THE POSSIBILITIES OF ENRICHING THE LIPIDS OF ESTONIAN QUAIL BROILER MEAT WITH Ω-3 FATTY ACIDS

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ABSTRACT. *In the trials carried out at Järveotsa quail farm (Estonia) the suitable amounts of linseed oil and linseed cake in the feed of quail chicks and the duration of feeding linseed oil and linseed cake to quail broilers were investigated.*

During the I stage of the experiment, 200 Estonian quail were used (5 trial groups with 40 quail in each); during the II stage, 4 additional trial groups were added with 20 quail in each. Thus, 280 young quail in total participated in the experiment.

The quail chicks were kept in similar conditions, but their feeding differed, depending on the trial group. Mixed concentrated quail feed was used which contained either 1.5 or 3.0% linseed oil or 15 or 30% linseed cake for the trial groups. Linseed cake contained 10% linseed oil. There was no linseed oil or linseed cake in the mixed concentrated feed of the control group. The mixed concentrated feed contained 24.2% raw protein and 12.96 MJ metabolizable energy.

The chicks of the I, II, IV, VI and VIII trial group were weighed on their 21st day of life and from each group 5 quail cocks and 5 quail hens with average body mass were slaughtered.

The quail chicks from the trial groups III, V, VII and IX were raised together until their 21st day of life, after which groups were formed, consisting of 20 young quail. The trial birds were weighed on their 42nd day of life, after which 5 cocks and 5 hens from each group were slaughtered. After slaughtering the carcasses were weighed and the dressing percentage was calculated. The breast muscles and liver were weighed. The content of ω-3 fatty acids in the breast muscle lipids was measured.

Keywords: *quail broilers, linseed oil, linseed cake, meat productivity of quail broilers, fatty acid composition of quail meat.*

Introduction

The dietary capacities of quail meat are of common knowledge and it has been considered suitable for dietary nutrition (Пигарева, Афанасьев, 1989). The suitability of 35–42-day-old Estonian quail for broilers was proven already in the previous century (V. Tikk *et al.*, 1989). The quality of quail broiler meat as foodstuff is the better the more its lipids contain ω-3 fatty acids.

Ω-3 fatty acids belong to polyunsaturated monobasic carboxylic acids which the human organism needs for its daily functioning. They are for example crucial for the synthesis of prostaglandins. The substances to be synthesized regulate the coagulation of blood as well as stricturing and expansion of arteries, decrease the content of blood cholesterol, having, furthermore, an impact on the metabolic processes of cells (Sardesai, Detroit, 1992). The daily need for ω-3 fatty acids in human consumption is 0.4–0.8 g on average (Leskanich, Noble, 1997; Farrell, 1997).

Bearing in mind the importance of ω-3 fatty acids in human consumption, worldwide attempts have been made to enrich regular foodstuffs with ω-3 fatty acids. In total lipids of quail meat, 1.4% of ω-3 fatty acids have been found on average (Decker, Cantor, 1992). In the course of studying the content of ω-3 fatty acids in regular quail meat in Estonia it was found out that of total lipids of quail meat these fatty acids make up 4.30% of breast muscle, 3.71% of haunch muscle, 2.53% of skin and 2.81% of internal fat in the case of quail fed on mixed feed concentrate (H. Tikk *et al.*, 2006[a], 2006[b]).

The aforementioned data reveal that even at feeding regular feed, the ω-3 fatty acid content in the different tissues of the carcass can be comparatively substantial.

Finding out the exact level at which to enrich the fat and internal fat of the carcasses of agricultural poultry with ω-3 fatty acids is essential also from the point of view of the developing dietology in the future as it may become necessary to enrich lipids with several agents, *e.g.* biogenic substances, to improve human immunity (Mulder, 2006). Both quail meat and quail eggs have been enriched successfully with ω-3 fatty acids at Estonian University of Life Sciences (Hämmal *et al.*, 1998; Mõttus *et al.*, 1999; Viigimaa *et al*., 2000; H. Tikk *et al.*, 2001), let alone hen broiler meat and eggs (H. Tikk, Lember, 2004; Lember *et al.*, 2006).

Possibilities for enriching quail meat with ω-3 fatty acids were studied already in 1998 in Estonia. It was found out that the addition of 4% linseed oil to the feed of quail almost doubled ω-3 fatty acid content in different parts of quail body (H. Tikk *et al*., 1999). The same results were obtained in the year 2000 in an

experiment which involved the addition of 3% linseed oil to quail feed (H. Tikk *et al.*, 2002; Hämmal, 2004), as a result of which of total lipids of quail meat ω-3 fatty acids made up the following share: 11.1% in breast muscle, 14.0% in haunch muscle, 9.7% in skin and 9.1% in fat.

The effect of smaller quantities of linseed oil and linseed cake on the chemical composition of quail meat lipids has not been studied yet.

Taking into consideration the fact that linseed oil is comparatively expensive and its excessive use would unnecessarily raise the cost of quail meat, both the effect of diminished quantities of linseed oil and the possibilities of substituting linseed oil with less expensive linseed cake needed investigation. From the point of view of assimilating ω-fatty acids, until now it was not clear what might be the optimal time of feeding feeds rich in fatty acids – whether it was best at the beginning or at the end of the growing period of the quail broilers or during the whole growth period.

Material and methods

The aim of the trial was to specify: 1) the amounts of linseed oil and linseed cake in the feed of quail chicks and 2) the duration of feeding linseed oil and linseed cake to quail broilers.

The aim of the experiment was to substantiate scientifically the consumption of quail meat in order to stabilize with its production the production activity of quail farms.

The trial was established at Järveotsa quail farm from April 18 to May 30, 2005. During the I stage of the experiment, 200 Estonian quail were used (5 trial groups with 40 quail in each); during the II stage, 4 additional trial groups were added with 20 quail in each. Thus, 280 young quail in total participated in the experiment.

The quail chicks were kept in similar conditions, but their feeding differed, depending on the trial group. Mixed concentrated quail feed was used which contained either 1.5 or 3.0% linseed oil or 15 or 30% linseed cake for the trial groups. Linseed cake contained 10% linseed oil. There was no linseed oil or linseed cake in the mixed concentrated feed of the control group. The mixed concentrated feed contained 24.2% raw protein and 12.96 MJ metabolizable energy.

The feeding scheme was following:

Trial group	I stage (1–21 days)	II stage (22–42 days)
I	mixed concentrated feed (control)	mixed concentrated feed (control)
II	98.5% mixed concentrated feed + 1.5% linseed oil	98.5% mixed concentrated feed + 1.5% linseed oil
III	mixed concentrated feed (control)	98.5% mixed concentrated feed + 1.5% linseed oil
IV	97% mixed concentrated feed + 3.0% linseed oil	97% mixed concentrated feed + 3.0% linseed oil
V	mixed concentrated feed (control)	97% mixed concentrated feed + 3.0% linseed oil
VI	85% mixed concentrated feed + 15% linseed cake	85% mixed concentrated feed + 15% linseed cake
VII	mixed concentrated feed (control)	85% mixed concentrated feed + 15% linseed cake
VIII	70% mixed concentrated feed + 30% linseed cake	70% mixed concentrated feed + 30% linseed cake
IX	mixed concentrated feed (control)	70% mixed concentrated feed + 30% linseed cake

During the I stage, the quail chicks of the 5 trial groups (I, II, IV, VI and VIII trial group) were kept in 40s in special wire mesh boxes made at the farm (the groups which were fed the trial feed). During the II stage, all the young quail of the 9 trial groups were kept separately by the trial groups in the cages for the layer quail. The chicks of the I, II, IV, VI and VIII trial group were weighed on their 21st day of life and from each group 5 quail cocks and 5 quail hens with average body mass were slaughtered (at this age the gender can be specified according to the colour of the breast feathers).

The quail chicks from the trial groups III, V, VII and IX were raised together until their 21st day of life, after which groups were formed, consisting of 20 young quail. The trial birds were weighed on their 42nd day of life, after which 5 cocks and 5 hens from each group were slaughtered. Before slaughtering, the quail were marked with wing tags. After slaughtering the carcasses were weighed and the dressing percentage was calculated. The breast muscles and liver were weighed. The content of ω-3 fatty acids in the breast muscle lipids was measured by S. Kuusik at the Laboratory of Ecochemistry at the Estonian Agricultural University.

Results and discussion

The meat characteristics of quail broilers

The body masses of 21-day-old quail broilers are provided in Table 1.

The addition of linseed oil to the feed did not have statistically plausible effect on the body mass of quail chicks at the beginning of the growing period, although the 3% linseed oil content in feed resulted in the biggest body mass among the quail hens in this group – 105.6 g. However, the 15 and 30% linseed cake content in feed had a lowering effect on the body mass of the quail chicks ($P<0.05$). The feathering of the chicks of the VIII group was noticeably worse as well.

Table 1. Body mass of 21-day-old trial quail (n = 15), g

Gender	Trial groups				
	I	II	IV	VI	VIII
♀♀	103.6	101.2	105.6	94.0	86.7
♂♂	99.9	95.7	99.6	88.5	83.9

The data of experimental slaughtering of 21-day-old trial quail are presented in Table 2 and 3. According to the tables, 30% linseed cake content in feed has a negative impact on the dressing percentage of the quail hens ($P<0.05$). The share of breast muscle mass in the carcass remained plausibly unaffected by the composition of the feeds used. The liver mass of the birds did not differ plausibly either, although it could have been expected due to the relatively big quantities of linseed cake.

The body masses of 42-day-old trial quail are presented in Table 4 and their meat productivity in Table 5 and 6.

Table 2. Meat productivity of 21-day-old quail hen broilers (n = 5)

Trial group	Live mass g	Carcass g	Dressing % %	Liver mass from live mass %	Breast muscle mass g	Breast muscle mass of carcass %
I group (control)	105.2	63.4	60.3	3.2	15.6	24.6
II group (1.5% linseed oil)	106.8	68.0	63.7	3.1	16.8	24.7
IV group (3.0% linseed oil)	107.6	68.6	63.8	2.7	18.0	26.2
VI group (15% linseed cake)	104.8	63.0	60.1	2.7	14.0	22.2
VIII group (30% linseed cake)	95.2	54.0	56.7	3.2	13.8	23.3

Table 3. Meat productivity of 21-day-old quail cock broilers (n = 5)

Trial group	Live mass g	Carcass g	Dressing % %	Liver mass from live mass %	Breast muscle mass g	Breast muscle mass from live mass %
I group (control)	97.2	58.0	59.6	3.2	14.6	25.2
II group (1.5% linseed oil)	104.4	65.4	62.6	2.5	16.0	24.4
IV group (3.0% linseed oil)	103.6	63.0	60.8	3.3	15.8	25.1
VI group (15% linseed cake)	91.2	55.8	61.2	3.4	13.8	24.7
VIII group (30% linseed cake)	92.6	55.4	59.8	2.4	13.4	24.2

Table 4. Body mass of 42-day-old quail broilers g (n = 10)

Trial group	♀♀	♂♂
I (control)	208.4	183.1
II (1.5% linseed oil, 1–42 days)	205.7	174.5
III (1.5% linseed oil, 22–42 days)	225.3	181.8
IV (3.0% linseed oil, 1–42 days)	210.2	188.0
V (3.0% linseed oil, 22–42 days)	208.6	176.5
VI (15% linseed cake, 1–42 days)	191.4	181.9
VII (15% linseed cake, 22–42 days)	206.0	170.1
VIII (30% linseed cake, 1–42 days)	180.5	171.8
IX (30% linseed cake, 22–42 days)	192.3	168.4

Table 5. Meat productivity of 42-day-old quail hen broilers (n = 5)

Trial group	Live mass g	Carcass g	Dressing % %	Liver mass from live mass %	Breast muscle mass g	Breast muscle mass from carcass %
I group (control)	209.6	144.4	68.9	2.9	41.2	28.5
II group (1.5% linseed oil, 1–42 days)	200.8	139.6	69.5	2.2	34.8	24.9
III group (1.5% linseed oil, 22–42 days)	223.6	151.0	67.5	2.5	42.0	27.8
IV group (3.0% linseed oil, 1–42 days)	208.8	145.4	69.5	1.9	41.2	28.3
V group (3.0% linseed oil, 22–42 days)	208.4	139.6	67.0	2.4	38.0	27.2
VI group (15% linseed cake, 1–42 days)	193.6	130.6	67.5	2.2	36.4	27.9
VII group (15% linseed cake, 22–42 days)	207.6	141.2	68.0	2.0	39.2	27.8
VIII group (30% linseed cake, 1–42 days)	183.2	120.4	65.7	2.1	34.0	28.2
IX group (30% linseed cake, 22–42 days)	191.6	128.0	66.8	2.2	36.0	28.1

Table 6. Meat productivity of 42-day-old quail cock broilers (n = 5)

Trial group	Body mass g	Carcass g	Dressing % %	Liver mass from live mass %	Breast muscle mass g	Breast muscle mass from carcass %
I group (control)	188.4	136.6	72.5	2.3	39.2	28.7
II group (1.5% linseed oil, 1–42 days)	172.8	125.6	72.7	2.1	34.4	27.4
III group (1.5% linseed oil, 22–42 days)	182.8	133.4	73.0	1.7	35.6	26.7
IV group (3.0% linseed oil, 1–42 days)	186.8	133.2	71.3	1.8	36.8	27.6
V group (3.0% linseed oil, 22–42 days)	174.8	127.8	73.1	1.8	35.6	27.9
VI group (15% linseed cake, 1–42 days)	182.0	126.8	69.7	2.1	37.2	29.3
VII group (15% linseed cake, 22–42 days)	169.6	120.8	71.2	2.5	34.4	28.5
VIII group (30% linseed cake, 1–42 days)	174.4	119.6	68.6	2.0	35.2	29.4
IX group (30% linseed cake, 22–42 days)	170.0	114.4	67.3	2.2	32.6	28.7

The comparison of body masses of 42-day-old trial quail reveals that in the II growing stage, a 1.5% linseed oil additive in feed resulted in a statistically plausibly bigger body mass of quail hens ($P<0.05$) compared to the quail of the control group. However, the use of a 30% linseed cake additive in feed, fed during 1.–42. days of life, diminished in the case of quail hens their body mass statistically plausibly. The differences of the rest of the body masses were not statistically plausible. Thus, the experiment allows us to conclude that the use of a great amount of linseed cake in quail feed is not recommendable.

The figures of meat productivity of trial quail (Table 5 and 6) prove as well the inexpediency of the use of 30% linseed cake. The dressing percentages in the case of such an amount of linseed cake were smaller than in the control group or the linseed oil group, although the difference was not statistically plausible (P>0.05). The best dressing percentage of the quail hens occurred in a long-term feeding with feed containing 1.5% linseed oil or in a short-term feeding with feed containing 30% linseed oil (69.5%). The dressing percentage of quail cocks appeared to be slightly higher in all the trial groups, reaching in the 3.0% linseed group even over 73%. With respect to the relative content of breast muscles and liver, the trial groups did not differ from each other significantly. These data were not even worsened by the use of 30% linseed cake.

The fatty acid composition of the meat of the trial broilers

The results of the fatty acid analysis of the breast muscles of the 21-day-old trial quail are presented in Table 7 and 8, the data concerning the 42-day-old trial quail in Table 9–12.

According to the data in Table 7 and 8, linseed oil and linseed cake, added to the feed during the first growth period, enhance the content of ω-3 fatty acids in total lipids by 2–4 times. A 1.5% linseed oil content in feed remains too low (the amount of ω-3 fatty acids increased 2-fold). At the same time, a 15% linseed cake content in feed increased the amount of ω-3 fatty acids in the total lipids of breast muscles approximately 3 times (15% linseed cake contained computationally 1.5% linseed oil). Thus, the quail broilers of the I growth stage assimilate ω-3 fatty acids from the feed very successfully. The content of saturated fatty acids in the breast muscles of the quail broilers remained more or less unaffected by the composition of the feeds; nevertheless, the content of linoleic acid which is the main representative of ω-6 fatty acids, decreased a little in all the trial groups.

Table 7. Fatty acid content of the breast muscles of 21-day-old quail hen broilers (% of total lipids)

Acid abbreviation	Trial group				
	I control	II 1.5% linseed oil	IV 3.0% linseed oil	VI 15% linseed cake	VIII 30% linseed cake
C14:0	0.6	0.7	0.4	0.5	0.5
C15:0	0.1	0.1	0.1	0.2	0.2
C16:0	23.4	23.4	20.7	23.1	19.9
C16:1	3.3	4.5	1.7	2.1	2.0
C17:0	0.2	0.2	0.2	0.2	0.4
C17:1	0.2	0.1	0.4	0.3	0.5
C18:0	11.8	9.6	11.6	12.2	10.5
C18:1	19.7	23.8	14.9	13.1	17.5
C18:2n6	25.7	21.0	24.3	25.4	24.2
C18:3n3	1.8	6.2	11.6	10.1	14.1
C20:0	0.2	0.2	0.1	0.2	0.1
C20:1	0.4	0.4	0.3	0.3	0.3
C20:4n6	4.2	2.0	2.7	2.4	2.7
C20:5n3	0.6	1.2	2.5	2.1	1.5
C22:5n3	0.8	1.4	1.8	1.5	1.2
C22:6n3	2.8	2.5	4.1	2.8	2.4
The rest	4.2	2.8	2.6	3.5	2.0
∑	100.0	100.0	100.0	100.0	100.0
∑n6	29.87	22.95	27.01	27.79	26.87
∑n3	**6.00**	**11.33**	**19.94**	**16.47**	**19.19**
n6/n3	4.98	2.03	1.35	1.69	1.40

Table 8. Fatty acid content of the breast muscles of 21-day-old quail cock broilers (% of total lipids)

Acid abbreviation	Trial group				
	I control	II 1.5% linseed oil	IV 3.0% linseed oil	VI 15% linseed cake	VIII 30% linseed cake
C14:0	0.7	0.7	0.5	0.5	0.4
C15:0	0.2	0.1	0.1	0.1	0.1
C16:0	23.5	22.7	20.4	21.9	20.3
C16:1	3.2	4.0	2.2	3.0	1.9
C17:0	0.2	0.2	0.2	0.2	0.3
C17:1	0.2	0.1	0.1	0.2	0.3
C18:0	11.0	10.7	10.8	11.3	11.6
C18:1	23.1	20.9	18.5	18.7	16.4
C18:2n6	25.3	21.9	23.3	22.3	22.4
C18:3n3	1.7	6.8	11.8	9.9	13.9
C20:0	0.1	0.2	0.2	0.2	0.1
C20:1	0.5	0.4	0.3	0.3	0.3
C20:4n6	3.1	2.4	2.2	2.2	2.6
C20:5n3	0.4	1.6	1.9	2.1	2.0
C22:5n3	0.8	1.4	1.6	1.7	1.6
C22:6n3	2.3	3.1	3.3	2.6	2.6
The rest	3.8	3.0	2.7	2.9	3.0
∑	100.0	100.0	100.0	100.0	100.0
∑n6	28.36	24.35	25.53	24.49	25.06
∑n3	**5.14**	**12.80**	**18.51**	**16.30**	**20.15**
n6/n3	5.52	1.90	1.38	1.50	1.24

Table 9. The effect of feed, containing linseed oil, on the fatty acid composition of the breast muscles of 42-day-old quail hen broilers (% of total lipids, n=5)

Acid abbreviation	Trial group				
	I control	II 1.5% linseed oil 1–42 days	III 1.5% linseed oil 22–42 days	IV 3.0% linseed oil 1–42 days	V 3.0% linseed oil 22–42 days
C14:0	0.7	0.5	0.6	0.5	0.6
C15:0	0.1	0.1	0.1	0.1	0.1
C16:0	24.6	23.2	22.6	21.6	21.0
C16:1	6.0	4.2	6.2	4.6	4.8
C17:0	0.2	0.2	0.1	0.1	0.2
C17:1	0.2	0.1	0.1	0.1	0.1
C18:0	9.8	9.6	7.4	8.8	8.2
C18:1	28.4	25.1	28.6	24.7	25.1
C18:2n6	18.3	18.9	18.3	18.2	18.4
C18:3n3	1.4	7.2	8.9	11.1	13.2
C20:0	0.1	0.1	0.1	0.1	0.1
C20:1	0.4	0.3	0.3	0.3	0.3
C20:4n6	3.2	2.4	1.6	1.7	1.8
C20:5n3	0.5	1.5	0.9	2.1	1.5
C22:5n3	0.4	0.8	0.5	0.7	0.7
C22:6n3	2.4	3.6	1.9	2.7	2.4
The rest	3.2	2.3	1.9	2.8	1.6
∑	100.0	100.0	100.0	100.0	100.0
∑n6	21.49	21.34	19.88	19.91	20.19
∑n3	**4.70**	**13.02**	**12.13**	**16.53**	**17.75**
n6/n3	4.57	1.64	1.64	1.20	1.14

Table 10. The effect of feed with linseed oil additive on the fatty acid composition of the breast muscles of 42-day-old quail cock broilers (% of total lipids, n=5)

Acid abbreviation	Trial group				
	I control	II 1.5% linseed oil 1–42 days	III 1.5% linseed oil 22–42 days	IV 3.0% linseed oil 1–42 days	V 3.0% linseed oil 22–42 days
C14:0	0.7	0.6	0.5	0.5	0.4
C15:0	0.1	0.1	0.1	0.1	0.1
C16:0	24.5	22.2	23.8	20.8	20.3
C16:1	4.9	4.1	3.9	5.1	3.8
C17:0	0.2	0.2	0.2	0.1	0.2
C17:1	0.1	0.1	0.1	0.1	0.1
C18:0	11.7	10.7	10.6	8.7	11.5
C18:1	24.9	24.2	22.7	26.0	21.7
C18:2n6	19.6	19.7	19.7	19.2	18.7
C18:3n3	1.4	7.5	7.3	11.1	9.0
C20:0	0.1	0.1	0.1	0.1	0.1
C20:1	0.3	0.3	0.3	0.3	0.2
C20:4n6	4.2	2.5	2.8	1.9	3.6
C20:5n3	0.8	1.6	1.4	1.5	2.3
C22:5n3	0.6	0.9	0.9	0.7	1.1
C22:6n3	3.1	3.1	2.8	2.2	4.0
The rest	2.9	2.1	2.9	1.7	2.9
∑	100.0	100.0	100.0	100.0	100.0
∑n6	23.78	22.24	22.52	21.10	22.34
∑n3	**5.86**	**13.10**	**12.38**	**15.45**	**16.47**
n6/n3	4.06	1.70	1.82	1.37	1.36

Table 11. The effect of feed with linseed cake additive on the fatty acid composition of the breast muscles of 42-day-old quail hen broilers (% of total lipids, n=5)

Acid abbreviation	Trial group				
	I control	VI 15% linseed cake 1–42 days	VII 15% linseed cake 22–42 days	VIII 30% linseed cake 1–42 days	IX 3.0% linseed cake 22–42 days
C14:0	0.7	0.5	0.5	0.4	0.4
C15:0	0.1	0.1	0.1	0.1	0.1
C16:0	24.6	20.7	20.9	19.4	19.6
C16:1	6.0	3.5	4.8	2.5	2.4
C17:0	0.2	0.1	0.2	0.5	0.2
C17:1	0.2	0.2	0.1	0.1	0.1
C18:0	9.8	10.6	9.0	11.6	10.7
C18:1	28.4	20.9	23.4	16.7	16.7
C18:2n6	18.3	20.0	18.3	20.8	20.3
C18:3n3	1.4	12.2	11.5	15.3	16.6
C20:0	0.1	0.1	0.1	0.1	0.1
C20:1	0.4	0.2	0.3	0.2	0.2
C20:4n6	3.2	2.1	2.4	2.2	2.6
C20:5n3	0.5	2.4	1.9	3.3	2.9
C22:5n3	0.4	1.0	1.0	1.6	1.2
C22:6n3	2.4	3.1	3.1	3.4	3.1
The rest	3.2	2.4	2.6	1.9	2.9
∑	100.0	100.0	100.0	100.0	100.0
∑n6	21.49	22.10	20.68	23.00	22.86
∑n3	**4.70**	**18.66**	**17.46**	**23.58**	**23.76**
n6/n3	4.57	1.18	1.18	0.98	0.96

Table 12. The effect of feed with linseed cake additive on the fatty acid composition of the breast muscles of 42-day-old quail cock broilers (% of total lipids, n=5)

Acid abbreviation	Trial group				
	I control	VI 15% linseed cake 1–42 days	VII 15% linseed cake 22–42 days	VIII 30% linseed cake 1–42 days	IX 3.0% linseed cake 22–42 days
C14:0	0.7	0.4	0.5	0.5	0.4
C15:0	0.1	0.1	0.1	0.1	0.2
C16:0	24.5	18.5	20.5	19.8	16.7
C16:1	4.9	2.4	3.2	4.2	1.8
C17:0	0.2	0.2	0.2	0.2	0.2
C17:1	0.1	0.1	0.1	0.1	0.1
C18:0	11.7	11.5	11.5	8.9	10.8
C18:1	24.9	17.8	18.0	23.2	15.7
C18:2n6	19.6	21.6	20.3	20.4	21.6
C18:3n3	1.4	13.7	11.4	13.7	20.9
C20:0	0.1	0.1	0.1	0.1	0.2
C20:1	0.3	0.3	0.2	0.4	0.5
C20:4n6	4.2	2.8	3.3	1.9	2.7
C20:5n3	0.8	2.7	2.7	1.8	2.5
C22:5n3	0.6	1.2	1.3	0.8	1.1
C22:6n3	3.1	3.9	3.7	2.4	2.8
The rest	2.9	2.9	3.0	1.7	1.9
∑	100.0	100.0	100.0	100.0	100.0
∑n6	23.78	24.38	23.58	22.27	24.24
∑n3	**5.86**	**21.54**	**19.09**	**18.62**	**27.29**
n6/n3	4.06	1.13	1.24	1.20	0.89

Summary and conclusions

The study of the meat characteristics of Estonian quail revealed the following as a result of the experiment under discussion.

1. To increase the amount of ω-3 fatty acids in quail meat during the I growth period (1–21 days), both 3% of linseed oil and 15% and 30% of linseed cake additive in mixed concentrated feed will do well. Taking into account also the body mass of quail, a feed with 30% of linseed cake content cannot be considered recommendable.

2. The ω-3 fatty acid content in the breast muscles of quail hen broilers who were fed feed enriched with linseed oil, increased by 3–4 times, in the case of quail cock broilers by 2–2.5 times during the second growth period (22–42 days). Better results were thereby obtained by the feed with a 3% of linseed oil content.

3. The use of feeds containing linseed cake during the II growth period exhibited better results in the breast muscles when the ω-3 fatty acid content was increased. In the case of quail hen broilers, the ω-3 fatty acid content in the total lipids of breast muscles increased by 3.5–5 times, in the case of quail cock broilers by 3–4.5 times. Based on these data, a 30% linseed cake additive in feed could be recommended, but it should not be forgotten, that feeding such an amount of linseed cake results in significantly lower body mass and dressing percentage of quail.

4. During the whole 42-day-long growth period the quail hen broilers and quail cock broilers who had been fed feed with 1.5% of linseed oil additive had more ω-3 fatty acids in their breast muscles than the quail who had received the feed only during the II growth period, but the difference was not statistically plausible. From the feed with a 3% linseed oil additive, the quail could assimilate only during the II trial period even more ω-3 fatty acids than during the whole growth period.

5. From the feeds which contained linseed cake, the quail broilers assimilated ω-3 fatty acids much better than from the feeds containing linseed oil ($P<0.05$), both during the II growth period as well as feeding during the whole growth period. In the I growth stage the difference was not so easily distinguishable (Table 7 and 8).

6. With the use of both linseed oil and linseed cake in the rations of quail it is possible to increase the ω-3 fatty acid content in quail meat and start the production of the so-called health meat.

7. The ratio of ω-6 and ω-3 fatty acids in the breast muscles of quail broilers was ideal from the point of view of human diet (being 0.96–2.03:1) with respect to all trial groups.

8. Taking into consideration the body masses, meat productivity and ω-3 fatty acid content in the breast muscles of the trial quail, it is recommendable to feed quail broilers with the following:

a) a feed containing 3% linseed oil to quail broilers during their II growth stage;
b) a feed containing 15% linseed cake to quail broilers during their II growth stage.

9. The enrichment of feed during the whole growth period will increase considerably the ω-3 fatty acid content in the meat of quail broilers, but is not economically expedient owing to the high cost of the additives.

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