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Chemical composition of leg muscles of six ducks strains

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Summary

The objective of the study was to compare the chemical composition of leg muscles of six duck strains. A total of 60 drakes out of four flocks of conservative (Miniduck K2, Polish Pekin P33-native, Pekin population-typeA3, synthetic Polish flock SB) and two breeding strains (A55, P66), aged seven weeks, were used for the study. The content of protein, lipids, moisture, essential amino acids, fatty acids and cholesterol were estimated. The muscles of K2 contained less lipids than the remaining ones. Fat of A55 and P66 leg muscles contained the least cholesterol. No significant differences in protein and moisture content were found. Isoleucine (Ile) and valine (Val) are amino acids limiting the biological value of meat proteins from leg muscles of A3, P33 and K2, and tryptophan (Trp) for A55, P66 muscles. Unsaturated fatty acids (UFA) were predominant in the muscle fat of all flocks. The fat of A55 muscles contained the most UFA. The highest level of PUFA was determined for K2 muscles. The PUFA/SFA and n-6/n-3 PUFA ratios were 0.74-0.92 and 4.17-5.66 respectively. The lipids of A55 were characterized by the best fatty acid profile among the investigated muscles' fat. Taking into consideration the nutritive value of proteins, cholesterol content and profile of fatty acids, A55 leg muscles appeared to be the most favorable from the perspective of human health.

Keywords: duck, meat

In Poland, at present, eight conservative and genetic reserve flocks of ducks are under the conservation program. Two conservative flocks of Polish origin ducks i.e. Pekin (P33) and Miniduck (K2) have been listed by FAO (2) and registered as the protected world genetic resources. The genetic diversity found among breeds is considered as one half of the genetic variability that occurs within species. From the breeding point of view, the maintenance of genetically diversified bird flocks is necessary to cause genetic variability in the selected populations. In case of ducks those conservative flocks were used in the development of new breeding and experimental strains and synthetic lines as well as in the search for heterosis effects in commercial sets (11, 12). The maintenance program for the preservation of duck genetic resources, which specifies, among others, the methods of management, evaluation and mating of parental stocks and size of the population is carried out in National Research Institute of Animal Production in Kraków. There have been selected five strains (A44, A55, P66, P77, K11) of meat type ducks which were recognized by Polish Ministry of Agriculture and Country Development as breeding strains. The populations of P33, K2, A3, SB belonging to the conservative flocks and A55, P66 ducks have been tested for reproductive and meatiness traits so far (13). The previous studies of the quality of ducks' meat confirmed differentiation between species and strains such as: body weight, yield of muscles, skin with subcutaneous fat and abdominal fat in the carcass (13, 17, 18). The meat of several genotypes and strains of ducks differ in the nutritional value (proportion of protein, fat, moisture), sensory attributes (appearance, colour, flavour, juiciness, tenderness) and functional properties such as: water holding capacity and cooking losses (4, 5, 7, 9, 17, 19, 23). The meat is recognized as one of main source of protein for human nutrition and therefore very impor-

tant is to know not only the protein content in meat, but the amino acid composition as well. The general opinion is that the incidence of some disorders would be reduced and the health of our society improved by the reduction in fat consumtion, reduction in dietary cholesterol and a change in the regimen of fatty acids in favor of increased levels of a range of polyunsaturates (14). Therefore the determination of fatty acids composition of lipids and cholesterol content is very important too. There are no adequate data on amino acid composition of protein and fatty acid profile of lipids in leg muscles of the above mentioned flocks (K2, A3, P33, SB, A55, P66). The aim of our investigation was to compare the chemical composition of leg muscles of six ducks strains (the results concerning breast muscles were printed in 25).

Material and methods

Investigation were carried out on ducks (drakes) of 4 conservative flocks and 2 selected breeding strains maintained by *in situ* method in the Department of Poultry Breeding in Dworzyska: Polish Pekin (P33) – native of an old indigenous breeding strain subjected to selection and taken from the farm at Borowy Młyn; Miniduck (K2) – was bred from wild mallards (*Anas platyrhynchos L.*) and Pekin type ducks; Pekin population – type A3 (progeny of a commercial stock imported from England in 1977) was included into conservative and genetic reserve flocks of ducks by Polish Ministry of Agriculture and Country Development in 1986 (13); synthetic strain SB – was obtained by crossing A1, A2 and A3 (progeny of stock imported from Cherry Valley Farm with each other for ten years (they have the same share of each group A1, A2, A3); the meat type A55 sire strain – was obtained by crossing A44 (was bred from Pekins and Aylesbury and selected over 22 years) with P8 (Pekins of Danish origin) and 17 consecutive years of selection; the meat type P66 maternal strain – was bred from Pekins of American and English-German origin (15).

Ducks were reared up to the fourth week of age in a poultry house of controlled air temperature, and afterwards they were kept on yards of restricted area, partially shedded and covered with straw. All birds were fed *ad libitum* on the same complete feeds. This diet was given until the third week of age and contained 19-20% of crude protein and 11.92-12.13 MJ metabolizable energy and later 16-16.5% of crude protein and 11.73-12.34 MJ metabolizable energy per 1 kg of feed. From each flock (comprising 60 birds) six 7-weeks-old males and body weight close to the arithmetic mean (K2 –1582 g, v% = 9.0; P33 – 2342 g, v% = 7.9; A3 – 2475 g, v% = 7.6; SB – 2498 g, v% = 6.5; A55 – 2869 g, v% = 6.5; P66 – 2617 g, v% = 6.9) within a given group, were taken for analysis. The slaughter of birds and cutting out of leg muscles were done in a local slaughterhouse. The leg muscles were held at 2-4°C for 24 h after slaughter and then examined. Muscle was separately minced in a meat grinder (2 mm) and mixed (Büchi Mixer B-400) to obtain a homogeneous mass.

Chemical analysis was carried out using the following methods: moisture, protein, and lipids – by standard methods AOAC (1). Cholesterol – using the enzymatic Human test (3) in an extract prepared by Folch et al. procedure (6). Amino acids composition – using HPLC Chromatograph Mikrotechma Amino Quant AAA T 339 type (Czech Republic). The hydrolysis of meat samples was made with 6 M HCl in the nitrogen atmosphere at 105°C for 24 h. Tryptophan was determined in the alkaline hydrolyzate (saturated solution of $Ba(OH)_2$ at 110°C for 48 h). The limited amino acids index (R%) for protein of leg muscles was established according to the formula: $R\ (\%) = 100\% \times A_m/A_s$, ($A_m$ – essential amino acid content in the duck meat protein; A_s – essential amino acid content in the standard FAO). The composition of fatty acids was determined using gas chromatography technique with the Agilent Tech. 6890N Chromatograph, equipped with a flame ionization detector. The fat from muscles was extracted by Folch et al. (6) procedure. The methyl esters of fatty acids were separated on the fused silica CP-Sil 88 (Chrompack, Netherlands) capillary column (100 × 0.25 mm), helium was used as the carrier gas. The separation was conducted at the programmed temperature from 165 to 200°C by increase rate at 2°C/min. The identification of fatty acids was accomplished by comparison with external standards. The fatty acids were calculated as percent of total fatty acids with the ChemStation v.4.0 Agilent Technologies programme.

Statistical analysis was based on arithmetic means and standard error. The effects of flock were analysed by one way analysis of variance (Anova) in a non-orthogonal sche-

Tab. 1. Chemical composition and essential amino acids (% of total protein) composition of leg muscles (n = 6, $\bar{x} \pm SEM$)

Parameter	Conservative flocks				Breeding strains		SEM	Effect of flock
	P33	K2	A3	SB	A55	P66		
Protein (%)	20.64	20.55	20.05	20.47	20.83	20.78	0.07	n.s.
Lipids (%)	1.73^a	1.40^b	1.85^a	1.76^a	1.74^a	1.81^a	0.08	*
Moisture (%)	77.21	76.49	76.72	76.52	76.27	76.42	0.18	n.s.
Cholesterol (mg/100 g)	112.22^a	107.34^a	116.93^a	115.71^a	66.8^b	65.15^b	0.13	**
Phe + Tyr	6.27^a	6.34^a	6.04^a	6.21^a	8.42^b	7.93^c	0.09	**
Ile	3.26^a	3.29^a	3.25^a	3.36^a	5.54^b	5.77^b	0.08	**
Leu	7.69^a	7.89^a	7.46^a	7.57^a	8.40^b	8.66^b	0.09	*
Lys	9.03^a	9.04^a	8.92^a	9.01^a	9.61^b	9.62^b	0.13	*
Met + Cys	3.28	3.38	3.56	3.78	3.42	3.30	0.11	n.s.
Thr	4.22^a	4.33^a	4.26^a	4.35^a	5.66^b	5.29^b	0.11	**
Trp	1.09^a	1.20^a	1.09^a	0.98^a	0.68^b	0.74^b	0.13	*
Val	3.66^a	3.82^a	3.63^a	3.73^a	6.96^b	6.54^b	0.08	**

Explanations: a, b, c – values with different letters at the same line are significantly different; n.s. = not significant; * = $p < 0.05$; ** = $p < 0.01$

me. Significant differences between the average values were determined by Duncan's multiple range test. The statistical analysis was conducted with the Software System Statistica, version 6.0.

Results and discussion

Comparing the chemical composition of leg muscles, the significant differences in lipids and cholesterol content were found. The K2 leg muscles content less ($p < 0.05$) lipids, while A55 and P66 (breeding strains) less ($p < 0.01$) cholesterol than remaining muscles dissected from the conservative flocks. There were no significant differences in protein and moisture content (tab. 1).

The muscle protein of investigated ducks contained all essential amino acids (tab. 1). The amino acid proportion of meat proteins depended on ducks' flocks, and differ from the genotype significantly. The leg muscles from A55 and P66 strains comprised more phenylalanine + tyrosine (Phe + Tyr), isoleucine (Ile), threonine (Thr), valine (Val) ($p < 0.01$), leucine (Leu), lysine (Lys) ($p < 0.05$) and less tryptophan (Trp) ($p < 0.01$) as compared to muscles of A3, P33, K2 and SB conservative flocks. The isoleucine and valine were amino acids limiting the biological value of meat proteins of A3, P33, and K2 while tryptophan for A55, P66 muscles (tab. 2). Except of them, the meat proteins of investigated raw materials contained more essential amino acids than the FAO standard. The lysine was characterized by the highest value of index R and thereby possessed the highest biological value among essential amino acids. Taking into consideration the biological value of proteins, the A55 and P66 leg muscles appeared to be the most favourable.

In spite of the same environmental conditions, the concentration of some fatty acids in the fat of leg muscles was different (tab. 3). The fatty acids of C4-C22 were determined in all muscles fat, but the contents of C4--C12 acids were lower than 0.1% of total fatty acids content. In the fat of investigated muscles the presence of the essential polyunsaturated fatty acids (PUFA) was observed namely as: C18:2, C18:3, C20:4, C20:5, C22:6. This is very important from the nutritional point of view. Among the identified fatty acids the highest contents of C18:1 and C16 was stated. Lipids of P66 comprised more C18:1, and that of K2 contained less C16 as compared to the fat of remaining muscles. The highest content of C20:4 was detected in the fat of K2 muscles. The unsaturated fatty acids (UFA) were predominant in fatty acids composition of fat for all flocks. The lipids of A55 comprised the most of UFA especially monounsaturated fatty acids (MUFA), however P33 muscles fat contained the most of saturated fatty acids (SFA). The highest content of PUFA was established in fat of K2 muscles. The UFA/SFA ratio was more favourable for fat of P66 and A55 than for the remaining muscles. The PUFA/SFA ratios were higher for fat of all muscles and the n-6/n-3 PUFA ratios were close to recommended. The lipids from leg muscles of A55 and P66 selected breeding strains were characte-

Tab. 2. Limited amino acids index (R%)

Amino acid	Conservative flocks				Breeding strains	
	P33	K2	A3	SB	A55	P66
Phe + Tyr	104.5	105.6	100.6	103.5	140.3	132.2
Ile	81.5	82.3	81.2	84.0	142.1	147.9
Leu	109.8	112.7	106.6	108.1	121.7	125.5
Lys	164.2	164.4	162.2	163.8	174.7	174.9
Met + Cys	93.7	96.0	101.7	108.0	97.7	96.28
Thr	105.5	108.3	106.5	108.7	141.5	132.3
Trp	109.0	120.0	109.0	98.0	68.0	74.0
Val	73.2	76.4	72.6	74.6	139.2	130.8

Tab. 3. Fatty acids composition of lipids from leg muscles

Fatty acid (%)	P33	K2	A3	SB	A55	P66	SEM	Effect of flock
C14	0.74^a	0.80^a	0.68^b	0.78^a	0.64^b	0.51^c	0.07	*
C16	19.12^a	17.70^b	19.72^a	19.55^a	19.85^a	19.90^a	0.06	**
C16:1	1.55^a	1.95^b	2.69^c	2.75^c	3.24^d	2.86^c	0.17	*
C18	11.72^a	11.65^a	9.54^b	9.76^b	9.40^b	9.11^b	0.09	**
C18:1	28.67^a	28.00^a	33.72^b	33.47^b	34.90^c	36.32^d	0.06	**
C18:2	13.97	14.43	13.46	13.85	13.40	14.06	0.09	n.s.
C18:3	1.11	1.12	1.22	1.28	1.30	1.34	0.08	n.s.
C20:1	0.43^a	0.40^a	0.44^a	0.47^a	0.31^b	0.31^b	0.09	*
C21	0.48^a	0.42^a	0.58^b	0.47^a	0.47^a	0.45^a	0.11	*
C20:4	7.65^a	10.15^b	6.96^c	9.67^b	6.63^c	6.10^c	0.13	*
C20:5	0.28^a	0.27^a	0.43^b	0.46^b	0.45^b	0.38^c	0.12	*
C22:4	0.75	0.98	0.68	0.77	0.59	0.60	0.13	n.s.
C22:6	2.73	2.75	2.82	2.79	2.71	2.60	0.13	n.s.
SFA	34.99	32.51	31.63	31.47	30.91	30.38	0.05	**
MUFA	30.75	30.49	36.93	36.27	38.82	39.23	0.07	**
PUFA	25.97	30.13	25.73	25.84	25.63	25.01	0.07	**
UFA	56.72	60.62	62.66	62.46	64.45	64.24	0.05	**
UFA/ SFA	1.62	1.86	1.98	1.98	2.08	2.11	–	–
PUFA/SFA	0.74	0.92	0.81	0.81	0.83	0.82	–	–
n-6/n-3	5.23	5.66	4.57	4.17	4.41	4.30	–	–

Explanations: as in tab. 1.

rized by the best fatty acid profile among the investigated birds.

Higher contents of lipids (1.9-6%) was found in leg muscles of different Pekin type and their crossbreds (10, 14, 16). The protein content in the investigated muscles was higher than that determined by Mazanowski and Książkiewicz (16) for meat type ducks (18.6--18.8%) and by Górska and Górski (7) for breed crosses of Pekin ducks (19.4%). In comparison with our results obtained for conservative flocks, considerably lower cholesterol content was reported for Pekin (68.5 mg/100 g) and force fed Mulard (74.1 mg/100 g) (8, 24). The A55 and P66 muscles proteins were characterized by higher content of isoleucine, methionine + cysteine (Met + Cys), valine and lower of phenylalanine + tyrosine than muscles from Mulard (force fed) and Muscovy ducks (24). However A3, P33, K2 and SB muscles proteins comprised more tryptophan, metionine + cysteine and less phenylalanine + tyrosine. We found that tryptophan was the amino acid limiting biological value of A55, P66 protein and isoleucine and valine for A2, P33, K2 muscles. The R index for lysine reached the highest value and this is in agreement with our own previous results obtained for Mulard ducks (24).

According to our findings with regard to the fatty acids composition, the major fatty acids were the C18:1, C16, and C18:2. The concentration of them in lipids extracted from the experimental muscles were generally similar to those reported for Muscovy, Pekin and Mulard ducks (20, 21, 24). The data with regard to the UFA and the MUFA contents in fat of A3, P33, K2, SB, A55 muscles were lower than those published for Muscovy ducks (by 1.9.-10.3% and 2.2--7.27% respectively), however for P66 were similar (20). Leskanich and Noble (14) reported more of the SFA and less of the UFA in fat of muscles of commercial Pekin ducks in comparison to our results. In our experiment the C16 and C18 were predominant among the SFA. The C16 (harmful for human health) content in fat of all flocks was lower than those reported for Pekin (by 2.9-6.2%) and Muscovy (by 1.4-4.9%) ducks, while the C18 (which is biologically neutral) generally do not differ (12, 18, 19). The PUFA/SFA and the n-6/n-3 PUFA ratios were significantly more favourable for investigated muscles than results obtained for Pekin and Muscovy ducks (4, 20-22). This is very important, because preference in human diets is given to the high level of the n-3 PUFA from the nutritional and physiological points of view.

Comparing the basic chemical and amino acid composition and profile of fatty acids of lipids, it could be concluded, that the A55 leg muscles are the most favourable from the nutritional point of view. Admittedly, they are also characterized by the highest content of lipids. However, taking into consideration the biological value of proteins, the fatty acids profile and cholesterol content, the A55 muscles appeared to be from nutrition point of view the most valuable. It is evident too, that muscles from all the examined flocks have been characterized by high nutritional value. In spite of the same feeding, housing condition and age the differences in chemical composition of leg muscles coming from examined ducks were observed. Probably different physiological mechanisms in the investigated ducks resulted in the differences in chemical composition.

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