Total Fat, n-3 Fatty Acids and Vitamin D_3 in Selected Fish Species Sampled Under USDA's National Food and Nutrient Analysis Program (NFNAP)

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Introduction

- Although omega-3 (n-3) fatty acids and vitamin D are available as dietary supplements, they also occur naturally, at various levels, in seafood.
- To obtain new analytical data on vitamin D in foods, a nationwide sampling of seafood was conducted using Food and Drug Administration's (FDA) list of the top 20 most frequently consumed fish in the United States to identify the species to be sampled.
- Samples were analyzed for a complete nutrient profile, including fat and fatty acids. The nutrient data will be migrated into the Nutrient Data Laboratory's (NDL) Nutrient Data Bank System (NDBS), compiled, and released into the USDA National Nutrient Database for Standard Reference (SR22) by September 2009 to provide current and accurate data for these foods.
- Preliminary results are presented here for eight seafood species which represent 75% of the per-capita consumption of seafood[1] organized by categories (low-fat finfish, high-fat finfish, crustaceans, and mollusks.

Materials and Methods

- **Sampling**
  - Retail samples of 21 species of finfish and shellfish were obtained from a nationally representative sampling plan as part of the National Food and Nutrient Analysis Program (NFNAP)[2].
    - Sample units of fish were picked up in each of 12 supermarkets or nearby fish markets across the US.
    - Supermarkets were randomly selected from a pool of stores with sales volumes exceeding $2 million/year.
  - Species and pick up dates of fish are shown in Table 1.
- **Sample Preparation and Storage**
  - All samples were shipped on dry ice (fresh samples) or at ambient temperature (canned) to the Food Analysis Laboratory Control Center (FALCC), Virginia Polytechnic Institute and State University, where they were stored prior to compositing.
    - Fresh samples were frozen and stored at -65ºC.
    - Shelf stable (canned) samples were stored at room temperature.
  - Sample composites were prepared using standard protocols previously established to insure homogeneity and to preserve nutrient integrity.
  - Composites were homogenized with liquid nitrogen, placed in jars under nitrogen, and stored frozen at -65ºC until they were shipped to the analytical laboratories.

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Materials and Methods cont.

- **Nutrient Analysis**
  - Certified reference materials and in-house prepared control materials were also shipped to monitor the analyses done by the laboratories.[3]
  - Commercial analytical laboratories, pre-approved for participation in NFNAP, analyzed the food samples and quality control materials using AOAC or other acceptable methods for proximates and fatty acids. Vitamin D analyses were done at Food Composition and Methods Development Laboratory (FCMDL), USDA.[4] (See Table 2)
- **Data Review**
  - FALCC and NDL conducted quality control review.
  - Approved data were migrated into the NDBS and compiled for release to SR, located at the NDL Web site (http://www.ars.usda.gov/nutrientdata).

Table 1. Sampling schedule for fish. All samples were analyzed raw except as noted.

Sampling date	Fish species
February 2007	Flatfish (flounder and sole species), wild sockeye salmon, shrimp, canned clams
February 2008	Farmed catfish, cod (Atlantic and Pacific), haddock, rainbow trout, ocean perch
March 2008	Halibut (Atlantic and Pacific), walleye pollock, Pacific rockfish, salmon (chum and pink), swordfish, yellowfin tuna
May 2008	Eastern oyster, crab, and northern lobster (all steamed) and scallop

Table 2. Methods used for nutrient analyses of fish samples.

Nutrient	AOAC Method Number	Method Description
Fat	954.02	Acid hydrolysis and solvent extraction
Fatty acids	996.06	Gas chromatography of fatty acid methyl esters with flame ionization detection
Vitamin D	Combined 992.26 and 2002.05	HPLC with UV detection and vitamin D_2 internal standard

Table 3: Fat in fish. The finfish are separated into low fat (<5g/100g) and high fat (>5g/100g).

Species (# composites)	Fat Mean(SE)	Species (# composites)	Fat Mean(SE)
Low-fat finfish		**Crustaceans**	
Flatfish (4)	1.93 (0.43)	Crab (3)	0.74 (0.04)
Pollock (8)	0.41 (0.03)	Shrimp (4)	1.01 (0.06)
High-fat finfish		**Mollusks**	
Catfish (12)	5.94 (0.37)	Clam (4)	0.96 (0.05)
Salmon, sockeye (4)	5.61 (1.69)	Oyster (3)	3.42 (0.11)

Figure 1: Omega-3 fatty acids in fish.

- Omega-3 fatty acids reported are ALA (18:3), EPA (20:5), DPA (22:5), and EPA (22:6).
- As expected, the low-fat finfish had low levels of omega-3 fatty acids.
- Salmon, with the highest fat level, had the highest total omega-3 level at 0.824g/100g .
- Catfish (a high-fat finfish), however, had a total omega-3 level of only 0.142 g/100g, similar to low-fat finfish.
- Oyster, at 3 times the fat level of the other shellfish, also had the highest level of total omega-3 fatty acids, 0.807g/100g. In fact, the level of total omega-3 fatty acids in oyster was almost as high as the level in salmon.

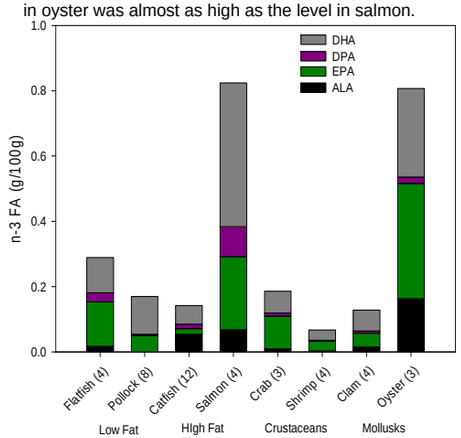

Table 4: Vitamin D in fish.

- The highest level of vitamin D reported on was in salmon at 11mcg/100g (441 IU/100g).
- Flatfish were next at 2.4mcg/100g (94 IU/100g).
- Catfish had a very small amount of a vitamin D: 0.14mcg/100g (6 IU/100g), an amount twice that found in pollock.
- The amount of vitamin D in shellfish is considered was insignificant.

Species (# composites)	Vitamin D IU/100g Mean(SE)	Vitamin D mcg/100g Mean(SE)	Species (# composites)	Vitamin D IU/100g Mean(SE)	Vitamin D mcg/100g Mean(SE)
Low-fat finfish			**Crustaceans**		
Flatfish (1)	94	2.4	Crab (1)	0	0.0
Pollock (1)	3	0.07	Shrimp (5)	2 (1.3)	0.05 (0.03)
High-fat finfish			**Mollusks**		
Catfish (1)	6	0.14	Clam (1)	0	0.0
Salmon (12)	441 (46)	11 (1.2)	Oyster (1)	1	0.03

Discussion

- As shown in Table 3, the amount of fat in seafood is highly variable. Among the other species of finfish analyzed but not shown here, swordfish and rainbow trout are also high in fat.
- The level of fat in farmed catfish may be due to the fact that these fish are farm fed and are raised in a controlled environment. None of the other shellfish sampled had a fat content as high as oyster.
- The high proportion of ALA in catfish may also be a result of their being farmed and may specifically relate to the presence of soy meal in their feed.
- It isn't clear why oyster has such a high percentage of total omega-3 fatty acids relative to fat content (23.6%) when compared to the relative percentages in salmon (14.7%) or in catfish (2.4%).
- The highest level of vitamin D was found in salmon which is also the finfish with the highest fat level. Vitamin D may be somewhat proportional to the fat content since flatfish have a fat content of about 34% of salmon and a vitamin D level of ~21% of salmon. However, this relationship doesn't hold with catfish since their fat level was slightly higher than that of salmon, but their vitamin D was only about 1% of that in salmon. It is possible that this has to do with catfish being a freshwater species that is farm raised.

Conclusions

- Seafood species provide the major natural sources of omega-3 fatty acids and vitamin D in the US diet.
- With this variety of species, the consumer can choose among a wide range of seafoods, some of which provide significant levels of these important nutrients.
- Vitamin D levels in the seafoods evaluated were not proportional to fat. Vitamin D content appears to be species-dependent.

References

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