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FATTY ACIDS COMPOSITION OF POULTRY MEAT PRODUCED IN INDOOR AND OUTDOOR REARING SYSTEMS

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SUMMARY

The research was carried out on chickens of Ross 208 provenience, which were divided into two groups. Chickens reared outdoor had statistically significantly higher portion of α-linolenic acid (P<0.05), linoleic and arachidonic acid, as well as higher total of PUFA n-6 acids (P<0.01) than chickens that were kept indoor. However, these chickens had higher portion of myristic and palmitic acid (P<0.01), as well as DHA (P<0.001) in the lipids of breast muscles. There was also higher content of myristic and linoleic acids (P<0.01) determined in the lipids of thigh muscles of chickens reared indoor, while chickens kept outdoor had higher content of EPA (P<0.01), palmitic, stearic and arachidonic acids (P<0.001). Chickens of the 2nd group exhibited more favorable ratio of PUFA n-6 / PUFA n-3 in the lipids of breast muscles. The same ratio for the lipids of thigh muscles was better in the 1st group.

Key-words: fatty acids, breasts, thighs, indoor rearing, outdoor rearing

INTRODUCTION

Ecologically aware people put significant emphasis on animal welfare. There is an increasing demand for poultry meat and eggs produced from free-ranged animals. This consequently leads to changes in animal rearing systems, which are not primarily conventional (indoor), but also focused on outdoor rearing and organic agriculture. The importance of fattening system to quality meat of broilers is emphasized by Kralik et al. (1998). In developed countries, there is a noticeable imbalance of PUFA n-6/PUFA n-3 ratio in human nutrition, mostly because of insufficient fish consumption and lack of cereals rich in omega-6 fatty acids in animal feeding regimes, which negatively affects composition of animal products (Simopoulos and Salem, 1989, Van Vliet and Katan, 1990). Over the last 10 000 years, the ratio of PUFA n-6/PUFA n-3 in people living in well-developed countries has been changed from 1-4/1 to 20-30/1 (Calvani and Benatti, 2003). According to Okuyama et al. (1997), this ratio should be as close as possible 1/1. Biological functions of PUFA n-3 were described by Lauritzen et al. (2001). Numerous researches point out the possibility to modify contents of fatty acids and improve the PUFA n-6/PUFA n-3 ratio in the lipids of breasts and thighs. Depending on starter and finisher diet composition, PUFA n-6 / PUFA n-3 ratio in lipids of breast muscles of fattening chickens fluctuated between 0.73-4.12 (Scaife et al., 1994), 3.9-13.6 (Komprda et al., 2001) and 2.30-6.37 (Kralik et al., 2001). Values of investigated ratio of PUFA n-6 / PUFA n-3 in the lipids of thigh muscles were between 4.9-19.2 (Komprda et al., 2001) and 2.87-7.56 (Kralik et al., 2001). Having in mind recent trends in respecting animal welfare and paying attention to proper human nutrition, this research was carried out with the aim to investigate the effect of different rearing environments on the fatty acids composition in chicken meat.

MATERIAL AND METHODS

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The research was carried out on 90 chickens of Ross 208 provenience, which were divided into two experimental groups. Up to 21st day of fattening, chickens were fed starter diets (A). First chicken group (n=45) was reared indoor in a conventional way, and the 2nd group (n=45) was kept outdoor from 22nd to 63rd day. During the whole fattening period, 1st group was kept indoor and fed the B diets from 22nd to 42nd day. Chickens of the 2nd group were kept outdoor from 22nd to 63rd day and also fed the B diets.

Table 1. Content of fatty acids in diets (% of total fatty acids)
Tablica 1. Sadržaj masnih kiselina u krmnim smjesama (% u ukupnim masnim kiselinama)

Fatty acid – *Masna kiselina*		Diet A *Smjesa A*	Diet B *Smjesa B*
Caprylic - *Kaprilna*	C 8:0		0.03
Capric - *Kaprinska*	C 10:0	0.06	0.05
Lauric - *Laurinska*	C 12:0		0.07
Tridecanoic - *Tridekanska*	C 13:0	0.09	0.10
Myristic - *Miristinska*	C 14:0	1.39	1.44
Pentadecanoic - *Pentadekaenska*	C 15:0	0.08	0.08
Palmitic – *Palmitinska*	C 16:0	20.35	18.99
Heptadecanoic - *Heptadekanska*	C 17:0	0.31	0.31
Stearic – *Stearinska*	C 18:0	10.23	9.41
Arachidic - *Arahinska*	C 20:0	0.24	0.09
Behenic – *Behenska*	C 22:0		0.09
Lignoceric - *Lignocerinska*	C 24:0		0.04
∑ SFA		32.75	30.61
Palmitoleic – *Palmitoleinska*	C 16:1	1.58	1.69
Oleic - *Oleinska*	C 18:1	32.11	30.60
Eicosenoic - *Eikozenska*	C 20:1	0.61	0.67
Nervonic – *Neuronska*	C 24:1		0.08
Erucic - *Eruka*	C 22:1		0.04
∑ MUFA		34.30	33.08
Linoleic - *Linolna*	C 18:2n6	23.37	24.39
Eicosadienoic - *Eikozadienska*	C 20:2n6	0.60	0.63
Eicosatrienoic – *Eikozatrienska*	C 20:3n6		0.09
Arachidonic – *Arahidonska*	C 20:4n6	0.22	0.26
∑ PUFA omega-6		24.19	25.37
α-linolenic - *α-linolenska*	C 18:3n3	1.28	1.31
Eicosapentaenoic - *Eikozapentaenska*	C 20:5n3	0.87	1.48
γ-docosapentaenoic - *γ-dokozapentaenska*	C 22:5n3	0.15	0.19
Docosahexaenoic - *Dokozaheksaenska*	C 22:6n3	0.47	0.73
∑ PUFA omega-3		2.77	3.71
∑ PUFA		26.96	29.08
SFA / MUFA		0.95	0.92
SFA / PUFA		1.21	1.05
PUFA n-6 / PUFA n-3		8.73	6.84

Feeding and watering regime of chickens was *ad libitum*. Tables 1 and 2 present contents of fatty acids (% of total fatty acids) and chemical composition of the A and B diets. In order to establish basic chemical composition of diets, analyses were performed as described: water content was determined by drying at 105°C up to constant weight. Protein content was determined by the Kjeldahl method, fat content by Soxhlet, and ash content by burning of samples at 550°C. The fatty acid composition in lipids of white and dark chicken meat was determined on 6 samples of each group by Chrompack CP-9000 chromatograph equipped with a flame ionization detector. Percentage of fatty acids was calculated according to Csapo et al., 1986. Differences between the groups were tested by the t-test on Statistica for Win v.6.0.

Table 2. Overview of basic chemical composition in diets
Tablica 2. Kemijska kontrola sadržaja osnovnih kemijskih sastojaka u smjesama

Content – *Sadržaj*	D i e t - *Smjesa*	
	A	B_1
Water – Voda, %	11.43	11.40
Crude proteins – Sirove bjelančevine, %	22.29	20.27
Crude fat - Sirove masti, %	7.80	7.82
Crude fibers – Sirova vlakna, %	3.41	3.09
Crude ash – Sirovi pepeo, %	7.69	8.22

RESULTS AND DISCUSSION

The content of fatty acids (g/100g of total fatty acids) in the lipids of breast muscles was presented in Table 3. Content of total saturated (SFA) and monounsaturated acids (MUFA) did not differ statistically ($P>0.05$) between investigated groups. When compared to the 2nd group, chickens of the 1st group exhibited considerably higher portion of myristic, palmitic and nervonic acids in the lipids of breast muscle ($P<0.01$). Chickens of the 2nd group had considerably higher ($P<0.01$) portion of linoleic and arachidonic acid, as well as total of omega-6 polyunsaturated fatty acids (PUFA n-6) than the 1st group. In comparison with conventional housing, extension of fattening period outdoors resulted in statistically relevant increase ($P<0.05$) of α-linolenic acid, and in decrease of docosahexaenoic acid (DHA) ($P<0.001$) in the lipids of breast muscles. Different rearing environments had not statistically relevant effect either on the composition of total omega-3 polyunsaturated acids (PUFA n-3), or on the investigated ratio of SFA/MUFA, SFA/PUFA and PUFA n-6/PUFA n-3.

Table 3. Content of fatty acids (g/100 g of total fatty acids) in the lipids of breast muscles
Tablica 3. Sadržaj masnih kiselina (g/100 g ukupnih masnih kiselina) u mastima mišića prsa

Fatty acid – *Masna kiselina*	1st group *1. skupina* $\bar{x} \pm s$	2nd group *2. skupina* $\bar{x} \pm s$	Significance of difference *Značajnost razlika*
Lauric – *Laurinska* C 12:0	0.51±0.19	0.48±0.15	n.s.
Myristic – *Miristinska* C14:0	0.90±0.13	0.68±0.14	**
Pentadecanoic – *Pentadekanska* C15:0	0.12±0.05	0.12±0.03	n.s.
Palmitic – *Palmitinska* C16:0	25.16±0.59	24.22±0.60	**
Heptadecanoic – *Heptadekanska* C17:0	0.33±0.05	0.34±0.05	n.s.
Stearic – *Stearinska* C18:0	14.74±1.69	13.78±2.20	n.s.
Arachidic – *Arahinska* C20:0	0.15±0.08	0.14±0.03	n.s.
Behenic – *Behenska* C22:0	0.26±0.11	0.21±0.02	n.s.
∑ SFA	42.17±2.03	39.97±3.03	n.s.
Palmitoleic – *Palmitoleinska* C16:1	1.65± 0.38	1.95±0.38	n.s.
Oleic – *Oleinska* C18:1	28.39±2.56	29.35±2.56	n.s.
Eicosenoic – *Eikozenska* C20:1	0.37±0.06	0.42±0.09	n.s.

Erucic – *Eruka* C 22:1n9	0.62±0.12	0.58±0.04	n.s.
Nervonic – *Neuronska* C24:1	1.80±0.49	1.10±0.49	**
∑ MUFA	32.83±2.03	33.40±2.32	n.s.
Linoleic – *Linolna* C18:2n6	14.61±1.39	16.15±1.40	**
Eicosadienoic – *Eikozadienska* C20:2n6	0.71±0.07	0.62±0.07	n.s.
Arachidonic – *Arahidonska* C24:4n6	3.78±0.91	3.95±0.95	**
∑ PUFA n-6	19.10±0.81	20.72±1.32	**
α-Linolenic - *α-linolenska* C18:3n3	0.58±0.12	0.85±0.04	*
Eicosapentaenoic – *Eikozapentaenska* C20:5n3	0.66±0.10	0.63±0.10	n.s.
Docosapentaenoic – *Dokozapentaenska* C22:5n3	2.03±0.50	2.15±0.02	n.s.
Docosahexaenoic – *Dokozaheksaenska* C 22:6n3	3.13±0.72	2.16±0.01	***
∑ PUFA n-3	6.40±1.11	5.79±1.12	n.s.
SFA / MUFA	1.28	1.20	n.s.
SFA / PUFA	1.65	1.51	n.s.
PUFA n-6 /PUFA n-3	2.98	3.58	n.s.

n.s. = not significant – *nije značajno*; P>0.05; *P<0.05; **P<0.01; ***P<0.001

Table 4. Content of fatty acids (g/100 g of total fatty acids) in the lipids of thigh muscles
Tablica 4. Sadržaj masnih kiselina (g/100 g ukupnih masnih kiselina) u mastima mišića zabataka

Fatty acid – Masna kiselina	1st group *1. skupina* $\bar{x}$ ± s	2nd group *2. skupina* $\bar{x}$ ± s	Significance of difference *Značajnost razlika*
Lauric – *Laurinska* C 12:0	0.33±0,20	0.32±0.15	n.s.
Myristic – *Miristinska* C14:0	1.14±0,08	0.95±0.14	**
Pentadecanoic – *Pentadekanska* C15:0	0.13±0,06	0.13±0.06	n.s.
Palmitic – *Palmitinska* C16:0	23.49±0,49	24.38±0.35	***
Heptadecanoic – *Heptadekanska* C17:0	0.32±0,04	0.32±0.04	n.s.
Stearic – *Stearinska* C18:0	10.48±1,18	12.95±1.15	***
Arachidic – *Arahinska* C20:0	0.17±0,05	0.17±0.03	n.s.
Behenic – *Behenska* C22:0	0.08±0,04	0.05±0.01	n.s.
∑ SFA	36.14±1,38	39.27±1.35	***
Palmitoleic – *Palmitoleinska* C16:1	3.02± 0,46	3.55±0.92	n.s.
Oleic – *Oleinska* C18:1	34.35±1,85	33.38±1.15	n.s.
Eicosenoic – *Eikozenska* C20:1	0.51±0,03	0.62±0.05	***
Erucic – *Eruka* C 22:1n9	0.42± 0,08	0.43±0.01	n.s.
Nervonic – *Neuronska* C24:1	0.50±0,21	0.31±0.01	*
∑ MUFA	38.80±2,06	38.29±3.10	n.s.
Linoleic – *Linolna* C18:2n6	18.58±0,78	17.25±1.15	**
Eicosadienoic – *Eikozadienska* C20:2n6	0.55± 0,04	0.59±0.04	n.s.
Arachidonic – *Arahidonska* C24:4n6	2.20±0,65	2.95±0.05	***
∑ PUFA n-6	21.33±0,61	20.79±0.52	n.s.
α-Linolenic - *α-linolenska* C18:3n3	0.89± 0,09	0.85±0.08	n.s.
Eicosapentaenoic – *Eikozapentaenska* C20:5n3	0.52± 0,06	0.59±0.03	**
Docosapentaenoic – *Dokozapentaenska* C22:5n3	1.02± 0,26	1.22±0.25	n.s.

Docosahexaenoic – *Dokozaheksaenska* C 22:6n3	1.53± 0,45	1.85±0.32	n.s.
∑ PUFA n-3	3.96±0,61	4.51±0.85	n.s.
SFA / MUFA	0.93	1.02	n.s.
SFA / PUFA	1.43	1.55	n.s.
PUFA n-6 /PUFA n-3	5.39	4.61	n.s.

n.s. = not significant – *nije značajno*; P>0.05; *P<0.05; **P<0.01; ***P<0.001

Chickens reared outdoor had higher portion of PUFA n-6 (P<0.01) in the lipids of breast muscles and higher portion of SFA (P<0.001) in the lipids of thigh muscles, as well. Content of MUFA and PUFA n-6 was higher in the lipids of thigh muscles (38.29-38.80 and 20.79-21.33) than in the lipids of breast muscles (32.83-33.40 and 19.10-20.72). Lipids of breast muscles, which are valuable for human health, contain higher portions of PUFA n-3 than lipids of thigh muscles (5.79-6.40 : 4.61-5.39). In terms of human health, more favorable ratio of SFA / MUFA was obtained in the lipids of thigh muscles than in the lipids of breast muscles (0.93-1.02 : 1.20-1.28). PUFA n-6 / PUFA n-3 ratio was more favorable in the lipids of breast muscles (2.98-3.58) than in the lipids of thigh muscles (4.61-5.39).

Determined ratios of PUFA n-6 / PUFA n-3 in the breast muscles of chickens fattened in two different systems were favorable and equal to a desirable 1:1 ratio (Okuyama et al., 1997). Similar results were obtained by Scaife et al., 1994; Komprda et al., 2001, as well as by Kralik et al., 2001. Examined ratio of PUFA n-6 / PUFA n-3 in the lipids of thigh muscles of chickens reared indoors was higher than 4:1, thus being considered as unfavorable for human health (Calvani and Benatti, 2003). The PUFA n-6 / PUFA n-3 ratio in the lipids of thigh muscles of chickens kept outdoor (4.61:1) was within values acceptable for human health. Obtained ratios of PUFA n-6 / PUFA n-3 in the lipids of thigh muscles were in accordance with the research results of Komprda et al. (2001) and Kralik et al. (2001).

CONCLUSION

Based upon completed study on the effect of different rearing systems of chickens on the content of fatty acids in the lipids of breast and thigh muscles, the following conclusions can be drawn:

- chickens reared outdoor had significantly higher portion of α-linolenic acid (P<0.05), as well as linoleic and arachidonic acids and total of PUFA n-6 (P<0.01), while chickens kept indoor had higher portion of myristic and palmitic acids (P<0.01), as well as DHA (P<0.001) in the lipids of breast muscles.
- higher content of myristic and linoleic acids (P<0.01) was established in the lipids of thigh muscles of chickens reared indoor, compared to chickens reared outdoor, which had more EPA (P<0.01), as well as more palmitic, stearic and arachidonic acid (P<0.001).
- chickens kept outdoor exhibited more favorable ratio of PUFA n-6 / PUFA n-3 in the breast muscles (3.58:2.98). The same ratio was more favorable in the lipids of thigh muscles of chickens reared indoor (5.39:4.61).

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SASTAV MASNIH KISELINA MESA PERADI U ZATVORENOM I SLOBODNOM UZGOJU

SAŽETAK

Istraživanje je provedeno na dvije skupine pilića Ross 208 provenijencije. Pilići utovljeni na ispustu imali su statistički značajno veći udio α-linolenske (P<0,05) te linolne i arahidonske i ukupnih PUFA n-6 kiselina (P<0,01), dok su pilići utovljeni u objektu imali veći udio miristinske i palmitinske (P<0,01) te DHA (P<0,001) u mastima mišića prsa. Utvrđen je veći sadržaj miristinske i linolne (P<0,01) kiseline u mastima mišića zabataka kod pilića utovljenih u objektu, dok su pilići utovljeni na ispustu imali veći sadržaj EPA (P<0,01) te palmitinske, stearinske i arahidonske (P<0,001) kiseline. Povoljniji omjer PUFA n-6 / PUFA n-3 u mastima mišića prsa imali su pilići 2.skupine, a navedeni omjer u mastima mišića zabataka bolji je kod pilića 1.skupine.

Ključne riječi: masne kiseline, prsa, zabaci, zatvoreni uzgoj, slobodni uzgoj

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