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THE EFFECT OF AGE ON THE QUALITY OF BROILER DUCK MEAT

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Abstract. The aim of the study was to evaluate selected quality characteristics of duck meat depending on the age of the ducks. The material consisted of 100 Pekin – STAR 53 H.Y. crossbred meat ducks of French origin. The ducks were reared for 8 weeks. During the entire period they were reared in an intensive system as broilers. The breast muscles contained from 22.15% to 23.34% crude protein, and the content of this component increased slightly with the age of the ducks. There was a marked increase in crude fat content in these muscles. The leg muscles of the ducks contained less crude protein than the breast muscles (from 21.03% to 22.34%) and markedly more crude fat (from 4.17% to 6.80%). No changes were observed in cholesterol content in the muscles in successive weeks of rearing; only an increasing tendency was noted for cholesterol content as fat content increased in the muscles. The breast muscles contained on average from 2 to 22 µg of retinol and from 10 to 28 µg of gamma-tocopherol per 100 g of muscle tissue, while the leg muscles contained from 10 to 22 µg of retinol and from 10 to 30 µg of gamma-tocopherol. As in the breast muscles, age was not found to affect retinol content in the leg muscles, but the amount of gamma-tocopherol in the leg muscles changed in a reverse in direction as in the breast muscles, i.e. it increased with the age of the ducks. The lipids of the breast muscles of the ducks in weeks 6, 7 and 8 of rearing contained from 46.0% to 47.8% saturated fatty acids (SFA) and from 52.2% to 54.0% unsaturated fatty acids (UFA). An increase was observed in the share of UFA and a decrease in that of SFA between the ages of 6 and 8 weeks. The leg muscles contained markedly less SFA and more UFA than the breast muscles.

Key words: meat quality, fatty acids, vitamins, broiler duck age, Pekin.

INTRODUCTION

Rearing of meat ducks is aimed at obtaining the best possible quality of raw carcass material, mainly muscle tissue. This is determined by the quantity and quality of protein, fat, cholesterol, minerals and vitamins. In recent years consumers have become very interested in these features. For this reason studies aimed at characterizing the microstructure of muscles and the chemical composition of duck meat are fairly numerous in Poland and abroad (Smith et al. 1993; Bons et al. 1998; Mazanowski et al. 2003; Mazanowski and Bernacki 2004; Adamski 2005; Wołoszyn et al. 2005). The chemical composition of the muscles, their nutritional value, and their sensory characteristics depend on numerous factors, including the origin of the ducks (Haraf et al. 2009), their diet (Balevi et al. 2001), age (Witak 2008), and muscle type (Chartrin et al. 2005, 2006; Witkiewicz et al. 2006). The

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results obtained by these authors indicate that duck meat has high nutritional value, i.e. a beneficial chemical composition, high content of protein and vitamins, and good digestibility. Pekin ducks of French origin, particularly Star 53 H.Y. crossbreds, are currently raised on a large scale in Poland. The meat obtained from these ducks is becoming more popular every year. This provides the justification for the present study, which was aimed at evaluating selected quality characteristics of the meat of ducks depending on their age.

MATERIAL AND METHODS

The material for the study consisted of 100 Pekin – STAR 53 H.Y. crossbred meat ducks of French origin. The ducks were reared for 8 weeks. During this entire period they were reared in an intensive system as broilers, kept in an enclosed facility in accordance with standards applicable to ducks. The conditions in which the ducks were kept during the study period are presented in Table 1.

Table 1. Conditions for ducks during the rearing period.

	Rearing period [weeks]		
	0–3	4–6	7
Density [duck/m^2]	10	8	5
Temperature [ºC]	week 1 – 30–32 week 2 – 30–25 week 3 – 22–20	18	18
Length of feeder edge [cm^2/duck]	7.0	15.0	15.0
Length of drinking trough edge [cm^2/duck]	1.5	3.0	3.5
Length of daylight [h/day]	week 1 – 24 week 2 – 18 week 3 – 16	14	14
Illuminance [lx]	35	25	25
Type of feed	complete feed mixture I	complete feed mixture II	complete feed mixture III
Form of mixture	Pellets		
Feeding system	*Ad libitum*		

Floor covered with straw litter in the form of chaff.

The birds received *ad libitum* complete feed mixtures with varying nutritional value (Table 2). In each week of rearing 10 ducks were randomly selected for slaughter. A total of 80 ducks were slaughtered. The head, shanks, inedible organs, and edible organs (heart, liver and gizzard) were separated and weighed on an electronic scale (to within 1 g). Dressing percentage was determined from the body weight of the duck before slaughter and the gutted carcass weight. After gutting, the carcasses were chilled at 8ºC for 24 h. Then the carcasses were dissected into tissue components. From each carcass the skin together with the subcutaneous and abdominal fat, the breast muscles, leg muscles (thigh and shank) and the remainder of the carcass (bones) were separated and weighed. At the same time, samples were taken from the muscles for chemical analysis, conducted by standard methods:

– dry matter by the oven-dry method according to PN-ISO 1442:2000,
– crude protein by Kjeldahl's method according to PN 75/A-04018,

– crude fat by the Soxhlet method according to PN-ISO 1444:2000,
– ash by combustion in a furnace at 550ºC according to PN-ISO 936:2000,
– retinol and gamma-tocopherol by high-performance liquid chromatography (HPLC),
– fatty acid profile by gas chromatography,
– quantitative determination of cholesterol by a modification of the Liebermann-Burchard calorimetric method.

Table 2. Nutritional value of complete compound feeds used in the diet of ducks and drakes during the rearing period

	Complete feed – period of use [weeks]		
	I	II	III
	0–3	4–6	7–8
Dry matter [%]	91.87	92.05	91.86
Crude protein [%]	22.10	19.66	17.31
Crude fibre [%]	3.96	4.67	5.31
Crude fat [%]	3.85	2.62	2.57
Crude ash [%]	5.71	5.00	4.63
Calcium [%]	0.95	0.90	0.88
Available phosphorus [%]	0.71	0.61	0.50
EM_n [kcal/kg]	2935	2988	2960

Statistical differences between the samples were tested using Tukey's test and ANOVA (STATISTICA version 10.0, StatSoft Inc., PL). The level of significance was set at $P \leq 0.05$ or $P \leq 0.01$.

RESULTS AND DISCUSSION

In successive weeks of rearing the amount of water in the breast muscles was found to continually decrease, from 75.30% in the first week to 71.20% in the eighth week of rearing (Table 3).

Table 3. Chemical composition of breast muscles

Week	Chemical composition				
	water [%]	crude protein [%]	crude ash [%]	crude fat [%]	cholesterol [mg/100g]
1	75.30 ± 4.21^a	22.48 ± 2.66	1.00 ± 0.02	2.09 ± 0.65^b	80.67 ± 5.09
2	74.96 ± 6.11^a	22.15 ± 1.11^b	0.93 ± 0.33	2.22 ± 1.03^b	81.13 ± 4.07
3	74.34 ± 3.32	22.30 ± 0.98	0.99 ± 0.07	2.44 ± 0.16^b	86.48 ± 5.12^a
4	73.38 ± 4.11	22.26 ± 3.13	0.98 ± 1.02	3.39 ± 0.21	82.88 ± 7.07
5	73.40 ± 4.02	23.01 ± 4.11	1.01 ± 0.03	2,82 ± 0.22	79.91 ± 6.21^b
6	72.01 ± 5.01	22.96 ± 2.99	0.94 ± 0.04	3.96 ± 0.31^a	86.47 ± 5.97^a
7	71.57 ± 3.87^b	22.98 ± 1.04^a	1.04 ± 0.02	4.54 ± 0,41^a	87.32 ± 8.02^a
8	71.20 ± 4.09^b	23.34 ± 4.02^a	0.99 ± 0.11	4.47 ± 0.02^a	84.76 ± 4.98

Mean values in columns marked with different letters differ significantly: a, b – $P \leq 0.05$.

In a study by Kokoszyński (2011), the muscles of 7-week-old Star 53 H.Y. ducks contained 74.0–75.5% water, while in an experiment by Mazanowski and Bernacki (2004) the breast muscles of ducks of the P66 and P77 strains contained 77.5% and 77.6%, respectively, and Smith et al. (1993) reported water content of 77.7%. Thus the relatively low water content in the breast muscles of the 5-, 6-, 7- and 8-week-old ducks indicates a somewhat higher content of nutrient substances in the birds as compared to those evaluated by the authors cited above. The breast muscles contained from 22.15% to 23.34% crude protein, with a slight increase observed in the content of this nutrient as the ducks grew older. A fairly pronounced increase in crude fat was noted in the in muscles, from 2.09% in the youngest ducks to 4.47% in the 8-week-old ducks. The level of ash remained at a similar level at all evaluation times.

The results for crude protein content were markedly higher than those reported by some authors (Mazanowski and Bernacki 2004; Mazanowski and Książkiewicz 2004), but similar to those obtained by Bons et al. (1998) and Bernacki et al. (2006). Kokoszyński (2011), in an analysis of the chemical composition of the breast muscles of 7-week-old ducks of varying origin, found that these muscles contained on average from 18.9% to 20.1% crude protein in Star 53 H.Y, AP54, PP54 and PP45 ducks, with the lowest content noted in the muscles of the Star 53 H.Y. ducks. The results for protein content in the breast muscles of the ducks were similar to those obtained by Bernacki et al. (2006). In the case of fat content in the breast muscles, our results were markedly higher than in studies by other researchers in Poland and abroad (Bons et al. 1998; Mazanowski et al. 2003; Witak 2008; Kokoszyński 2011). Cholesterol content in 100g of breast muscle tissue ranged from 79.91 to 87.32 mg. No changes were observed in cholesterol content in the muscles in successive weeks of rearing, but only a tendency for cholesterol to increase with the fat content in the muscles. The results are similar to those obtained by other researchers (Honikel and Arneth 1996), but much lower than in a study by Baéza et al. (1999). Wołoszyn et al. (2006) reported cholesterol content in the breast muscles of ducks from K2 and P33 flocks at an average level of 95–100 mg/100 g of meat. Łukaszewicz et al. (2011) noted cholesterol content of 174.6 mg/100 g of tissue in the breast muscles of P55 ducks. In a study by Orkusz (2015), the cholesterol content in the breast muscles of turkeys was 58.06 mg/100 g and in chickens 47–83 mg/100 g.

Table 4 presents results for the chemical composition of the leg muscles in successive weeks. They show that the leg muscles of the ducks contained less water than the breast muscles (73.25% in the first week and 69.73% in the eighth), less crude protein (21.03% in the first week and 22.34% in the eighth) and markedly more crude fat (4.17% in the first week and 6.80% in the eighth). The crude fat content was greater than in studies by Mazanowski and Książkiewicz (2004), Adamski (2005) and by Witak (2008). In an experiment by Kokoszyński (2011), the leg muscles of 7-week-old Star 53 H.Y. ducks contained 72.5% water, 18.0% crude protein and 5.1% crude fat. In these studies the leg muscles contained from 107.34 to 112.22 mg of cholesterol per 100g. In the present study, the cholesterol content in the leg muscles was similar to that noted in the breast muscles (Table 4), ranging from 76.11 to 90.25 mg/100 g of muscle tissue. Wołoszyn et al. (2006) reported mean cholesterol content of 111.82 mg/100 g of meat in the leg muscles of K2 and

P33 ducks, while Kowalska et al. (2012) obtained an average cholesterol content of 78.93 mg/100 g in the leg muscles of 6-week-old broiler chickens. In a study by Orkusz (2015), the cholesterol content in the thigh muscles of turkeys was on average 64.01, and in chickens 72–83 mg/100 g of muscle tissue.

Table 4. Chemical composition of leg muscles (thigh and drumstick)

Week	Chemical composition				
	water [%]	crude protein [%]	crude ash [%]	crude fat [%]	cholesterol [mg/100g]
1	73.25 ± 4.05[a]	21.03 ± 2.08[b]	0.95 ± 0.02	4.17 ± 0.93	83.51 ± 7.98
2	70.16 ± 5.01	21.35 ± 2.00	1.13 ± 0.34	6.43 ± 0.11[a]	86.43 ± 10.67
3	73.15 ± 3.99[a]	22.05 ± 1.98	1.00 ± 0.03	3.43 ± 0.21[b]	76.11 ± 7.98[b]
4	71.33 ± 4.12	22.10 ± 0.67	1.03 ± 0.17	5.01 ± 1.17	85.19 ± 8.54
5	70.22 ± 3.76	22.40 ± 3.02[a]	1.21 ± 0.23	6.11 ± 1.56	87.55 ± 10.01
6	71.10 ± 5.03	22.10 ± 1.77	0.99 ± 0.04	5.46 ± 0.88	89.63 ± 9.00
7	70.45 ± 2.31	22.31 ± 3.08	1.05 ± 0.01	6.09 ± 0.98[a]	90.25 ± 8.08[a]
8	69.73 ± 4.66[b]	22.34 ± 2.55	1.10 ± 0.34	6.80 ± 0.43[a]	86.11 ± 3.98

Mean values in columns marked with different letters differ significantly: a, b – $P \leq 0.05$.

Apart from the content of basic nutrients in the muscle tissue of poultry, increasing attention is given to its vitamin content, mainly vitamins A and E. Vitamin E is the name of a group of fat-soluble organic chemical compounds including tocopherols (T) and tocotrienols (T3) (Zielińska and Nowak 2014). In the human body vitamin E mainly functions as an antioxidant. Its prevents the formation of lipid autoxidation products by scavenging free radicals, thereby precluding the chain reaction which leads to further formation of peroxides. The main sources of tocopherols in the human diet are vegetable oils, meat, milk and eggs.

According to Koreleski and Świątkiewicz (2008), animal products may be sources of vitamin E in the human diet, particularly if the animals' feed is enriched with increased amounts of this vitamin. In meat of chickens receiving increased levels of vitamin E the concentration of α-tocopherol was found to increase in the heart, thigh muscles, liver and breast muscles (Sheehy et al. 1991).

Animal meat contains relatively little vitamin A, but it should not be overlooked in evaluating the nutritional value of meat (Kowalska et al. 2012). Numerous studies (Jensen et al. 1998; Gatellier et al. 2000; Sammet et al. 2006) indicate that feed enriched with tocopherols also exerts a beneficial effect on performance parameters, meat quality, and its nutritional value. According to Barroeta (2007), vitamin E retention in poultry meat is strongly influenced by PUFA content in the compound feed; when the level of PUFA in the feed ration increases, the content of α-tocopherol in the meat of chickens decreases, mainly during storage.

In the our study, the breast muscles contained on average from 2 to 22 µg of retinol and from 10 to 28 µg of gamma-tocopherol per 100 g of muscle tissue (Table 5). No tendency was observed for retinol content depending on age, although it was highest in the 7- and 8-week-old ducks. The amount of gamma-tocopherol in the breast muscles decreased as the ducks grew older. The leg muscles contained from 10 to 22 µg of retinol and from 10 to

30 µg of gamma-tocopherol in 100 grams of muscle tissue (Table 5). As in the breast muscles, age was not found to affect the content of retinol in the leg muscles, but the amount of gamma-tocopherol in the leg muscles changed in a reverse in direction as in the breast muscles, i.e. it increased with the age of the ducks. In a study by Kowalska et al. (2012), the leg muscles of 6-week-old broiler chickens contained on average 0.129 mcg/g of vitamin A and 4.222 mcg/g of vitamin E.

Table 5. Selected vitamins in duck muscles [µg/100g]

Week	Breast muscles		Leg muscles	
	retinol	gamma-tocopherol	retinol	gamma-tocopherol
1	14 ± 1.66	26 ± 7.02^{a}	10 ± 3.00^{b}	22 ± 4.11^{a}
2	12 ± 1.09	22 ± 5.01	14 ± 1.99^{b}	16 ± 3.12^{a}
3	10 ± 0.98^{b}	22 ± 3.33	20 ± 3.93^{a}	10 ± 2.11^{Bb}
4	10 ± 1.16^{b}	28 ± 8.32^{a}	18 ± 0.99	24 ± 3.05^{a}
5	11 ± 2.01^{b}	12 ± 0.88^{b}	10 ± 4.14^{b}	28 ± 1.88^{A}
6	10 ± 2.05^{b}	14 ± 3.45^{b}	14 ± 2.77^{b}	26 ± 3.21^{a}
7	22 ± 4.87^{a}	12 ± 4.04^{b}	22 ± 6.07^{a}	30 ± 0.77^{A}
8	21 ± 5.07^{a}	10 ± 1.88^{b}	16 ± 3.03	28 ± 5.04^{A}

Mean values in columns marked with different letters differ significantly: a, b – $P \leq 0.05$; A, B – $P \leq 0.01$.

Poultry meat, including duck meat, in contrast with the meat of other livestock animals, contains more unsaturated than saturated fatty acids. A study by Witkiewicz and Kontecka (2002) showed that the origin and sex of ducks affected the fatty acid content in their breast muscles. An effect of origin on fatty acid composition has also been confirmed by Wołoszyn et al. (2005) and Kokoszyński (2011). A study by Kiss et al. (1995) found that diet affected the fatty acid profile in the muscle tissue of ducks. The results of the present study for the fatty acid profile of the lipids of the breast muscles and leg muscles are presented in Tables 6 and 7. The breast muscle lipids of the ducks at the age of 6, 7 and 8 weeks contained from 46.0% to 47.8% saturated fatty acids (SFA) and from 52.2% to 54.0% unsaturated fatty acids (UFA). An increase in the proportion of UFA and a decrease in that of SFA were observed between 6 and 8 weeks of age.

In a study by Witak (2008), the breast muscles of ducks in weeks 7 and 8 of rearing contained 26.42% and 24.13% saturated fatty acids (SFA), respectively, and 37.88% and 40.15% unsaturated fatty acids (UFA), of which monounsaturated fatty acids (MUFA) accounted for 30.72% and 33.07% and polyunsaturated fatty acids (PUFA) for 7.16% and 7.08%. In an experiment by Witkiewicz and Kontecka (2002), the percentage of monounsaturated fatty acids in the breast muscles ranged from 50.4% to 55.7% in male ducks and from 49.9% to 52.3% in females, while the average percentage of polyunsaturated fatty acids was 12.3% and that of saturated fatty acids was 32.9–35.4%. The ratio of UFA to SFA ranged from 1.06 to 1.20 and the SFA to PUFA ratio from 3.09 to 4.38. The leg muscles of the ducks contained a markedly lower proportion of saturated fatty acids (41.6–43.0%) than the breast muscles and a higher percentage of unsaturated fatty acids (57.0–58.4%) – Table 7. The quantity of monounsaturated fatty acids was nearly three times greater than that of polyunsaturated fatty acids. The UFA to SFA ratio ranged from 1.33 to 1.40, and the

SFA to PUFA ratio from 2.96 to 3.19. The latter ratio was smaller than in the breast muscles. Witak (2008) reported that the leg muscles of ducks in the 7th and 8th week of rearing contained 22.79% and 23.54% saturated fatty acids (SFA), respectively, and 49.72% and 51.38% unsaturated fatty acids (UFA), of which monounsaturated fatty acids (MUFA) accounted for 34.88% and 38.74% and polyunsaturated fatty acids (PUFA) for 14.84% and 12.64%.

Table 6. Fatty acids in the lipids of breast muscles

Trait	Week		
	6	7	8
Saturated fatty acids (SFA) [%]	47.8	46.7	46.0
Unsaturated fatty acids (UFA) [%]	52.2	53.3	54.0
Monounsaturated fatty acids (MUFA) [%]	41.2	41.8	42.2
Polyunsaturated fatty acids (PUFA) [%]	11.1	11.5	11.8
UFA/SFA ratio	1.09	1.14	1.17
SFA/PUFA ratio	4.31	4.06	3.90

Table 7. Fatty acids in the lipids of thigh and drumstick muscles

Trait	Week		
	6	7	8
Unsaturated fatty acids (UFA) [%]	57.0	58.4	58.0
Saturated fatty acids (SFA) [%]	43.0	41.6	42.0
Monounsaturated fatty acids (MUFA) [%]	43.5	44.4	44.7
Polyunsaturated fatty acids (PUFA) [%]	13.5	14.01	13.3
UFA/SFA ratio	1.33	1.40	1.38
SFA/PUFA ratio	3.19	2.96	3.16

CONCLUSIONS

As the ducks grew older there was a slight increase in the content of crude protein in the muscles and a pronounced increase in crude fat. The leg muscles of the ducks contained less crude protein and much more crude fat than the breast muscles. No effect of age on cholesterol or retinol was noted in either the breast muscles or the leg muscles, while the amount of gamma-tocopherol in the leg muscles changed in a reverse in direction as in the breast muscles, i.e. it increased with the age of the ducks. The muscles were characterized by a beneficial fatty acid profile, with the leg muscles containing markedly less saturated fatty acids and more unsaturated fatty acids than the breast muscles.

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WPŁYW WIEKU NA JAKOŚĆ MIĘSA KACZEK BROJLERÓW

Streszczenie. Celem badań była ocena wybranych cech jakościowych mięsa kaczek w zależności od ich wieku. Materiał doświadczalny stanowiło 100 osobników mieszańców mięsnych kaczek typu Pekin – Star 53 H.Y., pochodzenia francuskiego. Odchów trwał 8 tygodni. Przez cały okres ptaki odchowywano systemem intensywnym jako brojlery. Mięśnie piersiowe zawierały od 22,15 do 23,34% białka ogólnego, przy czym zaobserwowano nieznaczne zwiększanie się tego składnika w mięśniach wraz z wiekiem kaczek. Z kolei dość wyraźnie zwiększała się zawartość tłuszczu surowego w badanych mięśniach. Mięśnie nóg kaczek, w porównaniu z mięśniami piersiowymi, zawierały mniej białka ogólnego (od 21,03 do 22,34%) i wyraźnie więcej tłuszczu surowego (od 4,17 do 6,80%). Nie zaobserwowano zmian w zawartości cholesterolu w badanych mięśniach w kolejnych tygodniach odchowu ptaków, a jedynie tendencję do zwiększania się zawartości tego składnika wraz ze zwiększaniem się zawartości tłuszczu w mięśniach. Mięśnie piersiowe zawierały średnio od 2 do 22 µg retinolu i od 10 do 28 µg/100 g tkanki mięśniowej gamma-tokoferolu, mięśnie nóg zawierały odpowiednio od 10 do 22 µg retinolu i od 10 do 30 µg gamma-tokoferolu. Podobnie jak w przypadku mięśni piersiowych, również w przypadku mięśni nóg nie ustalono wpływu wieku na zawartość retinolu, natomiast ilość gamma-tokoferolu w mięśniach nóg zwiększała się wraz z wiekiem kaczek. Lipidy mięśni piersiowych kaczek w 6, 7 i 8 tygodniu odchowu zawierały od 46.0 do 47.8% nasyconych kwasów tłuszczowych (SFA) oraz od 52,2 do 54,0% nienasyconych kwasów tłuszczowych (UFA). Zaobserwowano zwiększanie się udziału kwasów UFA, a zmniejszanie SFA wraz z wiekiem kaczek, tj. między 6 a 8 tygodniem życia ptaków. Mięśnie nóg, w porównaniu z mięśniami piersiowymi kaczek, zawierały wyraźnie mniej nasyconych, a więcej nienasyconych kwasów tłuszczowych.

Słowa kluczowe: jakość mięsa, kwasy tłuszczowe, witaminy, wiek, kaczka brojler, Pekin.