Color and Fatty Acid Profile of Abdominal Fat Pads from Broiler Chickens Fed Lobster Meal

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Abbreviated title: Broiler Chickens Fed Lobster Meal

Summary

Consumer demands for food products enriched with healthful omega-3 fatty acids are steadily increasing. Feeding marine by-products may provide an economical means of increasing the long chain omega-3 content of broiler tissues. A study was conducted to evaluate the effect of dietary lobster meal (LM) on the color and fatty acid profile of broiler chicken fatty tissue. Broilers were fed increasing levels (0, 2, 4, 6, 8, 10%) of LM for 35 days. Fat pad samples were collected at slaughter. Fat pad red colouration increased ($P<0.05$) as dietary LM increased. Fat pad EPA and DHA levels also increased ($P<0.0001$) in a linear fashion. The essential long chain fatty acids were lower for the 10% LM diet (0.37 mg EPA/g, 0.16 mg DHA/g) compared to the 8% diet (0.51 mg EPA/g, 0.27mg DHA/g). These results indicate that lobster meal is an excellent feed ingredient for enriching broiler fat with healthful omega-3 fatty acids. Consumer preferences for fat colour must be taken into consideration when incorporating lobster meal in broiler diets.

Keywords: Broiler, lobster meal, fat pad, color, fatty acid

Introduction

Due to the rising transportation and production costs of traditional feed ingredients, alternative ingredients are needed for North American livestock producers. Soybean meal has been the primary source of plant protein and limestone the primary source of calcium in broiler diets. In the past, fishmeal has also been included in regional poultry diets, primarily as a source of protein and calcium. However, due to the high cost associated with fishmeal, it is generally no longer included in poultry diets.

Lobster, crab and shrimp meals are available in coastal North America as by-products of the fishing industry. Lobster meal contains high levels of protein and calcium as well as antioxidants and long chain omega-3 fatty acids. A major concern with the use of shrimp and crab meals in poultry diets is the high level of chitin these waste products contain, which may decrease the nutritive vale of the feed (Rosenfeld *et al.*, 1997). St. Laurent Gulf Products, Ltd., located in north-eastern New Brunswick, Canada, has developed a method for producing lobster meal that is free of chitin and contains high levels of protein (44.5%) and calcium (7%).

The benefits to human health of increased consumption of dietary omega-3 fatty acids have been well documented (Hu *et al.*, 2002; Connor, 2000) and consumer demands for omega-3 enriched food products are steadily increasing. Lobster meal is an excellent source of the essential long chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docoso-hexaenoic acid (DHA) (Daniel 2008). The human health benefits of dietary antioxidants have also been well documented. Astaxanthin, the major carotenoid pigment found in fish and crustaceans, possesses high antioxidant activity (Guerin *et al.*, 2003).

Feeding marine by-products such as lobster meal may be a useful method of increasing the content of omega-3 fatty acids and antioxidants in broiler tissues. The objective of this study was therefore to evaluate the effect of dietary lobster meal on the color and fatty acid profile of broiler chicken fatty tissue. This project was part of a larger study conducted to evaluate crab meal and lobster meal as alternative ingredients for broiler chicken diets.

Materials and Methods

The experiment was conducted as a completely randomized design with level of lobster meal (LM) as the main factor. LM was prepared from American lobsters (*Homarus americanus*) and was provided by St. Laurent Gulf Products, Ltd. as a dried, ground meal with ethoxyquin added to prevent oxidation. Increasing levels of LM (0, 2, 4, 6, 8, 10%) were incorporated into standard broiler diets. All diets were formulated to be isonitrogenous and isocaloric. Starter diets contained 23% crude protein and 3050 kcal ME kg^{-1} and were fed as mash from day 1 to 14 days of age. Grower diets contained 20% crude protein and 3150 kcal ME kg^{-1} and were fed as mash from day 15 to 25 days of age. Finisher diets contained 18% crude protein and 3200 kcal ME kg^{-1} and were fed as pellets from day 26 to 35 days of age.

A total of 1512 day-old male broiler chicks (Ross) were housed in 36 floor pens ($0.075m^2$ $bird^{-1}$). Each of 6 experimental diets was fed to 2 replicate pens in 3 rooms. Feed and water were provided *ad libitum*. Weight gain (14, 25 and 35 d) and feed consumption (weekly) were recorded to monitor growth performance. Throughout the trial, birds were managed in accordance with local Animal Care and Use Committee guidelines that follow the Canadian Council on Animal Care Codes of Practice (1993).

At 35 days of age, 2 birds per pen were euthanized by cervical dislocation and fat pads were collected from 2 birds per pen for 2 of the 3 production rooms. Fat pad colour was measured using a MiniScan XE Plus colourimeter (Hunter Associates Laboratory, Reston, VA, USA). Following colour measurement, fat pads were stored at -80^{o}C for further analysis. Total lipids were extracted according to Folch *et al*. (1957). Briefly, 1 g fat pad samples were homogenized in chloroform: methanol: water in an 8: 4: 3 ratio. Following separation, the lower phase was removed and dried under a stream of nitrogen at room temperature. Dried lipid samples were placed in dichloro-methane with 0.01% BHT and transmethylated according to Hilditch and Williams (1964). Fatty acid methyl esters were identified by comparison to known standards (Sigma-Aldrich Inc., St. Louis, MO, USA) on a 30 m × 0.25 ID DB-23 column from Agilent using a Perkin Elmer Autosystem. The mean values for fat color coordinates and fatty acid concentrations for each pen were subjected to statistical analysis using the proc mixed procedure of SAS (SAS Institue, 1999). Contrast statements were used to determine relationships among treatments.

Results and Discussion

Fat Pad Coloration

Broiler fat pad coloration was affected by feeding increasing levels of lobster meal (LM) for 35 d (Table 1). Yellow (b*) coloration of the fat pad increased (P<0.05) as dietary LM increased, with b* being greatest in fat pads from broilers fed 10% LM. Red (a*) coloration followed a similar trend. Lightness (L*) of the fat fad decreased (P<0.05) as dietary LM increased from 0 to 8%.

The increase in b*and increasing darkness of broiler fat pads is most likely due to increased digestion and absorption of fat soluble carotenoid pigments in lobster meal. To our knowledge, there have been no other reports on the effects of dietary lobster meal on broiler fat pad coloration. Research with laying hens fed lobster meal (Daniel 2008) indicated that laying hens were able to deposit dietary carotenoid pigments in the egg yolk.

Table 1. Effect of increasing levels of dietary lobster meal on broiler fat pad coloration.

Lobster Meal (%)	Lightness (L*)	Red (a*)	Yellow (B*)
0	72.0^{a}	6.51	26.7^{ab}
2	71.0^{ab}	7.01	25.7^{b}
4	71.4^{ab}	7.10	28.9^{ab}
6	70.7^{ab}	7.24	28.2^{ab}
8	68.9^{b}	7.73	26.8^{ab}
10	71.2^{ab}	7.65	30.7^{a}
SE	0.57		1.02
ANOVA		P-value	
Treatment	0.040	0.071	0.044
Treatment × Room	0.081	0.022	0.627
Linear	0.037	0.0004	0.020

$^{a\text{-}b}$ Means within a column with different superscripts are significantly different (P≤0.05).

Fat Pad Fatty Acid Profile

The fatty acid profile of lipid extracted from broiler fat pads was also affected by feeding increasing levels of lobster meal (LM) for 35 d (Table 2). Total saturated (SAT; 29 mg/ g)) and monounsaturated (MONO; 54 mg/ g) fatty acids were not affected by level of dietary LM. Polyunsaturated fatty acids (PUFA), in particular n-3 PUFA, were higher (P<0.05) in fat pads from broilers fed 6% LM compared to those fed 10% LM. The 18 carbon chain fatty acids (oleic, linoleic and alpha-linolenic) decreased (P<0.01) as dietary LM increased, while levels of the long chain fatty acids EPA and DHA increased (P<0.0001) from 0% to 8% LM.

Increased levels of long chain fatty acids EPA and DHA in the fat pad indicates that these essential fatty acids are partitioned to fat storage areas when broilers are fed lobster meal. To our knowledge, there have been no other reports on the effects of dietary lobster meal on broiler fat pad fatty acid profile. Carrilo-Dominguez *et al*. (2005) fed crab meal to laying hens and found that egg yolk n-6 and n-3 fatty acids (including EPA) increased as dietary inclusion increased from 0 to 6%.

Conclusions

These results indicate that lobster meal is an excellent feed ingredient for enriching broiler fat with desirable omega-3 fatty acids. Further research is needed to determine how marine-based fatty acids and antioxidant carotenoid pigments are partitioned to other areas of fat deposition. Consumer preferences for fat colour must be taken into consideration when incorporating lobster meal in broiler diets.

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Table 2. Effect of increasing levels of dietary lobster meal on broiler fat pad fatty acid profile (mg FAME/ g fat pad).

Lobster Meal (%)	SAT	MONO	PUFA	n-3 PUFA	Oleic (18:1n9)	Linoleic (18:2n6)	α-Linolenic (18:3n3)	EPA (20:5n3)	DHA (22:6n-3)
0	27.6	54.9	17.5 [ab]	1.18 [d]	45.1 [a]	15.5 [a]	0.19 [a]	0.025 [e]	0.018 [d]
2	27.7	54.4	18.0 [ab]	1.54 [c]	45.0 [a]	15.5 [a]	0.16 [ab]	0.123 [de]	0.063 [cd]
4	28.1	54.5	17.4 [ab]	1.69 [bc]	44.7 [ab]	14.8 [ab]	0.15 [abc]	0.120 [cd]	0.118 [bc]
6	28.7	51.7	19.6 [a]	2.20 [a]	41.4 [c]	16.4 [ab]	0.14 [b]	0.288 [bc]	0.135 [bc]
8	29.4	53.6	17.0 [ab]	2.07 [ab]	42.0 [bc]	13.9 [ab]	0.12 [b]	0.508 [a]	0.265 [a]
10	61.5	53.5	15.1 [b]	1.62 [c]	42.1 [bc]	12.6 [b]	0.11 [c]	0.370 [b]	0.163 [b]
ANOVA	P-value								
Trt	0.055	0.057	0.003	<0.0001	0.002	0.001	0.001	<0.0001	<0.0001
Linear	0.004	0.048	0.016	<0.0001	0.0001	0.001	<0.0001	<0.0001	<0.0001
Quad	NS	NS	0.002	<0.0001	NS	0.008	NS	0.025	0.04

[a-b] Means within a column with different superscripts are significantly different ($P \leq 0.05$)