Fatty Acids in Raw and Processed Alaska Pink Shrimp

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Abstract

The fatty acid composition of lipids extracted from whole raw shrimp, raw meat, blanched meat, canned meat and peeler waste was determined by gas liquid chromatography. The analyses revealed 29 fatty acids with chain lengths ranging from 12 to 24 carbon atoms and with 0 to 6 double bonds. Commercial processing did not alter the distribution of polyunsaturated fatty acids in the shrimp meat.

Introduction

Pink shrimp (*Pandalus borealis*) which occurs circumpolar is the principal species of shrimp utilized by Alaska shrimp processors. In 1968, 44 million pounds of pink shrimp were harvested in Alaska (1). The potential annual harvest is more than 400 million pounds (2). Most of the processed shrimp meat is canned in oil-free water containing salt and citric acid. The present treatment of shrimp consists of peeling whole shrimp mechanically, blanching the meat at 212 F for 2 min, and retorting the canned product at 250 F for 15 min. This process may influence the fatty acid content of the lipid in the flesh.

Since the deterioration of a marine lipid is greatly influenced by its degree of unsaturation, the concentration of polyunsaturated acids of shrimp meat must therefore be considered in the maintenance of quality during processing and storage. Shrimp tail meat is that portion of the whole pink shrimp that is processed as a canned product for human consumption. Although this high protein food is canned in large quantities, the fatty acid composition of the lipid in the canned flesh has not been reported. The composition is also important because of the dietary effect of the lipid in human physiology (3). Shrimp peeler waste, which consists of heads, entrails, shells and particles of meat, is presently discarded. Alaska processors discard about 18,000 tons annually and will have about 170,000 tons to dispose when the potential harvest is attained.

This study was undertaken to: determine the fatty acid composition in whole raw shrimp, raw machine-peeled meat, blanched meat, canned meat and peeler waste, and to observe the effects of commercial processing on the fatty acid composition.

Experimental Procedures

One-pound samples of shrimp material were collected from commercial processing plants in Kodiak, Alaska, and were held frozen until analyzed. The samples consisted of the following materials: (a) whole raw shrimp held on ice for about three days, (b) machine-peeled shrimp consisting of raw, peeled shrimp tails, (c) blanched meat consisting of tails heated for 2 min at 212 F, (d) canned product consisting of blanched meat with added water, salt, and citric acid retorted at 250 F for 15 min, and (e) peeler waste consisting of raw shrimp heads, entrails, shells and miscellaneous pieces of flesh.

All canned products were stored at room temperature for one month to allow the meat and canning liquor to equilibrate before they were analyzed. Monthly samples of canned shrimp representing a span of one year were also analyzed to reveal seasonal differences, if any. Before analysis the shrimps were drained and the canning liquor discarded.

The lipids were extracted quantitatively with chloroform-methanol by the method of Bligh and Dyer (4).

Lipids obtained from the various samples of shrimp were saponified and converted to the methyl esters of the constituent fatty acids for subsequent analysis by gas liquid chromatography (GLC).

The methyl esters were prepared by a semimicro methanolysis adapted to the method of Metcalfe et al. (5). The methyl esters were analyzed with an Aerograph gas chromatograph equipped with a dual flame ionization detector. The columns used were each composed of stainless steel tubing 0.210 in. i.d. and 8 ft in length. The column contained 5.0% (by weight) of diethylene glycol succinate polyester supported on 80 mesh to 100 mesh chromosorb G-AW. The following operating conditions were used: flash heat temperature, 250 C; column temperature, 180 C; detector temperature, 225 C; and rate of flow of nitrogen carrier gas, 50 ml/min.

Some of the GLC peaks of the samples were identified by comparison with standard peaks obtained from pure methyl esters. Equivalent chain length values were determined according to the method of Miwa (6) and were compared with those reported by Hofstetter, et al. (7) for identifying peaks for which no pure methyl ester is available. A portion of each sample of oil was hydrogenated to confirm the correctness of the identification of the unsaturated acids. The area of each chromatographic peak representing a fatty acid present was obtained by multiplication

TABLE I
Fatty Acid Content in Solvent-Extracted Oils From Whole Raw Shrimp and Processed Shrimp

Fatty acids	Fatty acid concentration, wt %				
	Whole raw shrimp	Shrimp waste	Shrimp meat		
			Raw	Blanched	Canned
Saturated acids					
10:0	0.6	0.6	0.7	0.3	0.5
12:0	0.3	0.6	0.5	0.4	0.4
14:0	4.1	2.0	2.6	2.1	2.5
15:0	0.5	0.6	0.6	0.6	0.5
16:0	14.3	13.9	15.7	15.1	16.0
17:0	Trace	Trace	Trace	Trace	Trace
18:0	3.0	3.0	2.3	2.7	2.6
19:0	Trace	Trace	Trace	Trace	Trace
20:0	Trace	Trace	Trace	Trace	Trace
24:0	Trace	Trace	Trace	Trace	Trace
Total	22.8	20.7	22.4	21.2	22.5
Monounsaturated acids					
14:1ω6	Trace	Trace	Trace	Trace	Trace
15:1ω6	0.7	0.9	1.0	0.9	1.1
16:1ω7	9.6	6.7	6.0	5.4	5.8
17:1ω8	1.4	1.0	1.2	1.2	1.1
18:1ω9	20.3	23.5	18.6	19.9	19.0
20:1ω9	3.6	2.4	2.7	2.1	2.4
22:1ω9	3.4	2.7	1.8	1.7	1.6
Total	39.0	37.2	31.3	31.2	29.9
Polyunsaturated acids					
18:2ω6	1.6	0.8	1.4	1.7	1.5
18:3ω3	0.6	0.9	1.2	1.6	1.4
18:4ω3	1.6	Trace	1.2	0.5	1.0
20:2ω6	0.7	1.4	1.5	0.8	1.0
20:3ω6	Trace	Trace	Trace	Trace	Trace
20:4ω6	1.0	0.5	0.4	0.4	0.4
20:4ω3	Trace	Trace	1.0	0.5	0.8
20:5ω3	17.9	18.4	21.1	22.5	22.0
22:3ω6	1.7	4.7	2.0	1.5	1.2
22:4ω6	0.7	Trace	1.5	1.2	0.7
22:5ω3	1.0	2.4	1.2	1.4	1.2
22:6ω3	11.2	13.4	14.9	16.0	16.0
Total	38.0	42.5	47.4	48.1	47.2

of the height of each peak by the width at half height. The area of each peak was then compared with the total combined area of all of the peaks to obtain the percentage of each specific fatty acid.

Results and Discussion

The composition of shrimp may be affected by such environmental factors as season, depth and geographic location of catch. No attempt was made in this study, however, to evaluate the influence of these factors. The results therefore indicate only the composition at the time of sampling. It is noteworthy, however, that a monthly analysis of canned Alaska pink shrimp representing a span of one year shows little variation (±3% for the major fatty acids) in the total fatty acids and the average values are similar to the total fatty acid composition for drained canned shrimp shown in Table I. This finding indicates that season of catch does not significantly influence the fatty acid content in drained canned shrimp meat.

The extracted lipids were deep red in color, presumably due to carotenoids. Whole shrimp contained the greatest amount of oil with 2.8–3.0%, followed by shrimp waste with 1.0–4.0%. Machine peeled shrimp meat contained the least amount of oil, namely 1.2–1.5%. Blanching the raw meat caused a loss of water, thereby increasing the percentage of oil in the blanched and canned shrimp to 1.9–2.2%. The wide variety of fatty acids in shrimp products (Table I) includes a rather large amount of polyunsaturated C_{20} and C_{22} acids which are associated with phospholipids (8). Polyunsaturated C_{16} acids were present in a very small quantity in all samples, but were not identified separately.

In most respects the concentrations of fatty acids in shrimp meat are the same whether the product is raw, blanched or canned, indicating that blanching and canning does not affect the fatty acids. Four fatty acids (16:0, 18:1, 20:5 and 22:6) occur in relatively equivalent amounts, i.e., in the 15–22% range. These four fatty acids and 16:1 account for over 75% of the total.

The levels of fatty acids in shrimp meat differ somewhat from those in whole shrimp. Thus, total polyunsaturated acids are higher in shrimp meat (47–48%) than in whole shrimp (38%) or in shrimp waste (42.5%). It is noteworthy that the percentages of polyunsaturated acids in waste and raw meat are both higher than whole shrimp. This discrepancy is attributed to the selective loss of fine material (mostly intestines) into the large quantity of water used commercially to peel and wash away the waste material. The waste material assayed was collected by screening the effluent and thus represents commercially available waste material and not the total waste which also contains dissolved and very fine solids.

The monounsaturated acids occur at higher levels in whole shrimp and in shrimp waste (37–39%) than in shrimp meat (30–31%). Generally, total saturated fatty acids very little between whole shrimp and shrimp meat, ranging between 21.2–22.8%. Shrimp waste contains the lowest concentration of saturated acids (20.7%).

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