SHORT COMMUNICATION

Feeding flaxseed enhances deposition of omega-3 fatty acids in broiler meat portions in different manner

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Jia, W., Rogiewicz, A., Bruce, H. L. and Slominski, B. A. 2010. **Feeding flaxseed enhances deposition of omega-3 fatty acids in broiler meat portions in different manner**. Can. J. Anim. Sci. **90**: 203–206. Feeding a diet containing 12% flaxseed for 36 d significantly increased the n-3 fatty acid deposition in broiler meat. Based on this study, consuming 100 g of such fatty acid-enriched breast meat, whole leg or wing, a total of 0.2, 1.6 and 2.0 g of n-3 fatty acids, including 10.4, 20.3 and 25.3 mg of docosahexaenoic acid, respectively, would be provided by each portion, which offers consumers an alternative to enhance their daily n-3 fatty acid intake.

Key words: Flaxseed, n-3 fatty acid, broiler chicken

Jia, W., Rogiewicz, A., Bruce, H. L. et Slominski, B. A. 2010. **Donner des graines de lin aux poulets à griller accroît le dépôt d'acides gras oméga-3 dans la chair de diverses manières**. Can. J. Anim. Sci. **90**: 203–206. En nourrissant des poulets à griller avec une ration contenant 12 % de graines de lin pendant 36 jours, on note une hausse sensible du dépôt d'acides gras n-3 dans la chair. Selon cette étude, la consommation de 100 g de viande ainsi enrichie venant de la poitrine, des pattes ou des ailes donnerait, par portion, un supplément total respectif de 0,2, de 1,6 et de 2,0 g d'acides gras n-3, dont 10,4, 20,3 et 25,3 mg d'acide docosahexaénoïque (DHA). Les consommateurs disposeraient donc d'une autre façon d'augmenter leur dose quotidienne d'acides gras n-3.

Mots clés: Lin, acide gras n-3, poulets à griller

Full-fat flaxseed contains large amounts of oil (34%) rich in α-linolenic acid (ALA, $C_{18:3n3}$), which constitutes about 50% of the flaxseed oil. Over the past few years, feeding flaxseed to produce n-3-enriched eggs or meat products has attracted interest from the poultry industry. Various literature data have demonstrated that feeding flaxseed-containing diets to broiler chickens can modify the n-3 fatty acid contents of their meat. Although the increase in meat ALA is a gradual process (López-Ferrer et al. 1999), feeding 10% of flaxseed for 14 d under commercial conditions before slaughter has been shown to increase n-3 fatty acid deposition and thus may minimize the cost of n-3-enriched meat production (Gonzalez-Esquerra and Leeson 2000). Additional research in this area is warranted to further clarify the optimum inclusion rate and feeding time of flaxseed in order to achieve a steady production of n-3-enriched meat products and to minimize diet cost and any antinutritive effects.

The effects of flaxseed on growth performance and the incidence of necrotic enteritis in broiler chickens have recently been reported by our group (Jia et al. 2009). In this study, a pelleted diet containing 12% of flaxseed was fed to broiler chickens for the entire production cycle (0-37 d). Therefore, there was an opportunity to examine diet effects on n-3 fatty acid deposition because the conditions of the experiment (i.e., flax inclusion rate, duration) would favor the maximum n-3 fatty acid deposition. This, in turn, would allow for determination of the baseline values for the n-3 fatty acid contents in different parts of the carcass. Therefore, tissue samples from birds fed the control diets (wheat/barley/soybean

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Abbreviations: **ALA**, a-linolenic acid; **DHA**, docosahexaenoic acid; **DM**, dry matter; **EPA**, eicosapentaenoic acid; **MUFA**, monounsaturated fatty acid; **SFA**, saturated fatty acid; **TFA**, total fatty acid meal-based) without and with flaxseed addition (12%) were collected for a follow-up study on n-3 fatty acid deposition. Diets were formulated to contain 3100 kcal kg^{-1} metabolizable energy and 23% crude protein in the starter phase and 3100 kcal kg^{-1} metabolizable energy and 20% crude protein in the grower phase (Jia et al. 2009). In both phases of the experiment, the contents of ALA averaged 0.44 and 2.57%, respectively, for wheat/barley/soybean meal-based diets without and with flaxseed addition. All animal procedures were conducted according to the guidelines of the Canadian Council on Animal Care (1993). On day 36, six male Ross-308 broiler chickens were randomly selected from each treatment and sent to a commercial slaughter plant. Half of the eviscerated carcass was collected from each bird, sealed into a plastic bag and stored at $-20°C$. In preparation for analysis, the frozen carcasses were quickly thawed in warm water while still in their respective bags, and then hand-deboned. Tissue samples were separated into the following cuts: breast excluding skin and any visible fat, entire leg (thigh and drumstick) with skin, wing with skin, and breast skin with subcutaneous fat. Samples were ground using a commercial meat grinder. Following freeze-drying, samples were finely ground, and pooled to generate three replicate samples per treatment for the fatty acid analysis by the Lipid Analytical Laboratories, University of Guelph. A completely randomized design was used for statistical analysis, and data were tested using the GLM procedure of the SAS program (version 9.1, SAS Institute Inc., Cary, NC). All statements of significance are based on $P \leq 0.05$.

Results showed that flaxseed addition had no effects on dry matter (DM) and total fatty acids (TFA) contents in all tissue portions except for the wing samples, in which slightly, but significantly lower TFA and DM values were found for birds fed the flaxseed-containing diet (Table 1). However, the fatty acid profile in muscle and adipose tissues changed significantly among dietary treatments. In chickens fed flaxseed, the deposition of total n-3 fatty acids in all portions increased, which was attributed to the increase in not only ALA, but also eicosapentaenoic acid (EPA, $C_{20:5n\text{-}3}$) in both meat and skin tissues, and docosahexaenoic acid (DHA, $C_{22:6n\text{-}3}$) in the breast meat samples. The enrichment of ALA in the breast meat of chickens fed 12% flaxseed was 2.8 times higher than that of the control group, whereas a fourfold increase in the leg, wing and skin n-3 fatty acids was observed. The preferential deposition of ALA in the latter tissues can be explained by the fact that lipid fractions are unevenly distributed in chicken tissues with phospholipids predominating in the breast meat and triacylglycerols in the leg meat and skin (Leskanich and Noble, 1997). In contrast to the EPA and DHA that are prevalent in phospholipids, the concentration of ALA is relatively high in the triacylglycerol fraction, thus making broiler leg meat a rich source of ALA. The highest ALA content was found in the skin with subcutaneous fat, which was most likely due to the lipid storage process in the adipose tissue (Hargis and Van Elswyk 1993). The EPA and DHA deposition is a consequence of in vivo metabolism with ALA serving as a precursor for their synthesis through the desaturation-chain elongation pathway within the liver (Brenner 1971). Due to the complexity of this biosynthesis (Sprecher 2000), the increase of DHA in meat products would be expected to be lower than that of ALA. In the current study, the deposition of DHA in the breast meat of the flaxseed group was 1.8 times greater than that of the control group, whereas a 1.1- to 1.5-fold increase was found in the leg, wing and skin portions. The concentration of DHA accounted for 0.8, 0.2, and 0.2% of TFA in the breast meat, leg, and wing, respectively. Although DHA was preferentially deposited in the breast meat, the leg, wing, and skin still contained higher amounts of DHA as a result of their overall higher lipid content. The increased n-3 fatty acid deposition in the meat from birds fed flaxseed was at the expense of decreased concentrations of n-6 fatty acids in all portions, and saturated (SFA) and monounsaturated fatty acids (MUFA) in the skin, leg and wing tissues. Interestingly, feeding flaxseed for the entire 36-d production cycle significantly increased and nearly doubled the n-3 fatty acid contents in all meat portions when compared with the values reported by Gonzalez-Esquerra and Leeson (2000) for broilers given 10% of flaxseed-containing diets 14 d prior to slaughter. Such a response suggests that the duration of dietary flaxseed addition is critical for n-3-enriched meat production. In a recent study, Betti et al. (2009) calculated that deposition of 300 mg of n-3 fatty acids per 100 g of breast meat required 26.2 or 11.3 d when feeding diets containing 10 or 17% flaxseed, respectively. Although similar DHA concentration was reported (9.9 vs. 10.4 mg 100 g^{-1}, as-is basis), higher n-3 fatty acid values than those observed in our study for breast meat (401 vs. 206 mg 100 g^{-1}) were achieved in 35 d with a 10% level of flaxseed in the diet. In the current study, the breast meat from the flaxseed group contained 206 mg n-3 fatty acids 100 g^{-1} (as-is basis), which is lower than the minimum level (300 mg) regulated by Canadian Food Inspection Agency (2003) for n-3-enriched meat products. However, the low level of n-3 fatty acids determined in our study appear to be a consequence of sample preparation and the extent to which the skin and the fat tissues were removed from the breast cuts. It is of importance to note that the content of n-3 fatty acids, particularly ALA, determined in the breast skin with subcutaneous fat was very high (Table 1). Due to the removal of all the visible fat during sample preparation, the total breast fatty acid content determined in the current study was only half that (1.4 vs. 2.7 g per 100 g) reported by Betti et al. (2009). Therefore, different practices in skinless breast meat preparation by the processing plants or by the consumer would contribute to the variation in n-3 fatty acid content.

Table 1. The effect of flaxseed addition on the contents of major fatty acids of different broiler meat portions (DM basis)

	Linoleic C18:2n6	Linolenic C18:3n3	Eicosenoic C20:1	Eicosadienoic C20:2n6	Arachidonic C20:4n6	EPA[z] C20:5n3	DHA[y] C22:6n3	SFA[x]	MUFA[w]	n-3[v]	n-6[u]	TFA[t]	DM
	($g\ 100\ g^{-1}$ tissue)		($mg\ 100\ g^{-1}$ tissue)					($g\ 100\ g^{-1}$ tissue)					(%)
Breast meat, skinless													
Control	1.29	0.22	18.55	27.21	106.99	16.37	21.97	1.81	2.35	0.30	1.51	5.95	25.5
Flaxseed	0.98	0.61	10.87	19.77	66.33	51.29	40.48	1.55	1.95	0.80	1.11	5.41	25.7
SEM	0.05	0.05	1.82	2.59	8.10	2.71	3.17	0.09	0.16	0.05	0.04	0.31	0.1
P	0.01	<0.01	0.04	0.11	0.02	<0.01	0.01	0.12	0.15	<0.01	<0.01	0.29	0.21
Breast skin with subcutaneous fat													
Control	17.52	2.69	338.50	135.81	165.77	40.35	73.70	21.88	33.92	2.94	18.06	76.81	68.1
Flaxseed	13.71	10.75	293.67	108.96	146.45	148.03	80.62	18.34	29.69	11.21	14.13	73.38	64.1
SEM	0.74	0.31	22.23	6.08	7.62	10.44	5.13	0.45	0.87	0.32	0.74	1.60	1.8
P	0.02	<0.01	0.23	0.04	0.15	<0.01	0.39	<0.01	0.03	<0.01	0.02	0.21	0.19
Thigh and drumstick with skin													
Control	8.86	1.20	146.87	70.19	172.99	27.11	43.84	11.04	16.68	1.35	9.25	38.33	32.8
Flaxseed	6.37	4.80	96.99	65.39	130.72	98.70	64.86	8.51	13.35	5.16	6.66	33.69	31.3
SEM	0.24	0.08	17.80	6.59	9.25	7.28	6.02	0.43	0.84	0.10	0.25	1.37	0.5
P	<0.01	<0.01	0.12	0.63	0.03	<0.01	0.07	0.01	0.05	<0.01	<0.01	0.07	0.10
Wing with skin													
Control	9.74	1.36	222.86	90.94	170.45	22.33	56.89	11.94	18.74	1.54	10.20	42.41	35.4
Flaxseed	7.13	5.61	136.56	61.95	140.13	107.97	74.88	9.34	15.29	6.02	7.45	38.10	33.8
SEM	0.27	0.17	4.95	6.63	10.84	3.53	6.30	0.31	0.55	0.17	0.27	0.94	0.4
P	<0.01	<0.01	<0.01	0.04	0.12	<0.01	0.11	<0.01	0.01	<0.01	<0.01	0.03	0.03

[z]EPA = eicosapentaenoic acid.
[y]DHA = docosahexaenoic acid.
[x]SFA = saturated fatty acids; include: $C_{14:0}$, $C_{15:0}$, $C_{16:0}$, $C_{18:0}$, $C_{20:0}$, $C_{22:0}$ and $C_{24:0}$.
[w]MUFA = monounsaturated fatty acids; include: $C_{14:1}$, $C_{16:1}$, $C_{18:1}$, $C_{20:1}$, $C_{22:1}$ and $C_{24:1}$.
[v]n-3 fatty acids; include: $C_{18:3n3}$, $C_{18:4n3}$, $C_{20:3n3}$, $C_{20:4n3}$, $C_{20:5n3}$, $C_{22:5n3}$ and $C_{22:6n3}$.
[u]n-6 fatty acids; include: $C_{18:2n6}$, $C_{18:3n6}$, $C_{20:2n6}$, $C_{20:3n6}$, $C_{20:4n6}$, $C_{22:2n6}$, $C_{22:4n6}$ and $C_{22:5n6}$.
[t]TFA = total fatty acids.

In conclusion, meat portions from broiler chickens fed 12% flaxseed for 36 d contained high amounts of n-3 fatty acids, which would offer consumers an alternative to enhance their daily n-3 fatty acid intake. The consumption of 100 g of fatty acid-enriched breast meat, whole leg and wing would provide the consumers with a total of 0.2, 1.6 and 2.0 g of n-3 fatty acids, including 10.4, 20.3 and 25.3 mg of DHA, respectively.

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