Modification of the n-3 fatty acid profile of meat- and liver-type geese tissues

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26 week old meat-type geese (Kolos) were fed maize or a mixture of 90% maize and 10% linseed for 6 weeks. In a second experiment 9 week old liver-type geese (Grimaud G36) were force fed for 20 days either maize or the same mixture of maize and linseed as described above.
Linseed incorporation into maize in meat-type geese significantly decreased final body weight, the relative liver weight and abdominal fat pad content, but failed to change the fat content of liver, breast meat and the relative abdominal fat percentage. Feeding linseed however, increased significantly the total n-3 fatty acid content of liver and breast meat.
Force feeding with 10% linseed decreased significantly, by 51% the fatty liver weight and by 50% the fat content of liver. No significant effect of dietary treatment was found in the breast meat fat and abdominal fat contents. Using linseed during force-feeding increased the total n-3 fatty acid, linolenic acid, DPA and DHA contents of liver by 4-8 times and total n-3 fatty acids and linolenic acid content of breast meat by 2 times.
According to these results n-3 fatty acids inhibit hepatic lipogenesis dramatically in overfed liver-type geese. The modification of fatty acid profile of goose tissues can be more successful with meat-type birds.

Keywords: n-3 fatty acids; goose; liver; breast meat; linseed

Introduction

The consumption of higher level of n-3 polyunsaturated fatty acids (PUFA) may play a beneficial role in the prevention and treatment of several human diseases and health problems (British Nutrition Foundation, 1992). Besides the natural dietary sources of n-3 fatty acids, eggs and poultry meat enriched with n-3 PUFA by nutritional means are now available on the market. Poultry diets supplemented with various sources of animal and vegetable origin rich in n-3 fatty acids can be used for production of these so-called ”functional foods”. Compared to investigations with table egg, chicken and turkey meat in this regard, relatively few efforts have been directed towards the nutritional manipulation of products from water-fowl species (Baucells et al., 2000, Bartos et al., 2004; Rymer and Givens, 2006). Both liver- and meat-type goose has a special importance in the Hungarian poultry production, but scientific data concerning the n-3 fatty acid profile of goose liver and meat have been lacking. The fatty goose liver produced by overfeeding of maize is a special case of increased hepatic lipogenesis and liver steatosis that may greatly influence the accumulation of n-3 fatty acids in the liver and meat (Hermier, 1997). Therefore, the objective of the present study was to investigate the effect of feeding linseed on the n-3 fatty acid composition of liver, meat and abdominal fat pad lipids and some production parameters in liver and meat-type geese.

Materials and methods

In the first experiment male geese of the Kolos breed were reared in similar conditions until 26 wk of age. Birds were fed a commercial starter, grower and finisher diets from 0 to 10 d, from 10 to 28 d and from 28 to 42 d of age, respectively. From 6 wk of age, geese had a free access to pasture and a daily amount of 250 g feed (mixture of corn, wheat and triticale) per bird was provided. At 26 wk of age 12 birds were divided into two groups. Geese were fed maize (n = 6) or maize supplemented with 10% linseed (n = 6) *ad libitum* for 6 weeks. All birds had free access to water. After this fattening period body weight of animals was measured. Birds were slaughtered and weights of carcass, liver and abdominal fat pad were determined, samples of liver, breast meat and abdominal fat pad were collected. Tissue samples were stored at -20 °C for two months until analysis of fatty acid composition. In the 2nd experiment male geese of the Grimaud G36 liver-type breed were grown under similar conditions of light, temperature and nutrition until 9 wk of age. At 9 wk of age geese were divided into two groups and force-fed with corn (n = 5) or corn suplemented with 10% linseed (n = 9). Animals had free access to water at all times. 15 kg of feed per bird was fed by force-feeding for 20 days. The fatty acid composition of experimental diets is presented in *Table 1*.

Total fat content of diets was extracted and fatty acids were methylated by the method of AOAC (1990). Total fat content of breast meat, liver and adipose tissue was extracted according to the procedure of Folch et al. (1957) and methylated with 5% boron trifluoride methanol complex in methanolic solution (Morrison and Smith, 1964). The fatty acid methyl esters were separated and analyzed by gas chromatography in a TRACE 2000 chromatograph equipped with an Omegawax 320 capillary column (Supelco, Bellefonte, USA). Identification of individual fatty acids was made using a standard mixture of fatty acid methyl esters (PUFA-2, Supelco, Bellefonte, USA). Statistical analyses were carried out by t-test using the Statistica 5.0 statistical softver (StatSoft, Tulsa, USA).

Table 1 Fatty acid composition of experimental diets

Fatty acids	Meat-type geese		Liver-type geese	
	Maize	10 % Linseed	Maize	10 % Linseed
C14:0	-	-	-	-
C16:0	16,30	15,43	15,70	14,93
C16:1	-	-	-	-
C18:0	2,65	2,64	2,82	2,34
C18:1n-9	31,79	29,90	32,53	30,25
C18:2n-6	47,89	45,91	46,89	43,91
C18:3n-3	1,36	6,11	1,53	6,85

Results and discussion

The effects of dietary treatments on the production traits of meat-type geese are shown in *Table 2*. Supplementation of maize with 10% linseed decreased the body, carcass and liver weight and abdominal fat pad content significantly. However, total lipid content of liver and breast meat was not affected by the treatment. In contrast to these results, feeding linseed failed to change the body and carcass weight of force-fed liver-type geese (*Table 3*). Similarly, no significant effects of treatments were found in the breast meat fat and abdominal fat. Absolute and relative liver weight and total lipid content of liver in geese fed maize-linseed diet were about 50% lower than in those fed maize.

Some authors reported the decrease of feed intake of laying hens and broilers after feeding linseed or linseed oil due to palatability problems (Bartos et al., 2004; Scheideler and Froning, 1996) . The feed intake of meat-type geese fed *ad libitum* was not measured during the study, but lower feed intake may explain the lower body and carcass weight of geese fed linseed compared to birds fed maize. Liver-type breeds have the natural susceptibility to liver steatosis and ability to produce fatty liver (Fournier et al., 1997). The liver weight during force-feeding may increase more than 10-fold or up to 10% of the body weight (Hermier, 1997). Maize rich in starch has low level of lipotropic methionine and choline which enhances the *de novo* hepatic lipogenesis and interferes the secretion of lipoproteins. Thus, large proportion of triacylglycerols remains stored in the liver. The n-3 fatty acids can reduce hepatic synthesis of fatty acids and triacylglycerols (Phetteplace and Watkins, 1990). In our study the lower liver weight and lipid content of liver after feeding linseed may be attributed to the higher intake of linolenic acid (LNA) that decreased hepatic lipogenesis.

In meat-type geese, feeding linseed increased the total n-3 fatty acid content of liver and breast meat significantly. Among n-3 fatty acids, significant increase was detected only in the case of LNA and docosahexaenoic acid (DHA) content of liver (*Table 4*). Using linseed during force-feeding resulted in 4-8 times higher content of total n-3 fatty acids, LNA, docosapentaenoic acid (DPA) and DHA in liver lipids and 2 times higher content of total n-3 fatty acids and LNA in breast meat (*Table 5*). The increased amount of fatty acids from *de novo* hepatic lipogenesis due to force-feeding may reduce the incorporation rate of dietary LNA and its longer chain derivatives into tissue lipids. Therefore, the proportion of total n-3 fatty acids of liver and breast meat lipids and abdominal fat were higher in meat-type than in liver-type geese. In contrast to the results reported with broilers fed linseed oil (Bou et al., 2005), the proportion of DHA in liver lipids exceeded the concentration of LNA in the case of meat-type birds. According to our results the enzymatic capacity of goose liver to desaturate and elongate LNA to DHA may be higher than that of the chicken liver.

Table 2 Effect of dietary treatments on the production traits of meat-type geese

Parameters	Dietary treatments		Significance
	Maize	10 % Linseed	
Body weight (kg)	6,73 ± 0,18	6,00 ± 0,20	P < 0.05
Carcass weight (kg)	4,43 ± 0,11	3,80 ± 0,16	P < 0.05
Liver weight (g)	216 ± 43	115 ± 8	P < 0.05
Relative liver weight (%)	4,91 ± 1,02	3,02 ± 0,12	P < 0.05
Total fat content of liver (%)	4,53 ± 0,61	4,83 ± 0,14	NS
Total fat content of breast meat (%)	6,62 ± 1,73	4,33 ± 0,22	NS
Abdominal fat pad content (g)	354 ± 19	260 ± 26	P < 0.05
Relative abdominal fat pad (%)	8,03 ± 0,53	6,81 ± 0,56	NS

Results are means ± SEM (n = 6); NS = P > 0.05

Table 3 Effect of dietary treatments on the production traits of liver-type geese

Parameters	Dietary treatments		Significance
	Maize	10 % Linseed	
Body weight (kg)	6,26 ± 0,20	6,19 ± 0,23	NS
Carcass weight (kg)	3,65 ± 0,05	3,47 ± 0,18	NS
Liver weight (g)	557 ± 75	273 ± 36	P < 0,01
Relative liver weight (%)	15,21 ± 1,94	7,83 ± 0,91	P < 0,01
Total fat content of liver (%)	45,52 ± 1,74	22,89 ± 4,79	P < 0,01
Total fat content of breast meat (%)	6,11 ± 0,63	6,38 ± 0,58	NS
Abdominal fat pad content (g)	614 ± 40	696 ± 26	NS
Relative abdominal fat pad (%)	16,81 ± 1,01	20,28 ± 0,78	P < 0,05

Results are means ± SEM (n = 5 in maize group and n = 9 in linseed group); NS = P > 0.05

Table 4 Effect of dietary treatments on the polyunsaturated fatty acid composition of tissues of meat-type geese
(% of total fatty acids)

Fatty acids	**Liver**		**Breast meat**		**Abdominal fat**	
	Maize	**10% Linseed**	**Maize**	**10% Linseed**	**Maize**	**10% Linseed**
PUFA	28,55 ± 2,42	34,22 ± 0,75 *	14,61 ± 0,71	15,74 ± 0,30	12,70 ± 1,65	14,12 ± 0,67
Total n-6	27,53 ± 2,25	31,47 ± 0,61 *	13,96 ± 0,59	14,74 ± 0,22	11,17 ± 1,26	12,28 ± 0,29
Total n-3	1,02 ± 0,26	2,75 ± 0,17 *	0,65 ± 0,15	1,01 ± 0,10 *	1,53 ± 0,59	1,84 ± 0,51
C18:3n-3	0,38 ± 0,10	0,86 ± 0,17 *	0,47 ± 0,12	0,69 ± 0,04	1,48 ± 0,57	1,82 ± 0,51
C22:5n-3	0,27 ± 0,05	0,39 ± 0,09	0,10 ± 0,02	0,24 ± 0,10	0,02 ± 0,02	0,01 ± 0,01
C22:6n-3	0,37 ± 0,16	1,50 ± 0,27 *	0,07 ± 0,03	0,08 ± 0,03	0,02 ± 0,01	0,01 ± 0,01
n-6 to n-3 ratio	32,22 ± 6,40 *	11,60 ± 0,57	24,42 ± 3,18	15,21 ± 1,29	14,63 ± 5,39	8,48 ± 1,46

Results are means ± SEM (n = 5 in maize group and n = 9 in linseed group)
* Indicates significant differences (P < 0.05) between treatments within tissues

Table 5 Effect of dietary treatments on the polyunsaturated fatty acid composition of tissues of liver-type geese
(% of total fatty acids)

Fatty acids	Liver		Breast meat		Abdominal fat	
	Maize	**10% Linseed**	**Maize**	**10% Linseed**	**Maize**	**10% Linseed**
PUFA	2,08 ± 0,21	5,50 ± 1,03*	13,45 ± 1,04	12,42 ± 0,24	8,14 ± 0,46	8,38 ± 0,20
Total n-6	1,88 ± 0,22	4,53 ± 0,97	12,86 ± 0,97	11,44 ± 0,21	7,84 ± 0,45	7,71 ± 0,18
Total n-3	0,21 ± 0,08	0,97 ± 0,31	0,59 ± 0,16	0,98 ± 0,10*	0,30 ± 0,02	0,67 ± 0,03*
C18:3n-3	0,12 ± 0,09	0,66 ± 0,32	0,26 ± 0,01	0,59 ± 0,07*	0,29 ± 0,02	0,65 ± 0,04*
C22:5n-3	0,01 ± 0,01	0,07 ± 0,03	0,09 ± 0,05	0,10 ± 0,02	-	0,01 ± 0,01
C22:6n-3	0,08 ± 0,03	0,25 ± 0,05*	0,25 ± 0,11	0,29 ± 0,10	0,01 ± 0,01	0,02 ± 0,01
n-6 to n-3 ratio	13,45 ± 4,00	8,62 ± 2,18	28,51 ± 7,57*	12,84 ± 1,55	26,29 ± 0,55*	11,67 ± 0,44

Results are means ± SEM (n = 5 in maize group and n = 9 in linseed group)
* Indicates significant differences ($P < 0.05$) between treatments within tissues

In conclusion, feeding linseed may decrease final body and carcass weight of meat-type and liver weight of liver-type geese. Furthermore, n-3 fatty acids inhibit hepatic lipogenesis dramatically in overfed liver-type geese. The modification of fatty acid profile of goose tissues can be more successful with meat-type birds.

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