a row followed by different superscript letters, within experimental factors, are significantly different at $P \leq 0.05$.
SEM, standard error of the mean; UFAs, unsaturated fatty acids (MUFAs + PUFAs); MUFAs, monounsaturated fatty acids; PUFAs, polyunsaturated fatty acid.

Table 4. Fatty acid profile of intramuscular fat (% of total fatty acids) in guinea fowl meat depending on muscle type and sex.

Parameter	Muscle type		Sex		SEM	*P* value	
	Breast	Leg	Female	Male		Muscle type	Sex
UFA/SFA ratio	1.33 [b]	1.43 [a]	1.39	1.37	0.019	0.011	0.721
MUFA/SFA ratio	0.57 [b]	0.67 [a]	0.63	0.62	0.011	<0.001	0.677
PUFA/SFA ratio	0.75	0.75	0.74	0.75	0.018	0.913	0.879
DFAs	71.19	72.28	71.57	71.89	0.318	0.087	0.613
OFAs	28.81	27.72	28.43	28.10	0.318	0.087	0.614
DFA/OFA ratio	2.15 [b]	2.62 [a]	2.19	2.58	0.101	0.017	0.061
EFAs	19.24 [b]	25.77 [a]	23.47	21.54	0.768	<0.001	0.215

Values within a row followed by different superscript letters, within experimental factors, are significantly different at $P \leq 0.05$.
SEM, standard error of the mean; DFAs, hypocholesterolemic fatty acids (UFAs + C18:0); OFAs, hypercholesterolemic fatty acids (SFAs—C18:0); EFAs, essential fatty acids (C18:2 + C18:3).

concentrations of linoleic acid (C18:2) and linolenic acid (C18:3) ($P < 0.001$) than the IMF of leg muscles. A higher content of C18:3 ($P < 0.001$) and C20:3 n-6 (0.0042), and a lower content of eicosadienoic acid (C20:2) ($P = 0.024$) was also noted in the IMF of females than males.

The FA profile of IMF is presented in Table 4. Leg muscles were characterized by a higher proportion of essential fatty acids (**EFAs**) ($P < 0.001$) and higher UFA/SFA, MUFA/SFA, and DFA/OFA ratios ($P = 0.011$, $P < 0.001$, and $P = 0.017$, respectively) than breast muscles. Muscle type had no effect on the proportions of hypocholesterolemic fatty acids (**DFAs**) and hypercholesterolemic fatty acids (**OFAs**) or the PUFA/SFA ratio ($P > 0.05$). The FA profile of IMF was not differentiated by sex ($P > 0.05$).

In breast and leg muscles, C16:0 and C18:0 were the predominant SFAs, which was also observed by Batkowska et al. (2021) in guinea fowl muscles, by Gálvez et al. (2018) in turkey muscles, and by Franco and Lorenzo (2013) and Quaresma et al. (2016) in pheasant muscles. In both types of muscles, C18:1 was the major MUFA, whereas C18:2 and C20:4n-6 were the predominant PUFAs, and similar results were also reported in the cited studies.

Significant differences in the percentages of total SFAs, MUFAs, PUFAs, and UFAs as well as individual FAs in the IMF of breast and leg muscles from guinea fowl, observed in this study, could be attributed to differences in the type of muscle fibers and cellular metabolism in the compared muscles, as noted by Domínguez et al. (2014). The effect of muscle type on the proportions and profile of FAs in IMF in guinea fowl has never been analyzed in the literature; therefore, the present findings were compared with the results reported in pheasants. Franco and Lorenzo (2013) observed no significant differences in the proportions of total SFAs, MUFAs or PUFAs in the IMF of breast and drumstick muscles in pheasants ($P > 0.05$), but similarly to the present study, they found that breast muscles were less abundant in C18:2 and more abundant in DHA ($P < 0.05$) than leg muscles. Unsaturated fatty acids were the predominant FAs in the breast and leg muscles of both guinea fowl and pheasants. In comparison with the present study, Yildirim et al. (2020) reported a somewhat higher content of total UFAs (58.50%) and PUFAs (35.54%), and a lower content of total SFAs (38.15%) and MUFAs (22.96%) in the breast muscles of guinea fowl. In the current study, the content of individual FAs and the FA profile of IMF were significantly ($P < 0.05$) affected by muscle type, which is consistent with the results of an experiment performed on pheasants by Quaresma et al. (2016).

The nutritional value and the health-promoting properties of meat lipids can be assessed based on their FA profile and the proportions of DFAs, OFAs, and EFAs in IMF. In the present study, the PUFA/SFA ratio was identical in the compared muscles and consistent with the nutritional guidelines of the British Department of Health (1994) which state that the PUFA/SFA ratio in the human diet should exceed 0.45. In the work of Batkowska et al. (2021), the PUFA/SFA ratio and the content of DFAs in the breast and thigh muscles of guinea fowl were nearly identical to those noted in this study. Quaresma et al. (2016) reported lower values of the PUFA/SFA ratio in the breast and thigh muscles of pheasants (0.537 and 0.199, respectively), whereas the values noted by Franco and Lorenzo (2013) in the breast and drumstick muscles of pheasants (0.68 and 0.72, respectively) were similar to those observed in the present study. In the work of Mieczkowska et al. (2015), the content of FAs with hypocholesterolemic activity (DFAs) in the breast and leg muscles of female pheasants (62.89 and 67.28%, respectively), was somewhat lower than in the present study, and this parameter was lower in the breast muscles of males (66.96%) and higher in the leg muscles of males (79.13%). In turn, the content of FAs with hypercholesterolemic activity (OFAs) was similar to that noted in the present study (28.96 −30.99%).

In poultry, differences in the proportions and profile of FAs in IMF can be attributed to various factors, including diet (Chiroque et al., 2018; Batkowska et al., 2021), species and breed (López-Pedrouso et al., 2019), age (Flis et al., 2019), and type of muscle (Franco and Lorenzo, 2013; Quaresma et al., 2016), which was also observed in the present experiment performed on guinea fowl. According to Gálvez et al. (2018), the FA profile of meat can be also influenced by sex. In the cited study, the FA profile of IMF in turkey breast and thigh muscles differed significantly between the sexes ($P < 0.05$), which could be attributed to variations in IMF content,

Table 5. Physicochemical properties of guinea fowl meat depending on muscle type and sex.

Parameter	Muscle type		Sex		SEM	*P* value	
	Breast	Leg	Female	Male		Muscle type	Sex
pH	5.85 [b]	6.41 [a]	6.21	6.06	0.054	<0.001	0.184
Drip loss (%)	2.95 [a]	1.03 [b]	1.99	1.98	0.225	<0.001	0.982
Cooking loss (%)	22.24 [b]	30.77 [a]	25.81	27.21	0.766	<0.001	0.369
L*	69.66 [a]	55.01 [b]	62.46	62.22	1.397	<0.001	0.931
a*	6.29 [b]	8.33 [a]	7.59	7.03	0.242	<0.001	0.249
b*	16.16 [a]	7.86 [b]	12.45	11.58	0.772	<0.001	0.582
C*	17.36 [a]	11.51 [b]	15.02	13.85	0.593	<0.001	0.331
h°	68.66 [a]	42.95 [b]	55.08	56.54	2.303	<0.001	0.758

Values within a row followed by different superscript letters, within experimental factors, are significantly different at $P \leq 0.05$.
SEM, standard error of the mean.

metabolic rate, or the influence of sex hormones. However, sex had no significant ($P < 0.05$) effect on the FA profile of guinea fowl muscles in the current study, in a study of guinea fowl breast muscles (Bernacki et al., 2012), in studies of breast and leg muscles in pheasants (Mieczkowska et al., 2015; Quaresma et al., 2016; Kokoszyński et al., 2018), or in a study of breast muscles in pheasants (Daszkiewicz and Janiszewski, 2020), where sex exerted only a minor influence on the content of selected FAs in IMF.

Physicochemical Properties

The results presented in Table 5 indicate that the physicochemical properties of guinea fowl meat were significantly influenced by muscle type ($P < 0.001$), but not by sex ($P > 0.05$). Leg muscles were characterized by higher pH, and higher cooking loss, lower lightness (L*), and lower drip loss than breast muscles. In comparison with breast muscles, leg muscles had a higher contribution of redness (a*) and a lower contribution of yellowness (B*). The values of the remaining color parameters (C* and h°) were lower in leg muscles.

The physicochemical parameters of meat are important quality indicators that determine the processing suitability and eating quality of meat. pH is a very important indicator of meat quality which directly influences water-holding capacity (**WHC**) and meat color (Rayan et al., 2022). Very high pH values are undesirable because they promote bacterial proliferation, decrease the shelf life of meat products (Sarica et al., 2019), and induce undesirable changes in the color, taste, and aroma of meat.

In the present study, sex had no effect on the pH values of breast and leg muscles of guinea fowl, and similar observations were made by Nikolova et al. (2021), Sarica et al. (2019), and Gálvez et al. (2018) in turkey muscles. In the work of Vangelova et al. (2022), pH_{24} values were lower in breast muscles than in thigh muscles ($P < 0.05$) of 16-wk-old pearl gray guinea fowl, which is consistent with the results of the present study. However, the pH values of breast muscles were higher in the cited study (6.09±0.06 in males and 6.15±0.02 in females) than in this experiment. Batkowska et al. (2021), Yildrim et al. (2020), Sarica et al. (2019), and Zelleke et al. (2022) also reported higher pH values in leg muscles than in breast muscles. Leg muscles were generally characterized by high pH values that were determined at 6.41 in the current study, 6.48 by Vangelova et. al. (2022), 6.55 by Nicolova et al. (2021), 6.11 by Yildrim et al. (2020), 6.99 by (Sarica et al. (2019), and 6.2 by Zelleke et al. (2022). Lower pH_{24} values in the thigh muscles of guinea fowl were reported only by Batkowska et al. (2021) (5.64 ± 0.07 and 5.56 ± 0.06). High pH values in the leg muscles of guinea fowl can be attributed to higher glycogen levels in leg muscles than in breast muscles (López-Pedrouso et al., 2019), which indicates that guinea fowl meat should be stored under adequate conditions. According to Bida and Faruruwa (2019), freezer storage effectively prevents spoilage in guinea fowl meat, but its nutrient content may decrease with prolonged storage.

High pH increases the WHC of meat, which was observed in the present study. Drip loss was 1.92% lower in leg muscles than in breast muscles, but it was not significantly differentiated by sex, which was also reported by Sarica et al. (2019). Moreover, similarly to the present study, Dahouda et al. (2009) reported that sex had no effect on breast muscle drip loss and cooking loss in local guinea fowl. According to Vangelova et al. (2022), WHC can differ in oxidative and glycolytic muscles because their physicochemical parameters are influenced by postmortem biochemical and functional changes. Drip loss was also 0.83% lower in thigh muscles than in breast muscles in the work of Batkowska et al. (2021) and cooking loss was also 5% higher in thigh muscles than in breast muscles. According to Sarica et al. (2019), drip loss was 1.77% higher in the breast muscles than in the thigh muscles of 16-wk-old guinea fowl males, whereas in females, this difference was determined at only 0.04%. Moreover, in the present study, cooking loss 5% lower in the breast muscles than in the thigh muscles of 16-wk-old guinea fowl males, whereas in females, this difference was determined at 4.49%. However, in 18-wk-old females, drip loss was 2.61% higher in breast muscles than in thigh muscles. Vangelova et al. (2022) investigated the influence of age (16, 20, and 24 wk), sex, and muscle type on the WHC of guinea fowl meat, and found that the decrease in WHC was associated mainly with age, which is consistent with the findings of Musundire et al. (2017). In addition, the authors point out that differences in WHC may be the result of different temperature and cooking time of the samples, ultimate pH or muscle types, and different poultry species.

According to the literature, the color of poultry meat, including guinea fowl meat, can be affected by sex, muscle type, age, and diet (Gálvez et al., 2018; López-Pedrouso et al., 2019). In the current study, the color parameters of meat were significantly influenced by muscle type, but not by sex. Lightness (L*) values were higher in breast muscles than in leg muscles, which can be linked with the remaining physicochemical parameters of the studied muscles (Hasan et al., 2019; Zelleke et al., 2022). In breast muscles, lower pH was accompanied by higher drip loss and higher L* values, whereas leg muscles were darker and were characterized by high pH and lower drip loss. In a study by Sarica et al. (2019), sex influenced only the contribution of yellowness in the breast muscles of guinea fowl. In the cited study, the values of parameter b* were higher in the breast muscles of females than males. In turn, L* values were higher in breast muscles than in leg muscles, and the contribution of redness (a*) was lower in breast muscles, which corroborates the results of the present study. However, the values of a* reported by Sarica et al. (2019) in breast muscles (3.40−3.86) were considerably lower than in the present study. Breast muscles consist mainly of white muscle fibers, whereas leg muscles contain a large number of red muscle fibers that are more abundant in myoglobin and heme pigments, which is why a* values are usually higher in leg muscles (Weng et al., 2022; Faustman et al., 2023). Similarly to the present study, Weng et al. (2022) reported lower a* values and lower pH values in the breast muscles than in the leg muscles of broiler chickens. The cited authors attributed these differences to changes in the fiber composition of both muscle types.

Guinea fowl meat, in particular leg muscles, is characterized by a higher contribution of redness in comparison with the meat of other poultry species (López-Pedrouso et al., 2019; Nusairat et al., 2022; Zelleke et al., 2022). The values of a* in the current and cited studies indicate that guinea fowl meat is similar to venison, especially pheasant meat (Sarica et al., 2021; Tomasevic et al., 2021). This observation is confirmed by hue angle (h°) values in the breast muscles of male and female guinea fowl, which were highly similar to those reported by Daszkiewicz and Janiszewski (2020) in the breast muscles of pheasants (54.90 in males and 55.99 in females). The values of chroma (C*) and hue angle (h°), noted in this study, can be compared only with the results reported by Yildrim et al. (2020) because the color parameters of guinea fowl meat have not been investigated by other researchers. The cited authors reported similar values of h° and C* in breast muscles (68.41 and 19.20, respectively) and somewhat higher values of h° and C* in thigh muscles (51.93 and 15.82, respectively) than those observed in the present study.

According to Zelleke et al. (2022), guinea fowl reared in intensive systems are generally characterized by darker and redder meat than birds raised under extensive conditions with access to outdoor space. In the work of Musundire et al. (2017), sex significantly influenced ($P < 0.05$) the contribution of yellowness, and the values of parameter b* were higher in the meat of female guinea fowl. According to the cited authors, the higher contribution of yellowness can be attributed to the higher content of fat in the muscles of female birds. High values of parameter b* were also noted in the breast and leg muscles of free-range guinea fowl (Yildrim et al., 2020) which have access to plants rich in carotenoid pigments.

Sensory Properties

The experimental factors (muscle type and sex) had no significant influence ($P > 0.05$) on the sensory attributes (evaluated on a 5-point scale) or the shear force values of guinea fowl meat (Table 6). All of the evaluated parameters received very high scores (above 4.5 points) in both breast and leg muscles, which indicates that guinea fowl meat is characterized by high eating quality.

Sensory properties are among the most important attributes of meat, which determine consumer perception. The extent and rate of changes in sensory characteristics can be influenced by the processes that occur postmortem (and lead to changes in meat pH) and meat processing operations, but also by sex, age, diet, muscle type, and physiological changes that occur in muscles directly before slaughter (Gómez et al., 2020; Suleman et al., 2020). In the literature, the effect of sex on the sensory properties of guinea fowl meat has been rarely analyzed, whereas differences in the sensory properties of various muscles have been never investigated.

In this study, the sex of guinea fowl had no effect on the sensory attributes of meat, which corroborates the

Table 6. Sensory properties (points) and shear force values (N) of guinea fowl meat depending on muscle type and sex.

	Muscle type		Sex			*P* value	
Parameter	Breast	Leg	Female	Male	SEM	Muscle type	Sex
Aroma—intensity	4.69	4.86	4.81	4.75	0.051	0.099	0.590
Aroma—desirability	4.81	4.83	4.83	4.81	0.041	0.737	0.737
Taste—intensity	4.83	4.81	4.86	4.78	0.041	0.737	0.311
Taste—desirability	4.81	4.86	4.89	4.78	0.041	0.493	0.166
Juiciness	4.83	4.86	4.83	4.86	0.039	0.727	0.726
Tenderness	4.72	4.69	4.72	4.69	0.057	0.813	0.813
Shear force value	15.01	16.23	15.54	15.69	0.766	0.432	0.923

SEM, standard error of the mean.

findings of Kokoszyński et al. (2011) who also evaluated breast muscles in 16-wk-old pearl gray guinea fowl. However, the analyzed sensory attributes (aroma, juiciness, tenderness, and taste) received much lower scores in the cited study (3.5 points on average on a 5-point scale).

The shear force values of guinea fowl meat have been examined by a larger number of studies. In the work of Musundire et al. (2017), sex had no influence ($P > 0.05$) on the shear force values of breast muscles in guinea fowl. According to Vangelova et al. (2022), sex did not affect the shear force values of breast muscles in guinea fowl ($P > 0.05$) despite the fact that muscle fiber diameter increased with age in both sexes. Meat tenderness and shear force values are largely determined by the thickness of muscle fibers. Tenderness increases with a decrease in muscle fiber thickness. In addition, shear force values and tenderness are also influenced by the content, solubility, and cross-linking of collagen (López-Pedrouso et al., 2019). In the present study, collagen content was significantly higher in breast muscles than in leg muscles, but this difference did not affect the tenderness or the shear force values of the compared muscles. In comparison with the current study, Batkowska et al. (2021) reported similar shear force values in breast muscles (14.22 N or 12.66 N) and higher values in leg muscles (19.95 N or 21.00 N) of guinea fowl, whereas Daszkiewicz and Janiszewski (2020) observed higher values in the breast muscles of male and female pheasants (20.7 N and 21.67 N, respectively). Similarly to the guinea fowl muscles evaluated in the present study, pheasant muscles received very high scores for tenderness on a 5-point scale (4.88 and 4.81 points, respectively), and sex had no influence ($P > 0.05$) on tenderness or shear force values. In turn, Kokoszyński et al. (2018) reported higher shear force values in the breast muscles of 112-day-old male than female pheasants ($P = 0.035$). The shear force values noted in guinea fowl meat in the present and cited studies were lower than that reported in the breast muscles of broiler chickens (38.4 N) (Gou et al., 2021). In a study of Ross 308 broiler chickens (Weng et al., 2022), the shear values of breast muscles were similar (16.03±1.46), whereas the shear values of leg muscles were somewhat higher (22.86±1.66) than those noted in this experiment. In the cited study, shear force values differed significantly between breast and leg muscles ($P > 0.05$), which could be attributed to differences in their collagen content (Table 6).

CONCLUSIONS

The study revealed significant differences in the content of dry matter, total protein, fat, and total collagen between the breast muscles and leg muscles of guinea fowl. Breast and leg muscles also differed in the proportions of total SFAs, MUFAs, PUFAs and UFAs, as well as selected individual FAs in IMF. The evaluated physicochemical properties (pH, drip loss, cooking loss, color parameters) were significantly influenced by muscle type. Sex induced only minor differences in the content of selected FAs in IMF. The experimental factors (muscle type and sex) had no effect on the sensory attributes or shear force values of guinea fowl meat. Due to its unique sensory characteristics, high protein content, and low fat content, guinea fowl meat can be a dietary supplement and an addition to other types of meat consumed, especially that most guinea fowl are reared in extensive farming systems that contribute to sustainable food production. However, the quality of guinea fowl meat has not been sufficiently investigated to date, and further research on guinea fowl rearing and breeding is needed to promote guinea fowl meat among both consumers and breeders, and increase its competitiveness on the meat market.

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Ethical Statement: In the conducted studies, no experimental procedures were carried out on live birds. The research material was guinea fowl meat. Thus, ethical approval was not required.

DISCLOSURES

The authors confirm that there are no conflicts of interest.

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