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Carcass Characteristics, Physicochemical Properties and Nutritional Composition of Meat from two Wild Birds: Northern Pintail (*Anas acuta*) and Northern Shoveler (*Spatula clypeata*)

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A B S T R A C T

The objective of this study was to evaluate the characteristics of the carcass, physicochemical properties as well as nutritional composition in breast and leg meat (with skin) of two different genotypes of wild birds namely: pintail (*Anas acuta*) and shoveler (*Spatula clypeata*) with regard to sex effect. The study involved forty-eight birds, 24 pintail and 24 shovelers (1:1 sex ratio) harvested during the hunting season (in September and November 2020) in lake Nasser from the Gerf-Hussein region, south Aswan Government. After the slaughter and dissection. PH, WHC and color coordinates of the breast and leg muscles were specified after 24 h of slaughter. After the dissection, breast and leg meats minced with their skin were sampled to determine cross composition, some minerals, amino acids profiles. The studied birds showed significant differences in body weight (BW), carcass weight, dressing percentage and percentages of neck and gizzard. Genotype affected the redness (a*), yellowness (b*), moisture, fat, ash and energy value of breast muscles, and also pH_{24}, lightness (L*), redness (a*), moisture, fat, ash and energy value of leg muscles. Regardless of genotype, males showed higher body weight, carcass weight, as well as breast and leg cuts weight compared to females. The shovelers had a higher content of K, Mg, Ca, Fe and Co in breast and leg muscles compared to the pintail. While Pb and Cd exceeded maximum admissible levels which are recommended by European common regulation. Cd was detected only in breast and leg muscles from pintail. The essential amino acid content ranged from 39.73-44.45 g/100 g protein in pintails against 41.46-44.94 g/100 g protein in shovelers.

Introduction

Historically, hunting and game meat consumed has been practiced as a means of survival and obtaining food since ancestral times, moreover, considered the major part of meat consumed by man before the development of agriculture. Some European countries have been traditionally eaten game meat, such as Austria, France, Germany and Switzerland the annual consumption 0.6–1.0 kg per / person

(Membré *et al.,* 2011), in Norway 3.3 kg (Lillehaug *et al.,* 2005) and Northern Italy 4.0 kg (Ramanzin *et al.,* 2010). Game meat from wild animals is a healthier, thinner and tasty meat that arising from animals that be free of drugs such as antibiotics and hormones, furthermore, its distinguished by good nutritional value due to its a valuable source of protein higher than 20% sometimes up to 25% and contains less fat lesser to 5%, sometimes up to 0.5% fat (Costa *et al.,* 2016).

However, more research about the chemical composition and quality of meat from wild animals focused on (deer, rabbit, hare, etc.) meats. And thus, little research has been focused on the chemical composition and quality of meat from game bird meats, but Khalifa and Nassar, (2001) in pintail and garganey birds, studied the nutritional composition and observed that wild bird meats were a good source of protein 23.2%, iron 6.19 mg/100 g, essential amino acids 38.6 g/100 g protein and oleic acid 52.87%, moreover, Cobos *et al.,* (2000) and Janiszewski *et al.,* (2018) in mallards (Anas platyrhynchos), they studied the chemical and fatty acid composition and observed that game bird meats was a good source of protein, low fat, polyunsaturated fatty acids (PUFA) and are distinguished by high meat quality. However, meat from other wild birds may have different characteristics. Therefore, there is little information regarding other wild birds' meat, such as Northern pintail (*Anas acuta*) and Northern shoveler (*Spatula clypeata*).

These birds are two of the most common game birds hunted in Egypt. Both are had breeding sites across most of the Palaearctic areas, midwestern united states and Canada, moreover, they are migrating during the northern winter into southern Europe and northern sub-Saharan Africa (Madge and Burn, 1988). They also have various feeding styles, the pintail is granivorous and eats seeds such as cereals and rice, the shoveler is omnivorous and eats planktonic crustaceans and aquatic plants such as bulrushes, waterweeds and duckweeds (Hockey *et al.,* 2005). Thus, differences in feeding styles may affect the nutritional composition of pintail and shoveler meats.

The nutritional value and quality of poultry meats can be determined using the basis of parameters such as proximate composition, amino acid profiles, additionally, ultimate pH value and water holding capacity, furthermore, it's are mostly dependent on numerous factors such as species, sex, diet and rearing conditions (López-Pedrouso *et al.,* 2019). When compared to broiler chicken breast meats, duck breast muscles have a more favourable amino acid profile, with higher levels of leucine, lysine, tryptophan, phenylalanine, and tyrosine (Wołoszyn *et al.,* 2006 and Ali *et al.,* 2007). Although much research has been conducted on the characteristics of domestic duck meats (Kim *et al.,* 2010; Muhlisin *et al.,* 2013; Qiao *et al.,* 2017; Makram *et al.,* 2017; Kokoszyński *et al.,* 2019 and Kowalska *et al.,* 2020), data on carcass characteristics, nutritional value and physicochemical properties of game birds meat are very limited. Thus, this study aimed to evaluate carcass characteristics (body weight, carcass weight, dressing percentage and carcass composition), physicochemical properties (ultimate-pH, water holding capacity and color coordinates) as well as nutritional composition (basic chemical composition, content of some minerals, amino acids profile) of meat from two wild birds namely: pintail (*Anas acuta*) and shoveler (*Spatula clypeata*).

Materials and Methods

Assessment of carcass characteristics

Forty-eight birds, 24 Pintail (*Anas acuta*) and 24 shovelers (*Spatula clypeata*) were obtained in live and healthy formers directly from hunters, which were procured by lake Nasser hunters from Gerf-Hussein south Aswan Government in September and November 2020. The ratio of males to females was (1:1). Birds before the slaughter were weighed to the nearest 0.1. Then using a sharp knife, the birds were slaughtered and allowed to bleed for 5 minutes according to the Islamic method, then dry plucked and dressed carcasses were re-weighed, then the weight of feather and blood was calculated by variance. According to Ziołecki and Doruchowski, (1989) methods, the eviscerated carcasses were subjected to dissection. Therefore, the carcasses were dissected into various parts including breast cuts (pectoralis major and minor muscles), leg cuts (thigh with drumstick muscles), (back and rib cuts), and (wings and neck cuts) were with their skin and giblets of the carcass. Furthermore, using the electronic balance, the carcass parts were weighed, and their percentage of live body weight was calculated.

Assessment of physicochemical properties

After the dissection, breast and leg cuts were taken to determine color measurements on the external side of the sample (pectorals major and thigh muscles) in triplicate, by chroma meter (Konica Minolta, model CR 410, Japan). The color was expressed using the CIE L*, a*, and b* color system, lightness L* dark (0) to light (100), the redness a* values (+) reddish to (-) greenish and the yellowness b* values (+) yellowish to (-) bluish were estimated according to Commission International de l'E´ clairage, (1976). samples were analyzed at Cairo University Research Park (CURP), Faculty of Agriculture. The meat samples were taken from breast and leg muscles and finely minced with their skin in a blender. Afterward, the ultimate pH and water holding capacity (WHC) was determined. The pH values of meat samples were determined at 24 h post-mortem, and were measured using a pH-meter (Jenway 3510: Bench pH/mV Meter, UK) that was calibrated daily with standard pH buffers of 4.0 and 7.0 at 25°C. The water holding capacity (WHC%) was measured according to (filter paper press methods) mentioned by Tsai and Ockerman (1981).

Assessment of nutritional composition

The moisture, protein, fat and ash content of breast and leg muscles were determined using standard methods (AOAC, 2000). While, energy value was enumerated according to Zaitsev *et al.*, (1969) methods. The content of minerals (K, Mg, Na, Ca, Fe, Zn, Mn, Cu and Co) and heavy metals content (Ni, Pb and Cd) of breast and leg muscles were determined, 0.5 g of the dried meat samples were wet mineralized in a Milestone Ethos microwave digestion system (Ethos Sel/ Plus, Milestone S.r.l., Sorisole, Italy). The sample solutions were analyzed using atomic absorption spectrometry according to AOAC, (1995) methods, samples were analyzed at the Unit of Environmental Studies and Development at Aswan University, Faculty of Science. To determine amino acids profile of breast and leg muscles, was determined using the HPLC-Pico-Tag method was described by Heinrikson and Meredith, (1984), briefly, the sample corresponding to the protein ratio was weighted into 25 × 150 mm hydrolyzed tube using 6 N HCl and placed in 110ºC oven for 24 hr, samples were analyzed at National Research Centre, Amino Acids Unit, Giza, Egypt.

Statistical analysis

The numerical data of traits were expressed as the Arithmetic means with standard deviation were calculated for (body weight, carcass and carcass cut weight, dressing percentage and percentage of carcass cuts as well as physicochemical and basic chemical composition) were statistically analyzed, while the rest of meat traits were analyzed in one replicate of sample. Statistical differences between genotype and sexes were specified by two-way analysis of variance (ANOVA) using Duncan's Multiple Range Test at a significant level of 0.05 using the SPSS program for windows software, version 25 (IBM Corp., 2017). A probability (p-value) of > 0.05 non-significant difference while p-value < 0.05 was considered statistically significant.

Results and Discussion

Carcass characteristics

Pintails (*Anas acuta*) and Shovelers (*Spatula clypeata*) are characterized by great differences in size. Therefore, live body weight (BW), carcass weight, and weights of carcass parts of studied birds are presented in Table (1). Data revealed that, high significant ($P < 0.05$) effect of genotype and sex on BW, carcass weight (with neck and giblets), blood, feather, head, feet and alimentary tract weights. The average BW of pintail males and females was about 1.60 and 1.38 time of shoveler males and females, respectively. Our results are also in good agreement with the findings of Blais *et al.,* (2001) who found BW of pintail 711.68 g for males and 642.50 g for females and Williams, (2014) found BW of shoveler recorded 510 g to 440 g in Australasian. However, regardless of genotype, males were significantly heavier in BW and carcass components than females in compared strains ($P < 0.05$). Furthermore, females' weight constituted 78.49 %, 91.34% of males weight in pintail and shoveler, respectively. The same trend was reported for domestic ducks by Makram *et al.,* (2017).

The weights of body parts as a percentage of live BW are presented in Table (2). Data revealed that, high significant ($P < 0.05$) effect of genotype on carcass yield, neck and gizzard (%) as a percentage of live BW. Dressing percentages (carcass yield %) were 74.96 and 74.42% in pintail males and females, against 71.37 and 72.29% in shoveler, respectively. These findings comply with Khalifa and Nassar, (2001) and Kim *et al.,* (2010), it was higher compared to the findings obtained by Kokoszyński *et al.,* (2019). On the other hand, pintail had a higher neck and gizzard (%) as a percentage of live BW than shoveler ($P < 0.05$), while the latter had a higher head (%). No significant ($P > 0.05$) effect of genotype and sex on the other parts. The great differences between studied birds could be the difference in selective breeding or genetic selection, genotype, age, sex and feeding style.

Physicochemical properties

Physicochemical properties (pH24, WHC % and color coordinates) of breast and leg muscles from studied birds are summarized in Table (3). Data revealed that, no significant ($P > 0.05$) effect of genotype and sex on pH24 of breast muscles, while the leg muscles of shoveler exhibited higher ($P < 0.05$) pH24 than the muscles of pintail birds. Our results were in the same line with the results of Koréneková *et al.,* (2012) for free-living ducks recorded 6.22 to 6.75, Janiszewski *et al.,* (2018) for wild-living mallards recorded 6.05 to 6.09 and Tarricone *et al.,* (2020) for Starling (Sturnus vulgaris) in pectorals major muscles recorded 6.38. High pH24 values may indicate that the wild birds were unsteady and their muscles were highly effective before slaughter. In the end, the differences between compared strains depended on the life condition, physiological conditions during slaughtering and glycolysis in the muscles after slaughter. On the other hand, the pH24 of leg muscles was significantly higher than breast muscles in studied birds (6.55 to 6.75) vs (6.18 to 6.42), respectively.

Another parameter “water holding capacity” (WHC%) has been determined in wild bird meats. After slaughter and storage, high WHC% in normal meat (the best meat products without free liquid surrounding in packages), while lower WHC% (the bad meat products with free liquid surrounding in packages). Data in Table (3) revealed that, no significant ($P > 0.05$) effect of genotype and sex on WHC of breast and leg muscles which ranged from 62.19 to 63.37 for breast meats and 65.74 to 66.49 for leg meats. The obtained results were in agreement comparatively with the results of Muhlisin *et al.,* (2013) in imported commercial ducks recorded 65.90, but higher than in cherry valley English Pekin ducks were ranged between (58.01to 60.94) for breast muscles and (62.93 to 64.78) for leg muscles (Kowalska *et al.,* 2020). In our study, breast and leg muscles exhibited higher pH24 values, in turn, it was exhibited higher WHC values. Therefore, meat with a higher pH value has the best WHC reported by Witak, (2008). The reason for the higher WHC of leg muscles compared to breast muscles was associated with greater protein hydration, which caused increased binding of water in leg muscles.

Colour is the most common feature utilized by customers during meat purchasing. A shining red color is linked with freshness. On the contrary, meat with paleness. Data in Table (3) summarized that, a significant ($P < 0.05$) effect of genotype on the redness (a*) and yellowness (b*) of breast muscles, lightness (L*), and redness (a*) of leg muscles. Thus, the breast muscles of studied birds recorded a range of L* 38.03-39.77, a* 11.19-17.32 and b* 2.06-6.11, while leg muscles recorded a range of L* 39.14 -44.11, a* 10.71-14.73 and b* 4.28 -6.17.

The obtained results were in agreement somewhat with the results of Qiao *et al.,* (2017) and Janiszewski *et al.,* (2018) they reported a similar range of L* 35.92-39.9, a* 16.55-19.13 and b* 1.99-4.64, but it was lower than Kisiel and Książkiewicz, (2004) and Kwon *et al.,* (2014) in 7-week-old polish ducks (mini duck k2 and Pekin p33) & commercial meat-type ducks, respectively. The darker color of breast muscles in pintails (lower L* and higher a* values) than in shovelers was probably associated with the pintail birds were more active than shovelers in flying ability and oxidative muscles. Vestergaard *et al.,* (2004) observed a darker color from pasture-fed animals with higher levels of physical activity than grain-fed animals with lower levels of physical activity. The Colour of game meats depends on the myoglobin content (heme pigments quantity), intramuscular fat quantity and post-mortem conditions. Moreover, meat color may be influenced by genotype, sex, age, feeding styles, pre-slaughter conditions, slaughter methods, scalding and cold storage temperature.

Nutritional composition

The basic chemical composition and energy value of pintail and shoveler birds of breast and leg meats with their skin are shown in Table (4). Data revealed that there was a significant ($P < 0.05$) difference in genotype on moisture, fat, ash and energy value except for the crude protein ($P > 0.05$) of breast and leg meats. Moreover, the greatest moisture content in shoveler meats than pintail recorded a range of 58.80-69.15%. In an inverse pattern, the greatest fat, ash and energy value content in pintail meats than shoveler that recorded a range of 5.61-23.94, 1.32-1.78% and 602.19-1257.83 kJ/100 g, respectively. The moisture content was lower and fat content was higher than previously reported by Cobos *et al.,* (2000); Pomianowski *et al.,* (2009) and Janiszewski *et al.,* (2018) in-game duck and pigeon birds and Muhlisin *et al.,* (2013); Qiao *et al.,* (2017) and Kokoszyński *et al.,* (2019) for domestic ducks, the reason for that may be due to inclusive the skin with meat in our study. The obtained results were agreed with the findings of Khalifa and Nassar, (2001) and Khalifa, (2009) in wild duck meats (pintail, garganey and shoveler).

Besides, the crude protein of breast and leg meats recorded a range of 18.57-23.63%. Moreover, higher crude protein content was determined in the breast than in leg meats (21.66- 23.63) vs (18.57-21.88). Regardless of genotype, no wide differences occur between the basic chemical composition of male and female meats. But the moisture content of leg female muscles exhibited no significantly ($P > 0.05$) lower than leg male muscles, the reason for this may be related to increased fatness in female bodies.

Essential, beneficial and toxic metal concentrations (on a dry weight basis mg/100g) of studied birds from breast and leg meats are presented in Table (5). Data revealed that the shoveler birds had a higher content of potassium (987.50-1637), magnesium (144-276), calcium (39.16-60.11), Ferrum (18.83-27.40) and cobalt (0.14-0.53 mg/100g) in breast and leg muscles compared to the pintail birds. Regardless of genotype, the breast muscles of females had a higher content of magnesium, sodium and cobalt compared to the males. While, the leg muscles of females had less content of potassium, magnesium, sodium, copper and more cobalt compared to the males. Regardless of genotype and sex, muscle type had a higher effect on mineral concentrations, in turn, breast muscles had a higher content of Mg, Fe, Mn, Cu and less content of K, Na and Zn compared to leg muscles. The breast and leg muscles of the studied birds had a higher content of Na, K, Mn, Zn, Fe and Cu compared to the muscles of 49-day-old SM3 heavy Pekin domestic ducks (Kokoszynski *et al.,* 2016).

Table.1 Body characteristics of Northern pintail (*Anas acuta*) and Northern Shoveler (*Spatula clypeata*). *

	Northern Pintail		***Northern Shoveler***		***P-Value***	
Traits	***Male (n=12)***	***Female (n=12)***	***Male (n=12)***	***Female (n=12)***	***Genotype (G)***	***Sex (S)***
Live body weight(BW) g	683.34±100.89^{a}	536.33 ±41.91^{b}	426.44 ±39.53^{c}	389.51 ±50.91^{c}	<0.001	<0.001
Slaughter weight[a] (g)	638.96 ±98.30^{a}	511.04 ±40.01^{b}	406.32 ±37.70^{c}	371.10 ±49.11^{c}	*<0.001*	*<0.001*
Blood[b]+feather (g)	96.16 ±13.0^{a}	78.1 ±8.3^{b}	65.17 ±7.2^{c}	56.31 ±7.8^{d}	*<0.001*	*<0.001*
Dressed carcass[c] (g)	587.55 ±93.04^{a}	458.23 ±35.95^{b}	362.38 ±35.33^{c}	334.35 ±43.51^{c}	*<0.001*	*<0.001*
Head+feet (g)	52 ±3.2^{a}	40.33 ±2.8^{b}	42.93 ±3.5^{b}	37.85 ±3.6^{c}	*0.041*	*<0.001*
Alimentary tract (g)	20.97 ± 3.63^{a}	18.70 ±2.64^{a}	14.21 ±3.0^{b}	14.15 ±4.28^{b}	*<0.001*	*0.254*
Carcass weight[d](g)	513.94 ±88.55^{a}	399.24 ±33.84^{b}	304.44 ±29.83^{c}	281.73 ±38.41^{d}	*<0.001*	*<0.001*
Breast[e] (g)	189.42 ±41.23^{a}	147.76 ±19.68^{b}	111.74 ±10.06^{c}	105.23 ±15.85^{c}	*<0.001*	*0.001*
Leg and thighs[e](g)	62.96±15.65^{a}	47.80±4.49^{b}	37.29±5.30^{c}	33.99±6.78^{c}	*<0.001*	*0.001*
Neck (g)	42.96±9^{a}	29.67±2.9^{b}	23.02±4.2^{c}	20.60±3.4^{c}	*<0.001*	*<0.001*
Back and ribs (g)	93.13±20.40^{a}	71.25±7.79^{b}	56.73±9.38^{c}	51.97±6.8c	*<0.001*	*<0.001*
Wings (g)	83±8.39^{a}	67.60±4.14^{b}	54.07±8.71^{c}	48.15±5.28^{d}	*<0.001*	*<0.001*
Giblets[f] (g)	42.73± 5.81^{a}	35.73± 5.49^{b}	22.42±3.25^{c}	21.61±3.96^{c}	*<0.001*	0.007

Abbreviations: (*) Mean ± SD, (a) the weight after bleeding, (b) calculated as differences between (BW) and (a), (c) the weight after bleeding and defeathering, (d) Weight of carcass with giblets and neck, (e) with skin, (f) the sum of (heart, liver and gizzard).
Means in the same row with a common superscript letter differ significantly at (p <0.005) or without superscript letter did not differ significantly at (p >0.005) based on Duncan's Multiple Range test at significant level of 0.05.

Table.2 Body characteristics of Northern pintail (*Anas acuta*) and Northern Shoveler (*Spatula clypeata*) [% of live weight] *

	Northern Pintail		*Northern Shoveler*		*P-Value*	
Traits	***Male (n=12)***	***Female (n=12)***	***Male (n=12)***	***Female (n=12)***	***Genotype (G)***	***Sex (S)***
Live body weight (g)	683.34±100.89[a]	536.33±41.91[b]	426.44±39.53[c]	389.51±50.91[c]	<0.001	<0.001
Blood[%]	4.30±0.40	4.72±0.25	4.72±0.42	4.75±0.63	*0.099*	*0.098*
Feather [%]	9.89±1.63	9.84±1.05	10.57±1.07	9.72±0.61	*0.392*	*0.181*
Feet [%]	1.95±0.21	1.77±0.11	1.76±0.17	1.78±0.13	*0.061*	*0.105*
Head [%]	5.77±0.73[b]	5.77±0.51[b]	8.33±0.63[a]	8.00±0.80[a]	*0.041*	*0.001*
Alimentary tract [%]	3.11±0.61	3.49±0.44	3.33±0.60	3.61±0.76	*0.354*	*0.071*
Carcass yield[a] [%]	74.96±2.57[a]	74.42±1.60[a]	71.37±1.19[b]	72.29±1.56[b]	*0.001*	*0.717*
Breast [%]	27.45±2.87	27.49±2.40	26.22±0.74	26.98±1.12	*0.493*	*0.531*
Leg and thighs [%]	9.14±1.16	8.91±0.36	8.74±0.78	8.67±0.73	*0.181*	*0.542*
Back and ribs [%]	13.55±1.34	13.29±1.10	13.30±1.83	13.35±0.65	*0.812*	*0.772*
Wings [%]	12.26±1.14	12.62±0.47	12.66±1.39	12.42±1.00	*0.746*	*0.823*
Neck[b] [%]	6.28±0.78[a]	5.54±0.41[b]	5.37±0.61[b]	5.28±0.45[b]	*0.001*	*0.017*
Gizzard[c] [%]	3.29±0.53[a]	3.46±0.67[a]	2.26±0.58[b]	2.24±0.32[b]	0.001	0.671
Liver [%]	1.85±0.32	2.02±0.61	1.86±0.19	2.07±0.41	0.842	0.123
Heart [%]	1.16±0.11	1.19±0.11	1.13±0.14	1.24±0.19	0.752	0.118

Abbreviations: (*) Mean ± SD, (a) With giblets, (b) With skin, (c) Without opening.
Means in the same row with a common superscript letter differ significantly at (p <0.005) or without superscript letter did not differ significantly at (p >0.005) based on Duncan's Multiple Range test at significant level of 0.05.

Table.3 Physical properties of Northern Pintail and Northern Shoveler meats. *

Traits	Northern Pintail Male	Northern Pintail Female	Northern Shoveler Male	Northern Shoveler Female	PValue Genotype (G)	PValue Sex (S)
pH 24						
BM	6.20±0.02	6.39±0.01	6.42±0.03	6.18±0.02	*0.884*	*0.333*
LM	6.67±0.03[b]	6.55±0.04[c]	6.75±0.05[a]	6.73±0.03[ab]	*<0.001*	*0.064*
WHC (%)						
BM	62.76±0.9	62.19±0.6	62.83±1	63.37±1.3	*0.060*	*0.330*
LM	66.36±0.8	65.74±0.7	66.49±0.9	66.16±0.4	*0.050*	*0.061*
L*						
BM	38.03±1.8	38.23±0.5	39.35±2.4	39.77±1.4	*0.180*	*0.757*
LM	40.84±0.7[b]	39.14±0.3[b]	43.34±0.7[a]	44.11±1.6[a]	*<0.001*	*0.423*
a*						
BM	16.54±0.7[a]	17.32±0.8[a]	11.19±0.8[b]	12.57±1.2[b]	*<0.001*	*0.065*
LM	14.73±0.5[a]	14.17±0.3[a]	10.71±0.5[c]	13.02±0.8[b]	*<0.001*	*0.051*
b*						
BM	5.31±0.5[a]	6.11±0.1[a]	2.06±0.4[b]	3.25±0.8[ab]	*0.012*	0.325
LM	6.17±0.7	4.28±0.2	4.73±0.7	5.65±0.6	*0.922*	0.198

Abbreviations: (*) Mean ± SD, (BM) breast muscles, (L+TM) leg with thigh muscles, (*L) lightness, (a*)redness, (b*) yellowness.**
Means in the same row with a common superscript letter differ significantly at (p <0.005) or without superscript letter did not differ significantly at (p >0.005) based on Duncan's Multiple Range test at significant level of 0.05.

Table.4 Proximate chemical composition andenergy value of Northern Pintail and Northern Shoveler meats. *

	Northern Pintail		Northern Shoveler		PValue	
traits	***Male***	***Female***	***Male***	***Female***	***Genotype (G)***	***Sex (S)***
Moisture (%)						
BM	58.80 ± 1.2[b]	59.62 ± 3.2[b]	68.71 ± 0.4[a]	68.89 ± 0.2[a]	*<0.001*	*0.620*
LM	59.89±2.6[b]	55.54±1.5[c]	69.15±0.8[a]	67.77±0.3[a]	*<0.001*	*0.200*
Protein (%)						
BM	22.06 ± 1	21.66 ± 0.2	23.63 ± 0.8	22.76 ± 1.6	*0.052*	*0.314*
LM	21.36±1.6	21.70±1.2	21.88±0.3	18.57±0.4	*0.053*	*0.033*
FAT (%)						
BM	18.77 ± 2[a]	17.69 ± 1.5[a]	5.61 ± 0.6[b]	5.89 ±0.2[b]	*<0.001*	*0.789*
LM	19.13 ± 2.5[a]	23.94 ± 2[a]	7.83 ± 0.4[b]	10.42 ± 2[b]	*<0.001*	*0.780*
Ash (%)						
BM	1.59 ± 0.1[a]	1.77 ± 0.2[a]	1.33 ± 0.1[b]	1.33 ± 0.01[b]	*0.001*	*0.182*
LM	1.32±0.1[b]	1.35±0.3[b]	1.78±0.3[a]	1.67±0.1[ab]	*0.011*	*0.744*
Energy value [kJ/100 g]						
BM	1074.80 ± 80[a]	1027.82 ± 65[a]	606.17± 10[b]	602.19 ±21[b]	*<0.001*	0.647
LM	1257.83 ± 46[a]	1082.71 ± 57[a]	660.53±13[b]	702.41±81[b]	*<0.001*	0.230

Abbreviations: (*) Mean ± SD, (BM) breast muscles minced with skin, (L+TM) leg with thigh musclesminced with skin.
Means in the same row with a common superscript letter differ significantly at (p <0.005) or without superscript letter did not differ significantly at (p >0.005) based on Duncan's Multiple Range test at significant level of 0.05.

Table.5 Mineral elements profile of Northern Pintail and Northern Shoveler meats mg / 100 g basis on dry weight.

Elements	*Northern Pintail*				*Northern Shoveler*			
	Male		*Female*		*Male*		*Female*	
	BM	**LM**	**BM**	**LM**	**BM**	**LM**	**BM**	**LM**
Potassium (K)	1045.50	1481.50	1060.50	1118	1183	1637	1086	987.50
Magnesium (Mg)	216	192	217	144	192	276	264	216
Sodium (Na)	77.10	122.35	102.70	148.90	109.25	159.35	94.90	100.70
Calcium (Ca)	40	60	59.60	40.03	39.16	60.11	59.70	59.90
Ferrum (Fe)	25.01	18.83	25.52	16.02	29.02	21.29	27.40	22.52
Zinc (Zn)	6.18	10.66	5.15	11.48	5.16	10.72	4.73	11.47
Manganese (Mn)	0.39	0.26	0.31	0.03	0.15	0.14	0.22	0.14
Copper (Cu)	2.22	1.04	2.77	1.01	2.11	0.67	2.07	0.63
Cobalt (Co)	0.15	0.14	0.19	0.41	0.42	0.40	0.53	0.47
Nickel (Ni)	0.47	0.41	0.71	0.58	0.57	0.83	0.65	0.63
Lead (Pb)	1.43	1.07	1.08	1.08	1.55	1.63	1.64	1.64
Cadmium (Cd)	0.11	0.06	0.05	0.07	ND	ND	ND	ND

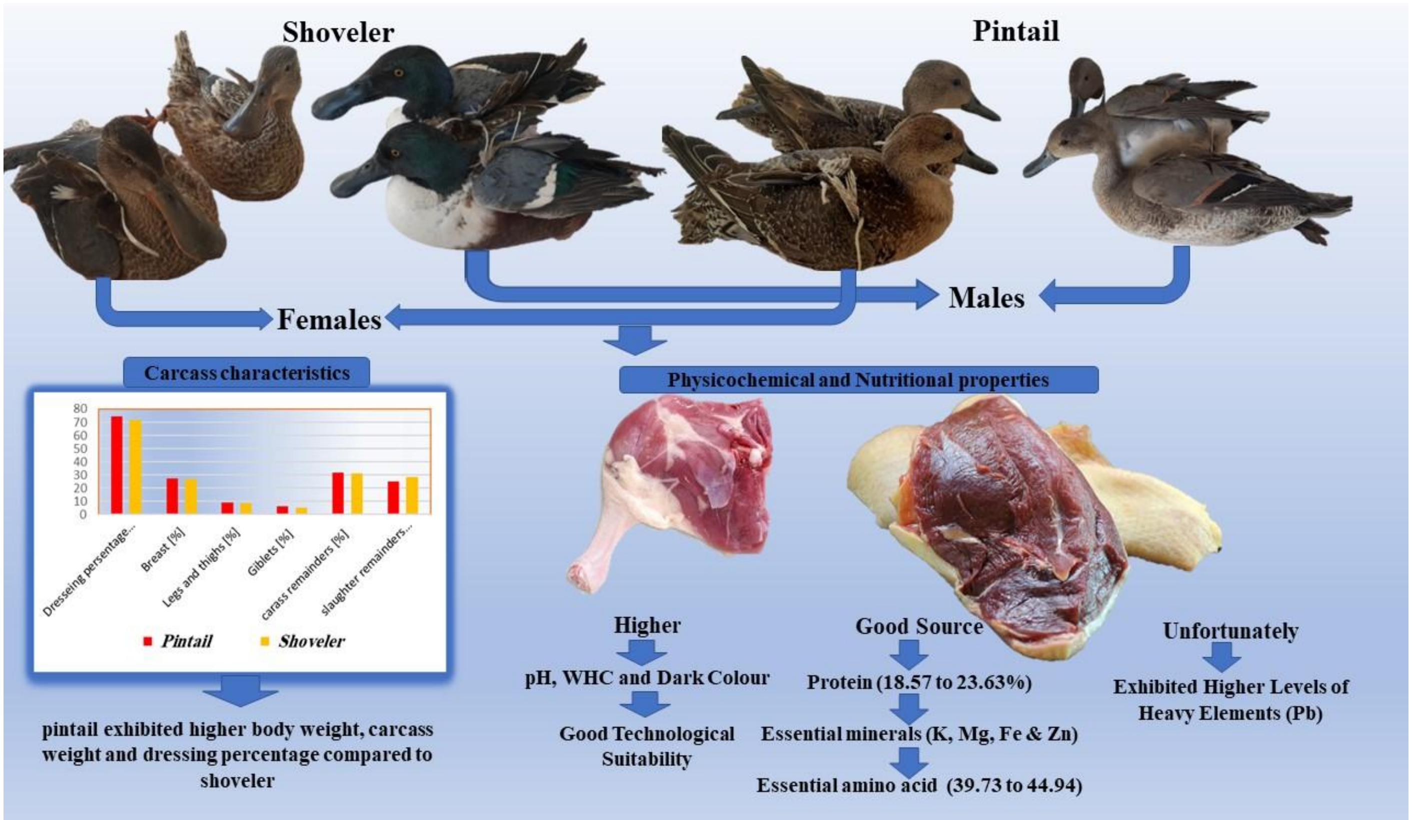
Abbreviations: BM- breast muscles, LM- leg muscles, ND- No detected

Table.6 Amino acid profile of Northern Pintail and Northern Shoveler meats.

Amino acids	*NorthernPintail*				*NorthernShoveler*			
	Male		*Female*		*Male*		*Female*	
	BM	**LM**	**BM**	**LM**	**BM**	**LM**	**BM**	**LM**
Threonine	5.56	4.58	4.76	5.37	3.02	2.91	2.76	4.78
Valine	7.99	6.65	6.65	6.04	6.74	6.36	6.69	5.93
Methionine	4.71	5.39	5.39	5.20	8.17	8.47	6.46	7.19
Isoleucine	2.21	2.93	2.24	2.55	1.41	2.00	1.47	1.62
Leucine	7.06	6.21	5.89	6.17	7.74	7.56	7.36	6.42
Phenylalanine	4.47	4.08	3.11	5.48	5.18	4.19	6.36	2.39
Lysine	9.48	13.11	11.69	13.64	11.17	13.45	10.70	13.13
Total EAA	41.48	42.95	39.73	44.45	43.43	44.94	41.80	41.46
Histidine	4.86	2.78	3.66	3.26	3.90	3.48	3.71	3.14
Arginine	4.72	4.00	3.35	4.59	4.38	2.46	3.69	3.63
Serine	5.14	6.59	4.33	4.43	4.55	4.42	5.14	3.85
Glutamic	11.98	11.39	12.99	12.60	12.33	14.00	13.78	13.16
Aspartic	8.78	10.06	7.57	6.30	8.20	6.63	8.44	7.60
Proline	1.64	2.27	2.34	2.96	2.31	2.12	1.81	2.22
Alanine	6.90	5.59	6.63	7.70	6.38	7.64	7.96	9.95
Cysteine	0.04	0.05	0.03	0.05	0.04	0.04	0.02	0.05
Tyrosine	3.64	2.64	4.24	3.55	3.42	3.20	2.54	3.33
Glycine	4.68	5.49	4.63	5.14	4.96	5.04	4.95	5.66
Totalnon-EAA	52.38	50.86	49.77	50.58	50.47	49.03	52.04	52.59
Totalamino acid	93.85	93.81	89.50	95.03	93.90	93.97	93.84	94.05
E/NE ratio	0.97	0.92	0.79	0.99	0.88	0.92	0.82	0.79

Abbreviations: BM- breast muscles, LM- leg muscles, E/NE ratio- Essential amino acid (EAA) /non-essential amino acid (non-EAA)

Fig.1 Graphical Abstract



The breast muscles of the studied birds were found to contain less Na, K and more content of Mg, Zn, and Fe compared to the breast muscles of game pheasants (*P. colchicus*) (Kokoszyński *et al.,* 2014).

These differences between game and farm birds could be a consequence of feeding styles (birds being supplied with this element or not and its availability in the natural environment) and living conditions, as well as the age and sex.

Toxic heavy metal concentrations were also investigated in the present study such as Lead, Cadmium and Nickel (on a dry weight basis mg/100g) of studied birds from breast and leg meats. The concentrations recorded a range of 1.07-1.64, ND-0.05 and 0.4-0.83, respectively. Lead concentrations in studied birds are lower than in other wild birds such as the Woodcock bird (0.59-0.89 mg /100gww), Turtledove bird (3.34 mg /100gww) and quail bird (9.85 mg /100gww) that investigated by Roselli *et al.,* (2016). Cadmium detected only in breast and leg muscles from pintail birds, its was concentrations are in agreement with that obtained by Aendo *et al.,* (2020), but it was higher than that obtained by Lucia *et al.,* (2008). The permissible limits of lead were 0.10 mg/kg ww and Cadmium 0.05 mg/kg ww established by EC, (2006) and thus, Pb and Cd exceeded maximum admissible levels.

Essential amino acids (EAA) contents of meat protein content are a critical factor for evaluating meat protein quality. Based on the majority of dieticians, typically amino acids which the human body is not able to produce eight EAA (leucine, lysine, valine, threonine, isoleucine, tryptophan, phenylalanine and methionine). Moreover, the proportion between nonessential and essential amino acids was 1.35:1 in fowl species meats that are considered an important resource of protein with a great profile of amino acids (Nedkov, 2004).

Therefore, in our study, amino acid profiles of the studied bird meats can see in Table (6). Regarding our results, there 17 amino acids were detected, comprehensive non-EAA and EAA except tryptophan and hydroxyproline. The total amino acid content in a range of 89.50-95.03 and 93.84-94.05 g/100 g protein in pintail and shoveler, respectively, of breast and leg muscles. Regarding ΣEAA in a range of 39.73-44.45 and 41.46-44.94 g/100 g protein, it was higher than that reported by Khalifa and Nassar, (2001) 34.3-38.1 g/100 g protein in wild ducks, but it was lower to that reported by Aronal *et al.,* (2012) 45.71- 49.16 g/100 g protein in domestic ducks. The EAA percentage in the protein of breast and leg muscles (13.64-9.48, 5.89-7.74, 4.73-8.52, 4.93-10.60, 5.93-7.99, 1.41-2.93 and 2.76-5.56 % for lysine, leucine, methionine + cysteine, phenylalanine + tyrosine, valine, isoleucine and threonine, respectively) are comparable to FAO/WHO which reported that the following percentages (5.5, 7, 3.5, 6, 5, 4 and 4 % for lysine, leucine, methionine + cysteine, phenylalanine + tyrosine, valine, isoleucine and threonine, respectively) of EAA should be present in standard protein, described by Ribarova *et al.,* (1987) and thus, in the present study had a higher percentage of eight EAA compared to a standard protein than recommended by FAO/WHO.

Generally, lysine (9.48-13.64), valine (6.04-7.99), leucine (5.89-7.06) and methionine (4.71-5.39) were the predominant among EAA in pintail bird meats against in shoveler birds' lysine (10.70-13.45), methionine (6.46-8.47), leucine (6.42-7.74) and valine (5.93-6.74) were the predominant among EAA. Such results are in agreement with the results of other fowl bird's meats Okruszek *et al.,* (2013) found that the predominant EAA of 17-wk-old geese recorded lysine (14.48), leucine (10.52), valine (6.18) and methionine (4.89). Furthermore, Haraf *et al.,* (2018) found that the predominant EAA of geese from four different Polish genotypes recorded lysine (13.0-14.6), and leucine (8.60-10.6), Valine (4.00-5.54) and Methionine (3.09-3.38). While, regarding non-EAA glutamic, Aspartic and Alanine were the predominant among non-EAA in pintail and shoveler bird meats. such results are in agreement with the results of Lorenzo *et al.,* (2011) who found that the main non-EAA of dry-cured duck breast were glutamic and aspartic acid. Moreover, the same observation was reported by Aronal *et al.,* (2012) who found that for domestic ducks the major non-EAA were glutamic, Aspartic, and Alanine. Furthermore, the results are in agreement with the results of Straková *et al.,* (2016) for wild feathered species meats, the highest levels of non-EAA in both breast and thigh muscles were represented by glutamic and Aspartic. Moreover, for wild duck meat Khalifa and Nassar, (2001) found that glutamic, Aspartic, arginine and Alanine presented the highest concentration of non-EAA. In addition, the E/NE ratio was recorded 0.79 to 0.99:1 in studied bird meats.

In summary, the pintail birds exhibited significantly higher body weight, carcass weight and dressing percentage compared to shoveler birds. Moreover, pintail birds exhibited the higher meat percentage including higher breast and leg muscles percentage compared to shoveler birds. The higher acidity, high water holding capacity and dark colour of the meat from two species is indicative of its higher technological suitability. Moreover, we conclude that wild pintail and shoveler are a good source of protein, essential and beneficial minerals as well as essential amino acids profile. Unfortunately, it is exhibited higher levels of heavy elements. The present study provides information about the carcass composition, physicochemical properties and nutritive value of wild bird's meat, which could be useful for consumers.

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Conflict of interest

The authors declare that there is no conflict of interest.

Abbreviations

WHC - Water holding capacity

CURP - Cairo University Research Park

AOAC - Association of official analytical chemists

HPLC - High-performance liquid chromatography

EC - European common regulation

EAA - Essential amino acid

FAO - Food and Agriculture Organization

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