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Effect of dietary linseed and rapeseed supplementation on fatty acid profiles in the ostrich. Part 1. Muscles*

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Forty ostriches were raised in five groups [control (C) or with 4% (L4) or 8% (L8) linseed, or 5% (R5) or 10% (R10) rapeseed in the diet]. Linseed supplementation (L4 and L8) improved the nutritive value of the ostrich meat by increasing (P<0.001) the α-linolenic acid content (>4.2%FA_{total}) and PUFA/SFA ratio (>1.0) as compared with the control group (1.7% FA_{total} and <0.94, α-linolenic

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acid and PUFA/SFA, respectively), whereas the effect of rapeseed was lower (2.2%, and <0.99, α-linolenic acid and PUFA/SFA, respectively). Dietary treatment lowered (P<0.001) the *n-6/n-3* ratio from *ca*. 11 in the C group to 4 in the L8 and L4 groups. Overall, the results indicate that inclusion of linseed into ostrich diets has a positive effect on the fatty acid composition, allowing the production of meat enriched with *n-3* fatty acids.

KEY WORDS: fatty acids / linseed / ostrich meat / rapeseed

It is well recognised that a direct relationship exsists between a high intake of fat in the diet, particularly saturated and the so-called 'diseases of the western world', with the latter predominantly being characterised by an increased incidence of heart disease [Scollan *et al.* 2001]. Red meat has frequently been criticised as contributing towards such diseases due to its high content of saturated fatty acids (SFA) as compared to polyunsaturated fatty acids (PUFA), which reportedly leads to increased blood cholesterol levels [Wood *et al*. 1999, Poławska *et al*. 2011]. A higher PUFA content of meat the higher meat's nutritive quality, which has a direct effect on human health, for example, the long-chain *n-3* PUFA docosahexaenoic acid (DHA) is reported to contribute to brain and liver development in human infants and may also play a role in the prevention and treatment of various diseases [Zhang *et al.* 2010]. During pregnancy and lactation, supplementation of the mother's diet with omega-3 fatty acids, especially eicosapentaenoic acid (EPA) and DHA, appears to result in better values for infant development indices [Decsi *et al*. 2005, Dunstan *et al*. 2008]. Consequently, numerous authors have attempted to alter the fatty acid profile of meat and to increase its omega-3 (*n*-3) fatty acid content (C18:3*n*-3, C20:5*n*-3, C22:6*n*-3) through the manipulation of the diets of ruminant and non-ruminant species [reviewed by Woods and Fearon 2009].

Ostrich meat is gaining in popularity worldwide due to its high nutritive value [Sales and Horbańczuk 1998, Sales *et al*. 1999], however its fat content and fatty acid profile are known to be influenced by species [Paleari *et al*. 1998] and subspecies [Horbańczuk *et al*. 1998, Hoffman *et al*. 2012], animal's age at slaughter [Hoffman and Fisher 2001, Girolami *et al*. 2003], muscle [Sales 1998, Girolami *et al*. 2003] and cooking method [Sales *et al*. 1996, Filgueras *et al*. 2011]. The effects on ostrich meat quality and composition due to the inclusion of citrus pulp [Lanza *et al*. 2004] into the diets of the birds has also been evaluated and a decrease in crude fat content and increase of PUFA content in the ostrich meat was confirmed. However, Lanza *et al*. [2004] obtained higher n-6/n-3 ratios than the level recommended for human health and suggested that fish oil or oilseed supplementation to the ostrich diet may give better results. The potential of fish oil has already been evaluated by Hoffman *et al*. [2005]. However, dietary oilseeds to enrich ostrich meat with long chain *n*-3 fatty acids have not been evaluated to date.

The current study aimed at detecting whether the fatty acid profile of ostrich meat can be manipulated through dietary oilseed supplementation by incorporating either linseed or rapeseed into the ostrich diets. The latter two differ widely in their omega-6/omega-3 (*n*-6/*n*-3) fatty acid ratios, with linseeds being rich in PUFA *n-3*, especially

α- linolenic acid (ALA – C18:3*n-3*), and rapeseeds being rich in monounsaturated fatty acids (MUFA), mainly oleic (C18:1*n-9*).

Material and methods

Animals, diets and sampling

The study was conducted using 40 ostriches (*Struthio camelus var. domesticus*), from hatching to months 12 of age on a commercial farm in Stypułów in western Poland (the farm is under scientific supervision of the Institute of Genetics and Animal Breeding of the Polish Academy of Sciences). Ethical clearance was obtained from the Local Ethics Commission for Experimentation on Animals (No 27/2009).

After hatching until month 5 of age, the birds were reared together and fed a commercial ostrich starter diet (215 $g.kg^{-1}$ crude protein and 2850 $kcal.kg^{-1}$ gross energy). The birds had free access to potable water during the entire study period. From the age of 5 months (about 40 kg body weight – BW), birds were randomly allocated into 5 groups and each group was randomly assigned to a different dietary treatment. Birds were weighed every two weeks and fed diets offered at 2% of body weight (BW). Experimental diets were formulated on the basis of a control diet, a part of which was replaced with linseed (4 or 8% – diet/group L4 and L8, respectively) or rapeseed (5 or 10% – diet/group R5 and R10, respectively). Different dietary fatty acid profiles were achieved by inclusion of either linseed or rapeseed at different concentrations into the diets. Protein and gross energy contents (150 $g.kg^{-1}$ crude protein and 2550 $kcal.kg^{-1}$ gross energy) were kept constant across the diets [Poławska *et al*. 2012]. The growth rate and feed conversion rate were similar in all investigated groups [Horbańczuk 2012].

The ostriches were slaughtered in an EU – approved commercial abattoir for cattle and pigs in Wolbrom (Poland) at 12 months of age when their live weight had reached 96.3±5.5 kg. Ostriches were fasted for 24 h before being electrically stunned. Bleeding and evisceration were performed according to standard slaughtering procedures for ostriches [Majewska *et al*. 2009]. Carcasses were divided into two halves, whereafter the legs and drumsticks were removed and cooled at *ca*. 4°C for 24 hours before deboning. Meat samples were taken from the *M. gastrocnemius pars interna* (GN) and *M. iliofibularis* (IF) muscles from the left side of the carcass, and transported to the laboratory in insulated containers, where they were stored at 4°C until further analyses.

Analytical

Fatty acids were extracted from homogenised samples (5 g) of muscles and diets with the chloroform-methanol (2:1 v/v) procedure by Folch *et al*. [1957]. Fatty acid methyl esters (FAME) were analysed using a GC-7890 AGILENT gas chromatograph equipped with a 60 m HEWLETT – PACKARD-88 capillary column (AGILENT J&W GC Columns, USA) with 0.25 mm inner diameter and 0.20 μm film thickness.

A 1 µl sample was injected at a split ratio of 1:40. Helium was used as a carrier gas at a flow rate 50mL.min^{-1}. The injector and detector were both maintained at 260°C. Column oven temperature was programmed to increase from 140°C (held for 5 min) at a rate of 4°C.min^{-1} to 190°C and then to 215°C at a rate 0.8°C.min^{-1}. Individual fatty acids were identified by comparison of retention times to those of a standard FAME mixture (SUPELCO 37 Component FAME Mix, 47885-U – 10 mg. ml^{-1} in methylene chloride, analytical standard, SIGMA−ALDRICH Co.) and expressed as a per cent sum of total fatty acids.

Calculations and statistical evaluation

The sums of SFA (<C12:0 + C13:0 + C14:0 + C15:0 + C16:0 + C18:0 + C20:0 + C21:0 + C22:0), MUFA (C15:1 + C16:1 + C17:1 + C18:1) and PUFA (C16:3 + C18:2 + C18:3 + C20:2 + C20:3 + C20:4 + C20:5 + C22:2 + C22:6) were calculated. The sum of *n-6* fatty acids was calculated as the sum of C18:2 + C20:2 + C20:3 + C20:4 fatty acids and the sum of *n*-3 fatty acids as the sum of C18:3 + C20:5 + C22:6 FA.

Analysis of variance was performed on the two muscles with diet as main effect using STATISTICA (ver. 9, StatSoft Inc., USA). Tukey-tests were obtained at a 5% significance level to compare treatment means for significant effects.

Results and discussion

The concentration of fatty acids in the ostrich diets is presented in Table 1. All experimental diets showed lower concentrations of SFA (16.1-19.9% FA_{total}), higher PUFA/SFA (2.6-3.6) and lower *n-6/n-3* (1.2-5.6) ratios compared to the control diet (21.7% FA_{total}, 2.2 and 6.3, respectively). The supplementation of linseed in the diets resulted in higher concentrations of PUFA *n-3* (18.7 and 28.3% FA_{total}, L4 and L8 diet, respectively); mainly ALA; in relation to the control diet. On the other hand, rapeseed supplementation to the diets enriched the MUFA content of the diets (35.2 and 41.4% FA_{total}, R5 and R10 diet, respectively); mainly oleic acid as compared to the control diet (Tab. 1).

The composition of fatty acids in the ostrich muscles is presented in Table 2 and 3. The fatty acid profiles of both muscles (GN and IF) were affected by the supplementation of the diets with oilseeds. Linseed supplementation improved the nutritive value of the ostrich meat. In both muscles, ALA content increased four-fold in L4 group and three-fold in L8 group (Tab. 2 and 3). The relatively smaller effect on ALA concentration in L8 group might be associated with the long-lasting (around 7 months) supplementation (from 5 to 12 month of age). Lopez-Ferrer *et al*. [2001] showed in chicken that a longer duration of linseed feeding does not result with higher accumulation of *n-3* long chain PUFA in tissues. It can be postulated that deposition of ALA in muscles is limited and that its dietary pool is used to produce other fatty acids of the omega-3 family. It is also probable that higher levels of ALA in diet stimulate this process. Moreover, it should be noted that monogastric animals absorb dietary FA

Table 1. Content of selected fatty acids (% of total fatty acids identified) of the experimental diets fed to 5 month old – ostriches

Fatty acid[A]	Diet / Group[B]				
	C	R5	R10	L4	L8
C14:0	0.24	0.17	0.12	0.15	0.13
C16:0	15.83	11.10	8.89	13.06	11.11
C16:1	0.20	0.32	0.29	0.26	0.23
C18:0	2.01	1.84	1.83	3.19	3.14
C18:1n-9	30.66	33.09	38.87	22.63	19.65
C18:1n-7	0.84	1.77	2.17	1.02	0.82
C18:2*n-6*	39.81	37.70	31.42	36.20	33.14
C18:3*n-3*	6.00	6.62	7.54	18.10	27.92
C20:4*n-6*	0.05	0.12	0.08	0.15	0.09
C20:5*n-3*	0.28	0.25	0.21	0.36	0.18
C22:6*n-3*	0.10	0.13	0.12	0.22	0.17
SFA	21.65	17.93	16.13	19.94	17.29
MUFA	31.73	35.21	41.35	23.91	20.71
PUFA	46.62	46.86	42.52	56.15	62.00
Σn-6	39.86	39.25	34.18	36.7	33.35
Σn-3	6.38	7.00	7.87	18.68	28.27
n-6/n-3	6.25	5.61	4.34	1.96	1.18
PUFA/SFA	2.15	2.61	2.64	2.82	3.59

[A]Σ*n-6* – sum of *n-6* polyunsaturated fatty acids; Σ*n-3* – sum of *n-3* polyunsaturated fatty acids; PUFA – sum of polyunsaturated fatty acids (C16:3 + C18:2n-6 + C18:3n-3 + C20:2 + C20:3n-6 +C 20:4n-6 +C 20:5n-3 +C22:2 + C22:6n-3); MUFA – sum of monounsaturated fatty acids (C15:1 + C16:1 + C18:1n-9 + C18:1n-7); SFA – sum of saturated fatty acids (≤C12:0 + C14:0 + C15:0 +C 16:0 + C18:0 + C20:0 + C21:0 + C22:0 + C24:0); *n-6*/*n-3* – ratio of *n-6* to *n-3* fatty acids; PUFA/SFA – ratio of polyunsaturated to saturated fatty acids.
[B]C – control group; R5 – diet with 5% of rapeseed supplementation; R10 – diet with 10% of rapeseed supplementation; L4 – diet with 4% of linseed supplementation; L8 – diet with 8% of linseed supplementation.

intact through the small intestine and incorporate them in unchanged form into tissues [Dalle Zotte *et al*. 2013]. Although ostrich is monogastric animal, its hindgut is more than 8 m long [Horbańczuk *et al*. 2003], what increases ingest retention time and creates an environment for microbial fermentation, like in ruminants. Further studies to obtain information about FA metabolism in ostrich tissues and to evaluate which period of growth and supplementation duration is optimal for fatty acids modification are thus required.

There were no differences in ALA content of both muscles between the birds fed the rapeseed supplemented and those fed control diets, an observation which can be interpreted as to the lack of differences between the content of this specific fatty acid in the control and rapeseed diets (Tab. 1).

ALA is a precursor for the production of long chain fatty acids, *i.e*., EPA (C20:5*n-3*), docosapentaenoic (DPA– C22:5*n-3*) and DHA (C22:6*n-3*), which are reported to

Table 2. Fatty acids profile (% of total fatty acids identified) of ostrich *M. gastrocnemius pars interna* fed diets of different fatty acid profiles

Fatty acids[1]	Group / Diet[2]					P
	C (n=8)	R5 (n=8)	R10 (n=8)	L4 (n=8)	L8 (n=8)	
C14:0	0.42±0.02	0.39±0.11	0.51±0.09	0.17±0.01	0.38±0.14	0.052
C16:0	15.69±1.48^{AB}	17.23±2.19^{A}	15.80±1.06^{AB}	13.55±1.87^{AB}	13.93±2.25^{B}	0.001
C16:1	5.33±0.90^{A}	5.12±0.88^{AB}	4.33±0.68^{AB}	3.91±0.49^{B}	4.75±1.12^{AB}	0.009
C18:0	12.05±0.95^{a}	10.46±0.95^{b}	11.46±1.67^{ab}	12.20±1.07^{a}	11.30±1.06^{ab}	0.011
C18:1*n-9*	24.02±2.08^{BC}	27.20±2.64^{A}	27.05±3.23^{AB}	20.90±1.90^{C}	22.74±2.37^{C}	0.0001
C18:2*n-6*	16.16±1.96	16.47±0.88	16.83±1.30	17.90±1.28	16.10±1.95	0.122
C18:3*n-3*	1.72±1.02^{C}	2.13±0.32^{C}	2.14±0.41^{C}	6.43±1.55^{A}	4.21±1.81^{B}	0.0001
C20:4*n-6*	9.10±1.54^{A}	7.24±1.41^{C}	7.66±1.41^{BC}	7.15±0.98^{C}	8.66±1.39^{AB}	0.009
C20:5*n-3*	0.24±0.13^{C}	0.38±0.17^{ABC}	0.50±0.16^{A}	0.45±0.11^{AB}	0.44±0.08^{AB}	0.001
C22:6*n-3*	0.41±0.11^{C}	0.65±0.21^{B}	0.59±0.15^{B}	1.57±0.47^{A}	0.68±0.28^{B}	0.0001
SFA	30.46±1.88	29.88±1.34	29.51±0.97	29.40±1.63	29.39±1.77	0.545
MUFA	40.97±1.73^{AB}	42.10±1.63^{A}	41.52±2.31^{AB}	35.52±1.88^{C}	39.14±3.07^{B}	0.0001
PUFA	28.57±1.94^{B}	28.02±1.94^{B}	28.96±2.28^{B}	35.07±1.31^{A}	31.46±3.20^{AB}	0.0001
Σ*n-6*	24.96±2.25	23.71±1.89	24.48±2.35	25.06±1.44	24.66±1.78	0.524
Σ*n-3*	2.21±0.49^{C}	3.16±0.39^{C}	3.23±0.44^{C}	8.46±1.45^{A}	5.31±1.76^{B}	0.0001
n-6/n-3	11.84±3.13^{A}	7.51±1.37^{B}	7.58±1.67^{B}	2.96±0.65^{C}	4.65±2.29^{BC}	0.0001
PUFA/SFA	0.94±0.12^{B}	0.94±0.09^{B}	0.98±0.09^{B}	1.20±0.09^{A}	1.08±0.15^{AB}	0.0001

[1]PUFA – sum (see Tab. 1) of polyunsaturated fatty acids; MUFA – sum of monounsaturated fatty acids; SFA – sum of saturated fatty acids; Σ*n-6* – sum of *n-6* polyunsaturated fatty acids; Σ*n-3* – sum of *n-3* polyunsaturated fatty acids; *n-6*/*n-3* – ratio of *n-6* to *n-3* fatty acids; PUFA/SFA – ratio of polyunsaturated to saturated fatty acids.

[2]C – control group; R5 – diet with 5% of rapeseed supplementation; R10 – diet with 10% of rapeseed supplementation; L4 – diet with 4% of linseed supplementation; L8 – diet with 8% of linseed supplementation.

[aA,...]Within rows means bearing different superscript letters are significantly different at: small letters – $P<0.05$; capitals – $P<0.01$.

have beneficial effects on human health [Russo 2009]. Among the long–chain fatty acids, the highest content of DHA was recorded in the linseed dietary groups. The R5 and R10 groups had lower DHA levels, which varied from 0.47 to 0.71% FA_{total}, although those concentrations were still higher than in the C groups (Tab.2 and 3). In turn, concentration of EPA was also higher in the linseed groups in the IF muscle (Tab. 3) of birds receiving L4 and L8 diets.

Hoffman *et al*. [2005] also reported increased levels of the long–chain EPA and DHA PUFAs in ostrich muscles when fish oil was used for dietary supplementation, which had an overall positive effect on the fatty acid profile of the muscle. However, their results cannot be directly related to this obtained in the present study as fish oil supplementation is a direct incorporation of EPA and DHA from the diet to the muscles. In literature there is no data on the influence of linseed supplementation on the fatty acids profile of ostrich muscles. Similar results were obtained in chickens fed linseed [Lopez-Ferrer *et al*. 2001]. On the other hand, Zelenka *et al*. [2008] observed that lower levels of linseed oil supplementation (5%) caused higher contents of arachidonic acid (AA) and DHA than did higher levels of linseed oil supplementation

Table 3. Fatty acids profile (% of total fatty acids identified) of ostrich *M. iliofibularis* fed diets of different fatty acid profiles

Fatty acids[1]	Group / Diet[2]					P
	C (n=8)	R5 (n=8)	R10 (n=8)	L4 (n=8)	L8 (n=8)	
C14:0	0.74±0.24^{A}	0.73±0.20^{A}	0.55±0.20^{AB}	0.40±0.16^{B}	0.49±0.13^{AB}	0.003
C16:0	19.34±1.72^{A}	19.46±1.01^{A}	17.54±2.22^{AB}	15.48±1.56^{B}	17.31±3.02^{AB}	0.002
C16:1	6.12±1.03^{A}	5.57±0.69^{AB}	4.79±0.71^{B}	4.60±0.49^{B}	5.26±1.19^{AB}	0.009
C18:0	10.71±1.17^{AB}	9.94±0.82^{B}	10.70±0.67^{AB}	11.86±0.66^{A}	11.06±1.06^{AB}	0.005
C18:1*n-9*	25.04±1.61^{B}	28.20±1.42^{A}	28.40±2.00^{A}	22.57±1.87^{B}	23.79±2.47^{B}	0.0001
C18:2*n-6*	18.55±1.39	18.86±0.79	19.01±1.53	20.08±1.01	18.67±1.89	0.286
C18:3*n-3*	1.72±0.34^{C}	2.21±0.25^{C}	2.24±0.38^{C}	6.03±1.06^{A}	4.85±1.33^{B}	0.0001
C20:4*n-6*	6.85±1.28	5.71±0.97	6.27±1.69	5.70±0.90	6.15±1.26	0.291
C20:5*n-3*	0.26±0.09^{B}	0.26±0.10^{B}	0.29±0.10^{B}	1.43±0.36^{A}	1.26±0.37^{A}	0.009
C22:6*n-3*	0.38±0.10^{C}	0.47±0.16^{C}	0.71±0.17^{B}	1.43±0.36^{A}	1.22±0.28^{A}	0.0001
SFA	31.80±1.29^{A}	30.76±0.71^{AB}	29.68±1.74^{AB}	28.91±0.83^{B}	29.22±2.28^{AB}	0.002
MUFA	41.04±0.74^{A}	41.05±0.74^{A}	41.09±1.25^{A}	36.23±2.34^{B}	38.41±2.08^{B}	0.0001
PUFA	28.54±2.20^{B}	28.19±1.06^{B}	29.22±2.24^{B}	34.86±2.34^{A}	32.36±3.88^{AB}	0.0001
Σ*n-6*	25.40±2.37	24.28±2.21	25.78±1.32	25.78±1.32	24.81±2.77	0.793
Σ*n-3*	2.36±0.34^{B}	2.94±0.25^{B}	3.24±0.38^{B}	8.89±1.00^{A}	7.33±1.33^{A}	0.0001
n-6/n-3	10.76±2.01^{A}	8.28±1.19^{B}	8.02±1.76^{B}	3.03±0.44^{C}	3.39±0.83^{C}	0.0001
PUFA/SFA	0.90±0.09^{C}	0.92±0.05^{C}	0.99±0.12^{BC}	1.21±0.12^{A}	1.12±0.20^{AB}	0.0001

[1]PUFA – sum (see Tab. 1) of polyunsaturated fatty acids; MUFA – sum of monounsaturated fatty acids; SFA – sum of saturated fatty acids; Σ*n-6* – sum of *n-6* polyunsaturated fatty acids; Σ*n-3* sum of *n-3* polyunsaturated fatty acids; *n-6*/*n-3* – ratio of *n-6* to *n-3* fatty acids; PUFA/SFA – ratio of polyunsaturated to saturated fatty acids.

[2]C – control group; R5 – diet with 5% of rapeseed supplementation; R10 – diet with 10% of rapeseed supplementation; L4 – diet with 4% of linseed supplementation; L8 – diet with 8% of linseed supplementation.

[aA...]Within rows means bearing different superscript letters are significantly different at: small letters – $P<0.05$, capitals – $P<0.001$.

(7%). In another study on chickens, with inclusion of linseed oil and tallow in the bird's diet, Lopez-Ferrer *et al*. [2001] showed that a longer feeding time (52 days) of linseed oil in chicken diets did not result in peripheral tissue accumulation of *n-3* long chain PUFA, although chickens can convert ALA to longer-chain metabolites in their liver from day 24 of age [Lopez-Ferrer *et al*. 2001]. The results from the latter study suggested that chickens have a limited capacity to desaturate and elongate ALA. The capacity in ostriches for this is unknown and Lopez-Ferrer *et al*. [2001] recommended therefore, that the lipid pathways should be thoroughly studied in order to understand the FA metabolism in poultry.

Rapeseed supplementation caused an increase in muscle C18:1 fatty acid content (above 27% FA_{total}, $P<0.001$) as compared to the groups receiving linseed or the control diets (below 25% FA_{total}) in both muscles. The sum of MUFAs decreased in both muscles with the supplementation of linseed (L4 and L8) in the diets (below 39% FA_{total}) as compared to the control and rapeseed groups (above 41% FA_{total}) ($P<0.001$).

The induce of 4% and 8% linseed to the ostrich diets decreased the content of

C16:0 (13.6 and 13.9% FA_{total}, respectively, P<0.001) in the GN muscles compared to that of the birds receiving the control diet (15.7 % FA_{total}) – Table 2. However, the birds receiving the rapeseed had similar levels of C16:0 in the GN compared to control's group. A similar trend was observed in the IF muscles (Tab. 3). The sum of the SFA also decreased in the IF muscles with 4% linseed supplementation in the diet (28.9 *vs*. 31.8% FA_{total} in L4 and C groups, respectively). There were no differences (P=0.54) in the GN muscles in terms of the SFA content (≈30% FA_{total}) between any of the dietary groups (Tab. 2).

The supplementation of linseed in the ostrich diets caused an increase in the content of total PUFA in both muscles (35.1 and 34.9% FA_{total}, GN and IF, respectively). However, the content of the MUFA in the muscles decreased (P<0.001) in this dietary group as compared to the muscles of the control group. The higher level of linseed in the diet (L8 group) compared to the control also caused an increase in the total PUFA (31.5% FA_{total}) in the GN muscle, but this was not so prominent as in the L4 group. In the IF muscles (Tab. 3), linseed supplementation (4% and 8%) increased the PUFA and lowered the MUFA content (P<0.001) in comparison to that of the control group. Lopez-Ferrer *et al*. [2001] obtained similar results in chicken meat after increasing the level of supplementation with linseed oil in the diet. However, Nam *et al*. [1997] did not find any significant differences in MUFA content when evaluating different levels of linseed oil in chicken diets.

The higher content of PUFA in the muscles of the ostriches receiving the linseed diets resulted in higher PUFA/SFA ratios (≥1.08), P<0.001) compared to the other groups (Tab. 2 and 3). Nam *et al*. [1997] and Zelenka *et al*. [2008] also reported higher contents of PUFA and linoleic acid (LA – C18:2*n-6)* – and ALA in chicken meat after the diet supplementation with linseed.

A minimum ratio of PUFA/SFA of 0.4-0.5 is recommended for human health [WHO/FAO, 2003]. Although ostrich meat fulfils this recommendation in terms of its PUFA/SFA ratio, there is still a need to improve the *n-6/n-3* ratio. A balanced *n-6/n-3* ratio in the human diet is essential for normal growth and development and should lead to decreased risk for cardiovascular and other chronic diseases, while improving mental health [Simopoulos 2002]. A *n-6/n-3* fatty acid ratio of less than 4 has been suggested to improve human health [FAO/WHO, 1994]. Dietary treatment influenced the *n-6/n-3* ratio by lowering the value from *ca*.11 in the C group to around 8 in the R5 and R10 groups, and down to about 4.6 and even 3 in the L8 and L4 groups, respectively (P<0.001). Therefore, enrichment of ostrich meat with *n-3* PUFA by supplementation with oilseeds, especially linseed, may provide a good source of these fatty acids in the human diet.

The results indicate that the inclusion of linseed in the ostrich diet influenced the fatty acids profile of both muscles: *M. gastrocnemius pars interna* and *M. iliofibularis*. It should be emphasised that the *n-6/n-3* ratio and the content of PUFA in the meat,

including EPA and DHA fatty acids, as well as the PUFA/SFA ratio were clearly improved. However further research assessing the oxidative stability of PUFA-enriched ostrich meat is required.

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