JMBFS
Journal of Microbiology, Biotechnology and Food Sciences
International peer-reviewed scientific online journal

Published by Faculty of Biotechnology and Food Sciences

MEAT PERFORMANCE AND MEAT QUALITY OF WILD DUCKS (*ANAS PLATYRHYNCHOS*) REARED IN DOMESTIC CONDITIONS

Peter Haščík[1], Adriana Pavelková[1], Martin Fik[2], Ondřej Bučko[2]*

Address(es):
[1] Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Institute of Food Sciences, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia.
[2] Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, Institute of Animal Husbandry, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia.

*Corresponding author: peter.hascik@uniag.sk

https://doi.org/10.55251/jmbfs.11148

ARTICLE INFO

Received 18. 3. 2024
Revised 19. 9. 2024
Accepted 19. 9. 2024
Published xx.xx.201x

Regular article

OPEN ACCESS

ABSTRACT

The aim of the work was to evaluate the meat performance, colour and basic chemical composition (g.100 g^{-1} of water, protein, fat, and cholesterol) of the breast and thigh muscles (n=20) of the wild ducks reared in domestic conditions. The L* values of the wild ducks ranged from 32.86 (breast muscle) to 36.88 (thigh muscle). The a* value ranged from 10.70 (thigh muscle) to 11.96 (breast muscle). By evaluating the b* parameter, we observed a similar tendency as with the L* value. The highest b* values were measured in the thigh muscle (10.13) and lower in the breast muscle (7.49). The proportion of breast (36.41%) and thigh (21.33%) from the carcass weight of wild ducks is relatively high, and a high average carcass yield (74.03%) was also found. The water content varied from 71% (thigh muscle) to 72.52% (breast muscle). The average protein content of breast 24.11 g.100 g^{-1} and thigh muscle was 22.84 g.100 g^{-1}. The higher fat content was measured in breast muscle (1.82 g.100 g^{-1}) and lower (1.45 g.100 g^{-1}) in thigh muscle. The cholesterol content in meat from wild ducks ranged from 0.049 g.100 g^{-1} (thigh muscle) to 0.051 g.100 g^{-1} (breast muscle).

Keywords: wild duck, domestic condition, meat performance, chemical composition, colour

INTRODUCTION

Consumer interest in good nutrition and a healthy lifestyle has increased recently. Not only should meals satisfy our senses, but they should also be nutritionally sound **(Brückner *et al*., 2005; Lin & Chang, 2005; Makała, 2013)**. Due to the rise in cardiovascular diseases in persons who primarily consume beef meat, physicians recommended to decrease their intake of red meat and increase intake for chicken meat **(Pfeuffer, 2001.** Consequently, we can see a steady rise in the consumption of poultry meat in many different countries. Dietetic quality is becoming increasingly important, even for ducks, especially for carcasses with meat **(Işguzar, Kocak & Pingel, 2002; Wawro *et al*., 2004)**. The main purpose of keeping ducks is to provide meat. According to **Huang *et al*. (2013),** ducks are one of the most economically significant species of waterfowl in the world and a major source of high-quality protein for many people. In compared to other fowl, experts have paid little attention to duck meat. More options for consumers on a diet are now available thanks to the increased availability of duck cuts like breast and thighs in recent times. The process of killing a duck is often the same as that of a chicken. Duck is regarded as red meat since its breasts contain more red muscle fibre than those of chickens **(Smith *et al*., 1993)**. Consumers from various nations have recently expressed increasing interest in native breeds of waterfowl, particularly ducks, in their quest for new food products that are safe and good to eat **(Uhlířova *et al*., 2018)**.
Based on native poultry breeds, it is possible to produce quality and safe foods desired by consumers in many countries. The carcasses obtained from native ducks aged 8 weeks have a high content of breast muscle (12.9% to 15.8% meat) that is high in protein and low in fat and has a desirable profile of fatty acids rich in polyunsaturated fatty acid, including linoleic and arachidonic fatty acids **(Gornowicz & Książkiewicz, 2011; Muhlisin *et al*., 2013)**. China produced the most duck meat in 2022 (4,800,000 tonnes), followed by Vietnam and France in a comparison of 69 countries. Global output of duck meat reached 6,068,757 tonnes in 2022, according to FAOSTAT. This is 28.1% greater than ten years ago and 2.31% less than the prior year. The total amount of duck meat produced has historically ranged from 335,922 tonnes in 1961 to 6,209,141 tonnes in 2021. Since 1961, the average annual growth has been 4.86%. China was the top-ranked nation, producing 79.1% of the world's duck meat. In 2022, the 10 largest countries will make up approximately 91.5%, with the top 3 holding an 84% share **(URL 1)**.
The objective of our study was to evaluate the meat performance, colour and basic chemical composition of the breast and thigh muscles of wild duck meat reared in domestic conditions.

MATERIAL AND METHODS

In the experiment, 20 pcs wild duck (*Anas platyrhynchos*) (10 females, 10 males) was used as the biological material. The farm breeding wild ducks were 133 days old. Table 1 indicate composition of feed mixtures for wild duck. The wild ducks were euthanized and slaughtered in a permitted manner and transported in cooling boxes to the Institute of Food Sciences, SUA Nitra.

Slaughter and measurements

We then subjected the wild ducks (*Anas platyrhynchos*) carcasses to slaughtering. The wild ducks were slaughtered by conventional neck cut, bled, feathers removed, and eviscerated. Examined parameters in experiment were as follows: live body weight (BW) at the and fattening period (133 d); carcass weight (CW); giblets weight; liver weight; gizzard weight; heart weight; neck weight; abdominal fat; gizzard fat; breast part weight; thigh part weight; breast muscle weight; thigh muscle weight; wings part weight (all in g), and carcass yield (CY) (%).
All animals used in this study were handled following the national legislation on animal welfare **(DL n. 126, 07/07/2011, EC Directive 2008/119/EC)**. Wild ducks were slaughtered in compliance with **Regulation 1099/2009 of the European Union** on the protection of animals at the time of killing.

Chemical composition

For the basic chemical analysis of the muscle tissue, we took samples of muscle tissue from arguably the most valuable parts of the wild duck carcass **(Haščík *et al*., 2023)**, which were stored at a temperature of 4 °C.
After the carcass had been previously deboned, we collected 25 g samples from each of the separate muscles, which allowed us to obtain an average meat sample. This process produced an average sample of 50 g, which was utilised for chemical analysis. At the Slovak Centre for Agricultural Research in Nitra, we processed the chemical composition of the muscle using the Fourier transform infrared spectroscopy (FTIR), Nicolet 6700 instrument. We assessed the water, total proteins, crude fat, and cholesterol contents in a g.100 g^{-1} sample of meat.

Table 1 Feed mixtures composition for wild duck (kg.100 kg^{-1})

Ingredients	Feed supplied from 1st to 21st day	Feed supplied from 22st to 133st day
Wheat meal	55.40	57.60
Soybean meal (48% CP)	17.40	10.00
Maize	17.00	17.40
Rapeseed oil	1.00	1.60
Calcium carbonate	0.80	6.00
Dicalcium phosphate	2.00	2.00
Premix Euromix[1]	1.00	1.40
Fish meal (71% CP)	5.40	4.00
Nutrient content (g.kg^{-1})		
ME_N (MJ.kg^{-1})	11.89	12.34
Crude fibre	30.30	36.43
Crude protein	205.20	179.40
Lysine	10.85	9.33
Methionine + Cystine	8.45	7.52
Tryptophan	2.31	2.02
Threonine	7.05	6.45
Ca	9.98	8.78
P	5.21	4.07

Notes: CP = crude protein; Ca = calcium; P = phosphorus; ME_N = nitrogen-corrected metabolizable energy; MJ = megajoule; [1]active substances per kilogram of premix: vitamin A 15 000 IU; vitamin E 20 mg; vitamin D_3 2 000 IU; riboflavin 6 mg; cobalamin 20 µg; Mn 60 mg; Zn 40 mg; Fe 40 mg; Cu 6 mg; I 1 mg; Se 0.2 mg.

Meat colour measurement

Instrumental colour measurements of meat samples were performed using a spectrophotometer (Konica Minolta CM-2600d, Osaka, Japan) with the Specular Component Included (SCI) setting according to **Haščík *et al.* (2023)**.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) using SAS software (version 9.3, Enterprise Guide 4.2, USA). Tables show the results as the mean with standard deviation (SD) **(SAS, 2008)**.

RESULTS AND DISCUSSION

The results of the analysis of wild duck carcasses are presented in **Table 2**. Wild ducks (*Anas platyrhynchos*) are characterized by considerable sexual dimorphism, manifested not only by differences in plumage but also by differences in size between the sexes, including differences in body weight (BW), carcass weight and weight of different carcass parts. In our study, the average body weight of males was 1393.55 g and was 121.75 g higher than that of females (1271.80; P≥0.05; Table 2). Similar BW was reported for wild ducks caught during the hunting season in Hungary **(Szász *et al.*, 2006)** or in Czech Republic **(Abdullah & Buchtová, 2022)** and for 8-week-old ducks reared in a semi-intensive system **(Książkiewicz, 2006)**. A lower live weight in males (1174.30 g) and in females (1034.10 g) of wild ducks was found by **Janiszewski *et al.* (2018)**. The average carcass weight of males (830.80 g) was 70.64 g higher than the carcass weight of females (760.16 g; P≥0.05). Higher carcass weight was reported in 12-week-old farm-raised ducks **(Ismoyowati & Sumarmono, 2019)**, but **Abdullah & Buchtová (2022)** found average lower CW (626.50 g). The most valuable parts of the carcass are the breast and thighs, followed by the back, wings and neck. Such attractiveness criteria also apply to wild poultry carcasses. In our study, the proportion of breasts and thighs from CW (meat including skin, subcutaneous fat and bones) represented 57.80% of the total weight of carcasses in males and 56.67% in females. The weight of the breast part was higher in males than in females (305.72 g ♂ and 273.27 g ♀; P≤0.05), similarly it was also higher in the thigh part (174.78 g ♂ and 165.17 g ♀; P≥0.05). **Wnuk *et al.* (2014)** and **Janiszewski *et al.* (2018)**. found slightly lower weights of valuable parts than in our experiment but confirmed the tendency for the weight of slaughter times to be influenced by gender. **Murawska *et al.* (2011)** found that muscle tissue weights and the percentage of giblets in chickens during growth have an inverse connection. The weight of giblets of wild ducks was 197.98 g for males, which is 13.61 g more than for females (184.37 g). Lower weights (78.83 g) are declared in their work by **Abdullah & Buchtová (2022)**, respectively **Janiszewski *et al.* (2018)** found the weight of giblets in male mallard ducks at the level of 159.87 g, or in females 145.90 g.

Table 2 Meat performance of wild duck (g)

Parameter	♂	♀	*p-value* (♂ : ♀)
Live BW	1393.55±90.54	1271.80±41.41	0.092
CW	830.80±51.81	760.16±31.97	0.098
Giblets	197.98±21.07	184.37±5.88	0.365
Heart	9.45±0.66	8.90±0.75	0.352
Liver	23.50±2.50	23.43±2.61	0.975
Gizzard	37.63±3.08[a]	30.87±1.02[b]	0.014
Neck	127.40±17.13	121.17±2.87	0.598
Abdominal fat	19.52±6.98	22.80±9.91	0.628
Gizzard fat	4.20±2.70	2.73±1.09	0.453
Heart fat	1.03±0.44	1.30±0.51	0.496
Internal fats together	24.75±7.80	26.83±8.44	0.755
CY (%)	73.81±0.75	74.25±0.92	0.515
Breast part	305.72±13.92[a]	273.27±11.02[b]	0.017
Breast muscle	195.88±7.16[a]	177.337±11.19[b]	0.033
Thigh part	174.78±17.06	165.17±10.41	0.455
Thigh muscle	97.07±6.53	89.23±10.09	0.256
Wings	112.10±4.64	106.37±4.59	0.166
Breast part of CW (%)	36.86±1.39	35.96±0.96	0.407
Breast muscle of CW (%)	23.70±2.12	23.31±0.72	0.796
Thigh part of CW (%)	20.94±1.03	21.71±0.45	0.311
Thigh muscle of CW (%)	11.68±0.32	11.71±0.85	0.957

Notes: BW – live body weight; CW – carcass weight; CY – carcass yield; mean±SD (standard deviation); a, b = means significant differences between column (P≤0.05) determined with Duncan test.

Table 3 Chemical composition of wild duck breast and thigh muscles (g.100 g^{-1})

Parameter	♀	♂	*p-value* (♀:♂)
		Breast muscle	
Water	71.92±0.31[b]	73.12±0.51[a]	0.005
Total Protein	24.17±0.22	24.05±0.40	0.646
Crude Fat	1.62±0.16	2.01±0.42	0.161
Cholesterol	0.050±0.01	0.053±0.01	0.264
		Thigh muscle	
Water	70.46±0.42[b]	71.55±0.64[a]	0.027
Total Protein	22.90±0.44	22.78±0.31	0.668
Crude Fat	1.24±0.18[b]	1.66±0.18[a]	0.012
Cholesterol	0.050±0.01	0.048±0.01	0.645

Notes: mean±*SD* (standard deviation); a, b = means significant differences between column (P≤0.05) determined with Duncan test.

Significant differences (P≥0.05) were found between male and female wild ducks in the breast and thigh muscles chemical composition (**Table 3**). We found differences between genders (P≥0.05) in the water content in the pectoral muscle (73.12 g.100 g^{-1} - male: 71.92 g.100 g^{-1} female) and in the thigh muscle in the water content (71.55 g.100 g^{-1} - female: 70.46 g.100 g^{-1} male) and fat (1.66 g.100 g^{-1} - female: 1.24 g.100 g^{-1} male). In general, the values of the breast muscle chemical composition were higher than in the thigh muscle in both sexes of mallard **(Söderquist *et al.*, 2022)**.

The average protein content in our experiment was higher (24.11 g.100 g^{-1}) than in breast muscle of chickens and wild ducks according to **Ali *et al.* (2007)**. The average protein content in our experiment was higher (24.11 g.100 g^{-1}) than in breast muscle of chickens and wild ducks according to **Ali *et al.* (2007)**, but a similar protein content (24.35 g.100 g^{-1}) was found in the meat of wild ducks by **Söderquist *et al.* (2022)**.

The observed differences in fat content between the breast and thigh portions of meat are not consistent with those previously reported in wild ducks **(Cobos *et al.*, 2000; Nuernberg *et al.*, 2011)** and Peking ducks **(Kokoszyński, 2011; Kokoszyński *et al.*, 2019, 2020)**, where the biceps muscle was always leaner than the thigh muscle. The fat content for a portion of breast meat is in the range of values previously reported for wild ducks (ranging from 0.82 to 3.76 g.100 g^{-1} fresh meat). We found a slightly lower fat content in the thigh meat of mallard duck compared to the works of other authors (2.80 to 4 g.100 g^{-1} of fresh meat) **(Cobos *et al.*, 2000; Nuernberg *et al.*, 2011; Janiszewski *et al.*, 2018)**.

Cholesterol content in breast and thigh muscle was lower than that found in Peking duck breast and thigh portions (0.071– 0.112 g.100 g^{-1} breast meat and 0.065–0.117 g.100 g^{-1} thigh meat) **(Wołoszyn *et al.*, 2006, 2007)**. Compared to other poultry species, the cholesterol content of mallard breast was above the values reported for chicken and turkey breast meat (0.043–0.044 g.100 g^{-1}), while the cholesterol content of mallard thigh was lower than cholesterol in chicken and turkey thigh meat (0.072–0.084 g.100 g^{-1}) **(Chizzolini *et al.*, 1999; Dinh *et al.*, 2011)**. The

cholesterol content in the breast and thighs of the wild duck of our experiment is above the values found by other authors in different species of game fowl kept for hunting, such as common pheasant (*Phasianus colchicus*) and red-legged partridge (*Alectoris rufa*) **(Quaresma *et al*., 2016; Antunes *et al*., 2019)**. Considering the nutritional recommendations, the daily intake of cholesterol should not exceed 300 mg **(Krauss *et al*., 2000)**. Therefore, the intake of 100 g of duck breast or thigh meat represents almost 17 to 19% of the recommended maximum daily cholesterol intake.

Table 4 Evaluation of wild duck meat colour

Muscle	L*	a*	b*
Breast ♂	33.09±1.14	13.17±0.75[a]	8.10±1.19
Breast ♀	32.64±1.57	10.75±0.84[b]	6.88±0.31
p-value	0.648	0.003	0.112
Thigh ♂	36.37±2.30	9.98±1.61	10.06±1.17
Thigh ♀	37.38±1.13	11.42±1.23	10.20±0.75
p-value	0.487	0.212	0.857

Notes: mean±*SD* (standard deviation); a, b = means significant differences between column (P≤0.05) determined with Duncan test.

The colour has a key role during meat purchasing. It is considered to reflect the freshness and suitability of meat for certain culinary purposes **(Isguzar *et al*., 2002)**. The most obvious sign of physiological and biochemical alterations in muscle is the meat colour. Muscle quality is often indicated by the colour, pH, and drip loss of the meat. Muscle myoglobin content and fat deposition have an impact on muscle brightness values; red values indicate myoglobin content, while yellow values indicate the impact of ration pigments **(Kim *et al*., 2008)**. Numerous prior research investigations evaluating the colour of the pectoral muscle meat have demonstrated that the higher the muscle quality, the greater the a* value, the smaller the b* value, and vice versa, the smaller the L* value **(Wu *et al*., 2018; Wen *et al*., 2020)**. Un like in Korean native ducks and commercial ducks **(Lee *et al*., 2015)**, no significant differences (P≥0.05) in or colour of breast and thigh meat (L∗, b∗, **Table 4**) were found between male and female wild ducks. Our values of L reached 33.09% in males and 32.64% in females, and they were similar to those're ported by **Kim *et al*. (2008)** in Chungdong ori (*Anas platyrhynchos*) ducks, but higher than in Korean native ducks and commercial broiler ducks **(Muhlisin *et al*., 2013; Janiszewski *et al*., 2018)**. We found significant values (P≤0.05) only for the value a* in the pectoral muscle, where they were slightly higher in males (13.17) compared to females (10.75).

CONCLUSION

In conclusion, it can be concluded that wild ducks (*Anas platyrhynchos*) reared in domestic conditions are characterized by adequate meat yield for this type of waterfowl. The nutritional composition of valuable carcass parts reached a relatively high protein content and low fat content, respectively. cholesterol and for this reason this type of meat can be considered dietary and recommended to be included in the menu of the general public.

Acknowledgments: This work was supported with KEGA 001SPU-4/2023.

REFERENCES

Abdullah, F. A. A., & Buchtová, H. (2022). Quantitative and qualitative properties of giblets from conventional, organic, and wild ducks. *Acta Veterinaria* Brno, 91(1), 107-114. https://doi.org/10.2754/avb202291010107

Ali, Md. S., Kang, G.-H., Yang, H.-S., Jeong, J.-Y., Hwang, Y.-H., Park, G.-B., & Joo, S.-T. (2007). A Comparison of Meat Characteristics between Duck and Chicken Breast. *Asian-Australasian Journal of Animal Sciences*, 20(6), 1002-1006. https://doi.org/10.5713/ajas.2007.1002

Antunes, I. C., Coimbra, M. C. P., Ribeiro, A. P., Ferreira, J. D., Abade dos Santos, F., Alves, S. P., Bessa, R. J. B., & Quaresma, M. A. G. (2019). Nutritional value of meat lipid fraction from red-legged partridge (*Alectoris rufa*) obtained from wild and farmed specimens. *Poultry Science*, 98(2), 1037-1046. https://doi.org/10.3382/ps/pey367

Brückner, B., Schonhof, I., Kornelson, C., & Schrödter, R. (2005). Multivariate sensory profile of broccoli and cauliflower and consumer preference. *Italian Journal of Food Science*, 17(1).17-32.

Cobos, Á., Veiga, A., & Díaz, O. (2000). Chemical and fatty acid composition of meat and liver of wild ducks (*Anas platyrhynchos*). *Food Chemistry*, 68(1), 77-79. https://doi.org/10.1016/s0308-8146(99)00164-8

Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing http://data.europa.eu/eli/reg/2009/1099/oj

Dinh, T. T. N., Thompson, L. D., Galyean, M. L., Brooks, J. C., Patterson, K. Y., & Boylan, L. M. (2011). Cholesterol Content and Methods for Cholesterol Determination in Meat and Poultry. *Comprehensive Reviews in Food Science and Food Safety*, 10(5), 269-289. Portico. https://doi.org/10.1111/j.1541-4337.2011.00158.x

Gornowicz, E., & Książkiewicz, J. (2011). Why diversity is important–ducks. *Polish Poultry*, 10, 12-7.

Haščík, P., Pavelková, A., Čech, M., Jurčaga, L., Mesárošová, A. & Fik, M. (2023). Physicochemical evaluation of badger (*Meles Meles*) meat. *Journal of Microbilogy, Biotechnology and Food Sciences*, 13(3), e10423. https://doi.org/10.55251/jmbfs.10423

Huang, Y. H., Li, Y. R., Burt, D. W., Chen, H. L., Zhang, Y., Qian, W. B., et al. (2013). The duck genome and transcriptome provide insight into an avian influenza virus reservoir species. *Nature Genetics*, 45(7), 776-783. https://doi.org/10.1038/ng.2657

Chizzolini, R., Zanardi, E., Dorigoni, V., & Ghidini, S. (1999). Calorific value and cholesterol content of normal and low-fat meat and meat products. *Trends in Food Science & Technology*, 10(4-5), 119-128. https://doi.org/10.1016/s0924-2244(99)00034-5

Işguzar, E., Kocak, C., & Pingel, H. (2002). Growth, carcass traits and meat quality of different local ducks and Turkish Pekins (short communication). *Archives Animal Breeding*, 45(4), 413-418. https://doi.org/10.5194/aab-45-413-2002

Ismoyowati, & Sumarmono, J. (2019). Duck Production for Food Security. IOP Conference Series: Earth and Environmental Science, 372(1), 012070. https://doi.org/10.1088/1755-1315/372/1/012070

Janiszewski, P., Murawska, D., Hanzal, V., Gesek, M., Michalik, D., & Zawacka, M. (2018). Carcass characteristics, meat quality, and fatty acid composition of wild-living mallards (*Anas platyrhynchos L.*). *Poultry Science*, 97(2), 709-715. https://doi.org/10.3382/ps/pex335

Kim, G. D., Jeong, J. Y., Moon, S. H., Hwang, Y. H., Park, G. B., & Joo, S. T. (2008). Effects of muscle fibre type on meat characteristics of chicken and duck breast muscle. Proceedings of 54th International Congress of Meat Science and Technology South Africa: Capetown. pp. 124.

Kokoszyński, D. Evaluation of meat traits in commercial crossbreds of Pekin type ducks. Rozprawy. Uniwersytet Technologiczno-Przyrodniczy w Bydgoszczy. 2011, 147. (In Polish). Available online: http://wu.utp.edu.pl/uploads/oferta/147_Kokoszynski_Dariusz_Habilitacja_147.pdf (accessed on 9 August 2022).

Kokoszyński, D., Arpášová, H., Hrnčar, C., Żochowska-Kujawska, J., Kotowicz, M., & Sobczak, M. (2020). Carcass characteristics, chemical composition, physicochemical properties, texture, and microstructure of meat from spent Pekin ducks. *Poultry Science*, 99(2), 1232-1240. https://doi.org/10.1016/j.psj.2019.09.003

Kokoszyński, D., Wasilewski, R., Stęczny, K., Kotowicz, M., Hrnčar, C., & Arpášová, H. (2019). Carcass composition and selected meat quality traits of Pekin ducks from genetic resources flocks. *Poultry Science*, 98(7), 3029-3039. https://doi.org/10.3382/ps/pez073

Krauss, R. M., Eckel, R. H., Howard, B., Appel, L. J., Daniels, S. R., Deckelbaum, R. J., Erdman, J. W. Jr., Kris-Etherton, P., Goldberg, I. J., Kotchen, T. A., Lichtenstein, A. H., & Mitch, W. E. (2020). AHA Dietary Guidelines Revision 2000: A statement for healthcare professionals from the Nutrition Committee of the American Heart Association. *Circulation*, 102(18), 2284-2299.

Książkiewicz J. 2006. A mallard duck – *Anas platyrhynchos L*., means a flat-billed duck. *Wiad. Zoot*., 1: 25-30. (in Polish)

Lee, H. J., Jayasena, D. D., Kim, S. H., Kim, H. J., Heo, K. N., Song, J. E., & Jo, C. (2015). Comparison of Bioactive Compounds and Quality Traits of Breast Meat from Korean Native Ducks and Commercial Ducks. *Korean Journal for Food Science of Animal Resources*, 35(1), 114-120. https://doi.org/10.5851/kosfa.2015.35.1.114

Lin, C.-H., & Chang, C.-Y. (2005). Textural change and antioxidant properties of broccoli under different cooking treatments. *Food Chemistry*, 90(1-2), 9-15. https://doi.org/10.1016/j.foodchem.2004.02.053

Makała, H. (2013). Trendy w produkcji żywności wygodnej i przykłady jej zastosowania w turystyce wybrane aspekty. *Zeszyty Naukowe, Turystyka i Rekreacja*, 105-116.

Muhlisin, M., Kim, D. S., Song, Y. R., Kim, H. R., Kwon, H. J., An, B. K., Kang, C. W., Kim, H. K., & Lee, S. K. (2013). Comparison of Meat Characteristics between Korean Native Duck and Imported Commercial Duck Raised under Identical Rearing and Feeding Condition. *Korean Journal for Food Science of Animal Resources*, 33(1), 89-95. https://doi.org/10.5851/kosfa.2013.33.1.89

Murawska, D., Kleczek, K., Wawro, K., & Michalik, D. (2011). Age-related Changes in the Percentage Content of Edible and Non-edible Components in Broiler Chickens. *Asian-Australasian Journal of Animal Sciences*, 24(4), 532–539. https://doi.org/10.5713/ajas.2011.10112

Nuernberg, K., Slamecka, J., Mojto, J., Gasparik, J., & Nuernberg, G. (2011). Muscle fat composition of pheasants (*Phasianus colchicus*), wild ducks (*Anas platyrhynchos*) and black coots (*Fulica atra*). *European Journal of Wildlife Research*, 57(4), 795-803. https://doi.org/10.1007/s10344-010-0489-3

Pfeuffer, M. (2001). Physiologie effects of individual fatty acids in animal and human body, with particular attention to coronary heart disease risk modulation. *Archives Animal Breeding*, 44(1), 89-98. https://doi.org/10.5194/aab-44-89-2001

Quaresma, M. A. G., Pimentel, F. B., Ribeiro, A. P., Ferreira, J. D., Alves, S. P., Rocha, I., Bessa, R. J. B., & Oliveira, M. B. P. P. (2016). Lipid and protein quality of common pheasant (*Phasianus colchicus*) reared in semi-extensive conditions.

Journal of Food Composition and Analysis, 46, 88-95. https://doi.org/10.1016/j.jfca.2015.11.005
SAS. (2008) 9.3 Enhanced Logging Facilities, Cary, NC: SAS Institute Inc., 2008.
Smith, D. P., Fletcher, D. L., Buhr, R. J., & Beyer, R. S. (1993). Pekin Duckling and Broiler Chicken Pectoralis Muscle Structure and Composition. *Poultry Science*, 72(1), 202-208. https://doi.org/10.3382/ps.0720202
Söderquist, P., Olsson, C., Birch, K., & Olsson, V. (2022). Evaluation of Nutritional Quality and Sensory Parameters of Meat from Mallard and Four Species of Wild Goose. *Foods*, 11(16), 2486. https://doi.org/10.3390/foods11162486
Szász, S., Sugár, L., Pőcze, O., Ujvári, J., & Taraszenkó, Zs. (2006). Some slaughter characteristics of the mallard (*Anas p. platyrhynchos, L.* 1758). *Acta Agr. Kaposvár*, 10, 321-323.
Uhlířová, L., Tůmová, E., Chodová, D., Vlčková, J., Ketta, M., Volek, Z., & Skřivanová, V. (2018). The effect of age, genotype and sex on carcass traits, meat quality and sensory attributes of geese. *Asian-Australasian Journal of Animal Sciences*, 31(3), 421-428. https://doi.org/10.5713/ajas.17.0197
URL1 https://www.helgilibrary.com/charts/which-country-produces-the-most-duck-meat/
Wawro, K., Wilkiewicz-Wawro, E., Kleczek, K., & Brzozowski, W. (2004). Slaughter value and meat quality of Muscovy ducks, Pekin ducks and their crossbreeds, and evaluation of the heterosis effect. *Archives Animal Breeding*, 47(3), 287-299. https://doi.org/10.5194/aab-47-287-2004
Wen, Y. Y., Liu, H. H., Liu, K., Cao, H. Y., Mao, H. G., Dong, X. Y. & Yin, Z. Z. (2020). Analysis of the physical meat quality in partridge (*Alectoris chukar*) and its relationship with intramuscular fat. *Poultry Science*, 99(2), 1225-1231. https://doi.org/10.1016/j.psj.2019.09.009
Wnuk, A., Łukasiewicz, M., Mroczek – Sosnowska, N., Niemiec, J., Popczyk, B., & Balcerak, M. (2014). Carcass analysis and basic chemical composition of mallard duck meat (*Anas platyrhynchos*). In: Proceedings of the XXVI International Poultry Symposium PB WPSA, Kazimierz Dolny nad Wisłą, Poland. September 08–09. pp. 190-191.
Wołoszyn, J**.,** Książkiewicz, J**.,** Skrabka-BŁotnicka, T**.,** Haraf, G**.,** Biernat, J., & Szukalski, G. (2007). Chemical composition of leg muscles of six ducks strains. *Medycyna Weterynaryjna*, 63(6), 658-661.
Wołoszyn, J., Książkiewicz, J., Skrabka-Błotnicka, T., Haraf, G., Biernat, J., & Kisiel, T. (2006). Comparison of amino acid and fatty acid composition of duck breast muscles from five flocks. *Archives Animal Breeding*, 49(2), 194-204. https://doi.org/10.5194/aab-49-194-2006
Wu, S., Jiang, B. Y., Song, Z. H., Hou, D. X., Shi, S. R. & He, X. (2018). Effects of botanical polyphenol on antioxidant capacity, intestinal morphology, and meat quality of yellow broilers. *Chinese Journal of Animal Nutrition*, 30(12), 5118-5126.