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EFFECT OF FLAX SEED IN FEED ON THE QUALITY OF QUAIL MEAT

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Abstract. The study was conducted on female Pharaoh quails aged from 7 to 20 weeks, divided into 3 dietary groups. The control group received standard feed for adult birds, whereas group I received feed containing 4% flax seed and group II received feed containing 7% flax seed. All feedstuffs used in the experiment were isoprotein based and isoenergetic. After the feeding period, 12 females were selected from each group and slaughtered. Separated breast and leg muscles were assayed in terms of water holding capacity, thermal drip, colour, basic chemical composition, fatty acid composition and sensory appeal. Based on the survey, it was ascertained that the feeds containing 4% and 7% flax seed had no effect on the chemical composition and physical properties of the quail breast muscles, while the leg muscles had lower dry matter content, total protein and fat. Sensory evaluation showed possible deviations of taste and smell of the meat and broth from quails receiving flax seeds. The use of 7% flax seed in feed resulted in significantly less fatty acids: C14 : 0, C16 : 0, C17 : 0, C18 : 0, and more unsaturated fatty acids: C16 : 1c, C18 : 1 n–9c, C18 : 3 n–3, C20 : 3 n–6, C22 : 5 n–6.

Key words: fatty acid profile, flax seed, meat quality, quail

INTRODUCTION

According to various authors the use of flax seed in feedstuff for animals significantly affects the fat composition in meat, descreasing the proportion of n–6:n–3 polyunsaturated acids. Enrichment of the muscle tissue fat with unsaturated alpha-linoleic acid (C18 : 3 n–3) improves the nutritional value of meat and shows a be-

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neficial effect human health [Ajuyah et al. 1993, Basmacioğlu et al. 2003, Azcona et al. 2008, Migdał et al. 2008].

However, flax seed is also known to have some adverse effects due to the presence of cyanogenic glycosides, trypsin inhibitor and phytic acid. In order to maximally limit the adverse effects of flax seed and use the beneficial properties, it is important to choose an adequate dose and period of feeding. According to Zuidhof et al. [2009], the optimal enrichment of broiler meat with polyunsaturated acids n–3 is ensured by a 10% content of flax seed in feed and a 24-day long period of feeding.

The introduction of flax seed as an additive to chicken feedstuff may similarly result in negative physicochemical and sensory changes in the meat after slaughter, affecting the perception of the product among consumers, as shown by Morrissey et al. [1998].

Moreover, Betti et al. [2009] observed that meat obtained from chickens fed with flax-enriched feed for 16 days had a too low pH, excess drip loss, and increased cooking loss. Lopez-Ferrer et al. [2001] and Jamroz [2004] showed that the increased content of polyunsaturated acids (C20 : 5 n–3, C22 : 6 n–3, C22 : 5 n–6) in the muscle fat may worsen its sensory attractiveness, primarily the taste and texture.

In available literature data we have not found any results concerning the effect of flax seed enriched feedstuff on the quality of quail meat.

Therefore the aim of this paper is to assess whether feeding quails with feedstuff containing 4% and 7% flax seed from the 7th to 20th weeks of life has any effect on meat quality.

MATERIAL AND METHODS

The experiment was conducted on female Pharaoh quails. The birds were reared from chicks in standard conditions and fed according to the demands of growing quail (ad libitum). At the 7th week of age, 96 females were randomly divided into 3 dietary groups, including 32 pieces in each group. In the control group quails were given standard feed for adult birds. In group I, feed contained 4% flax seed, and in group II feed contained 7% flax seed. All feeds used in the experiment were isoprotein based and isoenergetic. The experiment was conducted until the quails reached 20 weeks of age. After the feeding period, 12 females were randomly selected from each group and after 12 hours of feed deprivation the birds were slaughtered by decapitation with a sharp knife after prior stunning. After exsanguination, plucking and evisceration, carcasses were stored at a temperature

of about 6°C for 24 hours. After this period, breast and leg muscles were collected to perform the following determinations:

1. The hydrogen ion concentration using a pX–processor PM-600 pH meter with a ESAgP–307 glass electrode.
2. Water holding capacity - based on the percentage of free water in meat according to Grau and Hamm [1953] with Pohja and Niinivaara modifications [1957]. Meat samples weighing 300 mg (weighed to 1 mg) were placed on Whatmann filter paper and subjected to pressure of 2 kg between two glass plates for 5 minutes. A planimeter was used to determine the area (in cm^2) of the two patches formed by the pressed meat juices and of the meat. In order to determine the percentage of free water in the meat, the drip area (cm^2) resulting from the difference between the two patches was divided by the mass of the weighed sample.
3. Measurement of colour – determined after placing meat samples in measurement dishes and storing them for 20 minutes in a refrigerator at 4°C to allow oxygenation of myoglobin in the surface layer of the meat. Colour was measured using a MiniScan XE Plus 45/0 with a port hole diameter measuring 31.8 mm adapted to measure the colour of minced meat, using a scale of CIEL*a*b* according to CIE [1976], and the illuminant D65 and standard observer 10°. Calibration of the apparatus was made using black and white reference standards with coordinates $X = 78.5$, $Y = 83.3$ and $Z = 87.8$.
4. Basic chemical composition of muscle by AOAC [2003].
5. Fatty acid composition in breast muscles using gas chromatograph-mass spectrometry (GCMS), "Claus 600" [PN–EN ISO 5508, PN–EN ISO 5509, PN–EN ISO 5555].
6. For the purposes of sensory evaluation was carried out by the placing of muscle samples in 300 ml glass jars and covered with 100 ml of water. The jars were then closed, placed in a hot water bath until reaching a temperature of 85°C inside the muscle, according to the methodology specified by Baryłko–Pikielna et al. [1964]. The sensory characteristics of the meat and broth were evaluated using a 5–point scale, where 1 point meant the worst score, and 5 points the best. This assessment was conducted by a team of five according to specified norms [PN–ISO–4121]
7. Thermal drip by evaluating the difference between the weight of the meat sample before cooking and it was expressed as a percentage of the weight of samples before cooking.

The results were statistically analysed using a univariate analysis of variance. The significance of differences was determined using Duncan's test and Statistica 7.0 software.

RESULTS AND DISCUSSION

The presented results, obtained from the determination of basic chemical composition (Table 1) are similar to those obtained by Daszkiewicz et al. [1998]. Feeding quail with feed enriched with 4% and 7% flax seed did not increase the protein content in breast muscles. There was a slight decrease in fat content and dry matter in breast muscles from birds fed with 7% flax seed feed compared to control. In leg muscles the use of flax seed in the feed resulted in a statistically significant decrease in dry matter, protein and intramuscular fat in both experimental groups. This lower content of intramuscular fat and subcutaneous fat have also been observed in other animal species fed with flax seed (pigs, chickens, goat) [Pietras et al. 2000, Barowicz and Brzóska 2001, Grześkowiak et al. 2008, Horoszewicz et al. 2010].

Table 1. The chemical composition of breast and leg muscles in quails (%)

Tabela 1. Skład chemiczny mięśni piersiowych i nóg przepiórek (%)

	Groups – Grupy		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
Breast muscles – Mięśnie piersiowe			
Dry matter – Sucha masa	28.17 ± 0.73	27.86 ± 0.64	27.41 ± 0.73
Total protein – Białko ogólne	24.00 ± 0.58	24.09 ± 0.57	24.22 ± 0.50
Raw fat – Tłuszcz	2.58 ± 0.90	2.58 ± 0.32	2.03 ± 0.79
Ash – Popiół	1.28 ± 0.06	1.17 ± 0.11	1.16 ± 0.15
Leg muscles – Mięśnie nóg			
Dry matter – Sucha masa	26.46A ± 1.96	24.48B ± 0.22	24.84B ± 0.10
Total protein – Białko ogólne	20.89a ± 0.70	19.70b ± 0.61	20.08b ± 0.48
Raw fat – Tłuszcz	4.65a ± 1.46	3.66b ± 0.37	3.55b ± 1.03
Ash – Popiół	0.92 ± 0.11	1.09 ± 0.24	1.01 ± 0.05

A, B – significance of differences at $P \leq 0.01$; A, B – różnice istotne na poziomie $P \leq 0{,}01$.
a, b – significance of differences at $P \leq 0.05$; a, b – różnice istotne na poziomie $P \leq 0{,}05$.

The pH of the breast muscle (Table 2) in all groups was typical for quail muscle and ranged from, which is consistent with the data cited by Daszkiewicz et al. [1998] and Gardzielewska et al. [2010]. Analysis of data obtained from determinations of physicochemical characteristics of quail breast muscle shows that the use of flax seed in quail feed had no effect on the meat quality traits.

The results of sensory evaluation of cooked meat and broth (Table 3 and 4) showed that in most cases there were no differences in the sensory appeal of the meat or broth between the control and experimental groups. In several samples, the meat and broth in groups I and II had a distinct taste and smell of fat, which affected the average assessment of the flavour and aroma in these groups. The deviations in flavour and aroma may have been associated with a greater share of

unsaturated fatty acids in the groups receiving flax seed, which is consistent with the findings of Van Elswyk [1997] regarding the impact of the increased content of unsaturated fatty acids on the sensory characteristics of meat. However, results concerning other animals are ambiguous. In an experiment on porkers [Nuernberg et al. 2005] feed with 5% flax seed showed negative effects on the taste of the meat, whereas cooked meat samples from pigs fed with flax seed oil showed neither olfactory nor gustatory deviations from the norm [Grześkowiak et al. 2008].

Table 2. Results of the evaluation of physicochemical characteristics of quail breast muscles

Tabela 2. Wyniki oceny fizykochemicznej mięśni piersiowych przepiórek

	Groups – Grupy		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
pH	5.75 ± 0.13	5.74 ± 0.05	5.75 ± 0.11
Lightness (L*) – Jasność barwy	33.18 ± 2.50	33,70 ± 1.46	35.06 ± 1.34
Redness (a*) – Udział barwy czerwonej	10,80 ± 1.17	11.26 ± 0.63	10.68 ± 0.31
Yellowness (b*) – Udział barwy żółtej	9.37 ± 1.69	9.99 ± 0.88	9.30 ± 0.99
Free water (%) – Woda wolna	3.60 ± 0.70	3.25 ± 1.41	3.27 ± 1.90
Thermal drip (%) – Wyciek termiczny	36.37 ± 3.78	36.06 ± 2.27	34.96 ± 1.77

The fatty acid composition is shown in Tables 5 to 8. In the examined quail meat, the predominant saturated fatty acid was palmitic acid C16 : 0 (from 23.99 to 24.27), whereas the unsaturated fatty acids were dominated by oleic acid C18 : 1 n–9c (from 39.93 to 40.39) and linoleic acid C18 : 2 n–6c (from 17.60 to 17.81). Similar values for quail meat have been presented by Tarasewicz et al. [2001].

The results of determinations of fatty acids in quail meat show statistically significant differences in the amount of unsaturated and saturated fatty acids between the control group and experimental group II (7% flax seed). The meat of quails fed with 7% flax seed feed contained significantly less fatty acids C14 : 0, C16 : 0, C17 : 0, C18 : 0, C14 : 1, in comparison with the control group. They also had statistically significantly more unsaturated fatty acids: C16 : 1c, C18 : 1 n–9c, C18 : 3 n–3, C20 : 3 n–6 and C22 : 5 n–6. There was also a notable increase in unsaturated n–3 fatty acids (C18 : 3 n–3, C22 : 6 n–3) known to have a pro-health effect [Grashorn 2006]. A decrease in saturated fatty acid content after using feed supplemented with flax seed has also been observed in experiments on broiler chickens [Pietras et al. 2000]. Also research on eggs obtained from hens receiving flax seed have shown decreased saturated fatty acids and increased unsaturated fatty acids, including omega-3 fatty acids [Scheideler and Froning 1996, Niemiec et al 2000]. The beneficial effect of flax seed on the fatty acid profile has also been observed in experiments on rabbit meat [Bianchi et al. 2009] and pork [Barowicz and Brzóska 2001].

Table 3. The results of sensory evaluation of cooked breast and leg muscles (in points)

Tabela 3. Wyniki oceny sensorycznej gotowanych mięśni piersiowych i nóg (w punktach)

	Groups – Grupy		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
	Breast muscles – Mięśnie piersiowe		
Flavour – Zapach	5.00a ± 0.00	4.20b ± 0.45	3.90b ± 0.55
Tenderness – Kruchość	4.30 ± 0.45	4.10 ± 0.25	4.05 ± 0.30
Juiciness – Soczystość	3.60 ± 0.89	4.10 ± 0.30	4.00 ± 0.00
Palatability – Smakowitość	4.30a ± 0.27	3.90b ± 0.84	3.80b ± 0.95
	Leg muscles – Mięśnie nóg		
Flavour – Zapach	5.00a ± 0.00	4.50b ± 0.55	4.40b ± 0.64
Tenderness – Kruchość	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00
Juiciness – Soczystość	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00
Palatability – Smakowitość	5.00a ± 0.00	4.60b ± 0.55	4.20b ± 0.27

a, b – significance of differences at $P \leq 0.05$; a, b – różnice istotne na poziomie $P \leq 0{,}05$.

Table 4. The results of sensory evaluation of broth cooked from breast and leg muscles (in points)

Tabela 4. Wyniki oceny sensorycznej bulionu (w punktach)

	Groups – Grupy		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
	Breast muscles – Mięśnie piersiowe		
Flavour – Zapach	5.00a ± 0.00	4.10b ± 0.57	3.60b ± 0.55
Clarity – Klarowność	4.80 ± 0.45	4.80 ± 0.44	4.80 ± 0.47
Colour – Barwa	4.70 ± 0.27	4.70 ± 0.27	4.60 ± 0.22
Palatability – Smakowitość	4.60a ± 0.89	4.00b ± 0.54	3.90b ± 0.86
	Leg muscles – Mięśnie nóg		
Flavour – Zapach	4.00a ± 0.00	3.60b ± 0.47	3.50b ± 0.52
Clarity – Klarowność	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00
Colour – Barwa	4.40 ± 0.54	4.20 ± 0.44	4.00 ± 0.00
Palatability – Smakowitość	4.90a ± 0.22	4.10b ± 0.41	3.90b ± 0.56

a, b – significance of differences at $P \leq 0.05$; a, b – różnice istotne na poziomie $P \leq 0{,}05$.

After balancing all fatty acids, broken down into saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fats (Table 8), it turned out that birds receiving 7% supplementation with flax seed had a significantly higher amount of unsaturated fatty acids (UFA), including MUFA, and a decreased amount of SFA.

Table 8 shows that 2/3 of all fatty acids were the UFA and 1/3 were SFA. Among UFA, approximately 70% were MUFA and about 30% PUFA. The ratio of PUFA to MUFA was from 0.27 (group II) to 0.28 (groups II and control). In the experiment by Tarasewicz et al. (2001) who used oats in the quail diet, this ratio ranged from 0.68 to 0.98. The ratio of UFA to SFA ranged from 2.27 (groups

I and control) to 2.31 (group II). In breast muscles the ratio of n–6 fatty acids to n–3 acids was 16.55 in the control group. In the group receiving 4% flax seed supplementation it was 16.63 and in the group receiving 7% flax seed – 16.28.

Table 5. Saturated fatty acids (SFA) (% of total fatty acids)

Tabela 5. Skład kwasów tłuszczowych nasyconych

	Groups – Grupy		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
C 12 : 0	0.0564 ± 0.002	0.0553 ± 0.00	0.0547 ± 0.00
C 14 : 0	0.802a ± 0.004	0.802a ± 0.00	0.792b ± 0.00
C 15 : 0	0.100 ± 0.002	0.101 ± 0.00	0.099 ± 0.00
C 16 : 0	24.25A ± 0.095	24.27A ± 0.11	23.99B ± 0.14
C 17 : 0	0.0193a ± 0.000	0.0192a ± 0.00	0.0190b ± 0.00
C 18 : 0	5.13a ± 0.057	5.13a ± 0.07	5.06b ± 0.05
C 20 : 0	0.149 ± 0.002	0.152 ± 0.00	0.149 ± 0.00
C 22 : 0	0.0248 ± 0.002	0.0248 ± 0.00	0.0244 ± 0.00
Σ SFA – kwasy tłuszczowe nasycone	30.53a ± 0.133	30.55a ± 0.15	30.19b ± 0.5

a, b – significance of differences at P ≤ 0.05; a, b – różnice istotne na poziomie P ≤ 0,05.

Table 6. Monounsaturated fatty acids (MUFA) (% of total fatty acids)

Tabela 6. Skład kwasów tłuszczowych jednonienasyconych

	Groups – Grupy		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
C 14 : 1	0.295a ± 0.007	0.292a ± 0.006	0.287b ± 0.006
C 16 : 1c	8.54b ± 0.050	8.53b ± 0.043	8.63a ± 0.051
C 16 : 1 t	0.030 ± 0.000	0.303 ± 0.000	0.030 ± 0.000
C 18 : 1 n–9 c	39.94A ± 0.123	39.93A ± 0.149	40.39B ± 0.213
C 18 : 1 n–9 t	0.898 ± 0.005	0.898 ± 0.004	0.887 ± 0.004
C 20 : 1	0.352 ± 0.004	0.353 ± 0.004	0.351 ± 0.006
C 22 : 1 n–9	0.098 ± 0.002	0.097 ± 0.001	0.099 ± 0.002
Σ MUFA – Kwasy tłuszczowe jednonienasycone	50.16a ± 0.164	50.12a ± 0.173	50.68b ± 0.244

A, B – significance of differences at P ≤ 0.01; A, B – różnice istotne na poziomie P ≤ 0,01.
a, b – significance of differences at P ≤ 0.05; a, b – różnice istotne na poziomie P ≤ 0,05.

CONCLUSIONS

Quail feed containing flax seed at 4% and 7% had no statistically significant effect on the chemical composition and physical properties of breast muscles. Only in the muscles of the legs was there a significantly lower dry matter content, total protein and fat levels. Sensory evaluation showed that the meat and broth from birds receiving flax seeds may show deviations in taste and smell. The use of 7% flax seed supplementation in quail feed significantly decreased the content of fatty

acids: C14 : 0, C16 : 0, C17 : 0, C18 : 0, and increased the content of unsaturated fatty acids : C16 : 1c, C18 : 1 n–9c, C18 : 3 n–3, C20 : 3 n–6 and C22 : 5 n–6.

Table 7. Polyunsaturated fatty acids (PUFA) (% of total fatty acids)

Tabela 7. Skład kwasów tłuszczowych wielonienasyconych

	Groups – Grupy		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
C 18 : 2 n–6 c	17.80 ± 0.0750	17.81 ± 0.071	17.60 ± 0.11
C 18 : 3 n–3	0.903a ± 0.0066	0.898a ± 0.01	0.911b ± 0.00
C 18 : 3 n–6	0.011 ± 0.0003	0.011 ± 0.00	0.0113 ± 0.00
C 20 : 2 n–6	0.057 ± 0.0029	0.059 ± 0.00	0.058 ± 0.00
C 20 : 3 n–6	0.0640a ± 0.0006	0.0644a ± 0.00	0.0651b ± 0.00
C 20 : 4 n–6	0.284 ± 0.0061	0.287 ± 0.01	0.289 ± 0.00
C 20 : 5 n–3	0.197 ± 0.0051	0.197 ± 0.00	0.195 ± 0.00
C 22 : 5 n–6	0.00213a ± 0.0000	0.00213a ± 0.00	0.00215b ± 0.00
C 22 : 6 n–3	0.001 ± 0.0000	0.001 ± 0.00	0.001 ± 0.00
Σ PUFA – Kwasy tłuszczowe wielonienasycone	19.32 ± 0.0750	19.33 ± 0.07	19.13 ± 0.10

a, b – significance of differences at P ≤ 0.05; a, b – różnice istotne na poziomie P ≤ 0,05.

Table 8. The composition of fatty acids, by type

Tabela 8. Skład kwasów tłuszczowych z podziałem na rodzaje

	Groups – Grupa		
	Control Kontrolna	I – 4% flax seed Nasiona lnu	II – 7% flax seed Nasiona lnu
Saturated fatty acids (SFA) Kwasy tłuszczowe nasycone	30.53a ± 0.13	30.55a ± 0.15	30.19b ± 0.15
Monounsaturated fatty acids MUFA) Kwasy tłuszczowe jednonienasycone	50.16a ± 0.16	50.12a ± 0.17	50.68b ± 0.24
Polyunsaturated fatty acids (PUFA) Kwasy tłuszczowe wielonienasycone	19.32 ± 0.07	19.33 ± 0.07	19.13 ± 0.10
Unsaturated fatty acids (UFA) Kwasy tłuszczowe nienasycone	69.47A ± 0.13	69.45A ± 0.15	69.81B ± 0.15
PUFA/MUFA	0.28	0.28	0.27
UFA/SFA	2.27	2.27	2.31
PUFA n–6/PUFA n–3	16.55	16.63	16.28

A, B – significance of differences at P ≤ 0.01; A, B – różnice istotne na poziomie P ≤ 0,01.
a, b – significance of differences at P ≤ 0.05; a, b – różnice istotne na poziomie P ≤ 0,05.

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WPŁYW ZASTOSOWANIA NASION LNU W ŻYWIENIU PRZEPIÓREK NIEŚNYCH NA JAKOŚĆ ICH MIĘSA I TŁUSZCZU

Streszczenie. Badania przeprowadzono na przepiórkach samicach rasy Faraon w wieku od 7. do 20. tygodnia życia podzielonych na trzy grupy żywieniowe; grupę kontrolną otrzymującą paszę standardową przeznaczoną dla dorosłych ptaków, grupę i otrzymującą paszę zawierającą 4% nasion lnu i grupę II, w której mieszanka paszowa zawierała 7% nasion lnu. Wszystkie mieszanki paszowe użyte w doświadczeniu były izobiałkowe i izoenergetyczne. Po zakończonym doświadczeniu wybrano po 12 samic z każdej grupy i poddano ubojowi. W wydzielonych mięśniach piersiowych i nóg określano: wodochłonność, wyciek termiczny, barwę, podstawowy skład chemiczny, skład kwasów tłuszczowych i ocenę sensoryczną. Na podstawie przeprowadzonych badań stwierdzono, że podanie przepiórkom paszy zawierającej nasiona lnu w ilości 4% i 7% nie miało wpływu na skład chemiczny i cechy fizykochemiczne mięśni piersiowych. W mięśniach nóg zaobserwowano niższą zawartość suchej masy, białka ogólnego i tłuszczu. Ocena sensoryczna wykazała, że w mięsie i bulionie pochodzących od ptaków otrzymujących nasiona lnu mogą pojawić się odchylenia smaku i zapachu. Istotnie mniej kwasów tłuszczowych nasyconych: C14 : 0, C16 :0, C17 : 0, C18 : 0 i więcej kwasów tłuszczowych nienasyconych: C16 : 1c, C18 : 1 n–9c, C18 : 3 n–3, C20 : 3 n–6 oraz C22 : 5 n–6 uzyskano przy zastosowaniu 7% nasion lnu w mieszance paszowej.

Słowa kluczowe: jakość mięsa, nasiona lnu, profil kwasów tłuszczowych, przepiórki

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