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Nutrient content and variability in newly obtained salmon data for USDA Nutrient Database for Standard Reference

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Introduction

Among seafood species consumed in the United States, salmon is an important contributor of many nutrients. The Food and Drug Administration (FDA) includes six species of salmon in two separate categories in its list of the top 20 most frequently consumed fish in the United States for voluntary nutrition labeling. Salmon is also a highly consumed, nutrient dense food in the diet of Alaska Natives (AN). The objective of this work was to generate nutrient data for various forms, sources, and species of salmon, not sampled before or re-sampled. 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 (SR) to provide current and accurate data for these foods.

Materials and Methods

- Sampling

Retail samples of salmon were obtained from a nationally representative sampling plan as part of the National Food and Nutrient Analysis Program (NFNAP).[1]

  - Analytical composites of retail (R) *raw wild, raw farmed,* and *canned* salmon were picked up in each of 12 supermarkets across the US.
  - Supermarkets were randomly selected from a pool of stores with sales volumes exceeding $2 million/year.
  - Multiple local samples of *raw wild, smoked,* and *canned* AN salmon were obtained with the assistance of tribal representatives and researchers.[2]
  - Species and scientific names of the sampled salmon are shown in Table 1.

Table 1. Salmon species and scientific names

Salmon Species Name	Scientific Name
Atlantic	*Salmo salar*
Chum	*Oncorhynchus keta*
Coho	*O. kisutch*
King (Chinook)	*O. tshawytscha*
Pink	*O. gorbuscha*
Red (Sockeye)	*O. nerka*

- Sample Preparation and Storage
  - All samples were shipped on dry ice, where necessary, 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
    - Prepared (smoked) samples were frozen and stored at -65ºC.
    - Shelf stable (canned) samples were at room temperature.
  - Sample composites 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.
- Nutrient Analysis
  - Together with the food samples, FALCC also sent certified reference materials and in-house prepared control materials to monitor the analyses done by the laboratories.[3]
  - Commercial analytical laboratories, pre-approved for participation in NFNAP, analyzed the food samples and the QC materials using AOAC or other acceptable methods for general nutrients (proximates, minerals, vitamins, fatty acids and amino acids) (see Table 2).

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

Nutrient	AOAC Method Number and Description
Moisture	934.06 – vacuum oven
Protein	968.06 – combustion
Fat	954.02 – acid hydrolysis
Calcium	984.27 – ICP
Fatty acids	996.06 – gas chromatography
Cholesterol	994.10 – gas chromatography
Niacin	944.13 – microbiological
Vitamin B_{12}	952.20 – microbiological

- 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).

Results

Sample size (number of composites analyzed) varies for the fish items and nutrients because some of the foods were sampled using different protocols. Also, in a few cases the values were calculated. In Tables 3-6, values with sample size = 1 represent multiple samples with only a single composite analyzed. A sample size = 0 represents a calculated value.

Table 3: Data on the moisture, protein, and total lipid content of seven forms of salmon. The moisture level in the AN red, smoked sample (26.9 g/100g) is significantly lower than that in the AN and R raw samples (66.0 – 76.4 g/100g). Protein is also correspondingly higher in the AN red, smoked sample (56.9 g/100g) than in the other AN and R samples (19.8 – 21.3 g/100g). Total lipid is the most variable nutrient among the proximates shown, ranging from 3.45 to 11.7 g/100g, regardless of the form of salmon. In general, nutrient content increased as moisture content decreased.

Table 3. Proximate composition of salmon samples

Salmon Species/form	Moisture (g/100g)	Protein (g/100g)	Total lipid (g/100g)
Source: Alaska Native (AN)			
King, raw	66.0 (2)[1]	20.2 (2)	11.7 (2)
Chum, raw	72.3 (1)	20.7 (1)	3.67 (1)
Red, smoked	26.9 (1)	56.9 (1)	11.0 (1)
Retail (R)			
Atlantic, farmed, raw	68.9 (2)	19.9 (2)	10.8 (2)
Atlantic, wild, raw	68.5 (21)	19.8 (9)	6.34 (7)
Pink, raw	76.4 (141)	19.9 (141)	3.45 (144)
Red, raw	70.2 (48)	21.3 (45)	8.56 (48)

[1]Number of samples analyzed

Table 4: Calcium values for nine forms of salmon. Raw salmon tissue contained between 6 and 13 mg/100g. Retail canned salmon with bone had 221 to 277 mg/100g. Other processed forms had intermediate levels of 28 to 69 mg/100g.

Table 4. Calcium content of salmon samples

Salmon Species/form	Calcium (mg/100g)
Source: Alaska native	
Chum, raw	7 (1)
Red, smoked	34 (1)
Red, canned, w/o bone	28 (1)
Red, canned, smoked	69 (1)
Retail	
Atlantic, wild, raw	12 (3)
Pink, raw	13 (0)
Pink, canned, solids w/bone	277 (41)
Red, raw	6 (1)
Red, canned, solids w/bone	221 (25)

[1]Number of samples analyzed

Table 5: Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), two omega-3 fatty acids typically found in fish, and cholesterol in 10 forms of salmon. Moisture and total lipid contents are given for comparison. The EPA content ranged between a low level of 0.04 g/100g in AN raw chum and R red, raw and a high level of 0.62 g/100g in R raw, farmed Atlantic salmon. The DHA content ranged between 0.41 g/100g in AN raw chum and 1.42 g/100g in red, smoked salmon. The highest level of cholesterol (141 mg/100g) was in the lower-moisture AN smoked red salmon. Raw salmon had cholesterol values ranging between 52 and 62 mg/100g. Cholesterol in the retail canned red salmon was 44 mg/100g and the retail canned pink was 82 mg/100g.

Table 5. Moisture, fat, EPA[1], DHA[2], and cholesterol in salmon samples

Salmon Species/form	Moisture (g/100g)	Total lipid (g/100g)	EPA (g/100g)	DHA (g/100g)	Cholesterol (mg/100g)
Source: Alaska native					
King, raw	66.0 (2)[3]	11.7 (2)	0.12 (1)	0.71 (1)	61 (1)
Chum, raw	72.3 (1)	3.67 (1)	0.04 (1)	0.41 (1)	59 (1)
Coho, raw	69.4 (1)	5.57 (1)	0.18 (1)	1.38 (1)	58 (1)
Red, smoked	26.9 (1)	11.0 (1)	0.28 (1)	1.42 (1)	141 (1)
Retail					
Atlantic, farmed, raw	68.9 (2)	10.8 (2)	0.62 (2)	1.29 (2)	59 (2)
Atlantic, wild, raw	68.5 (21)	6.34 (7)	0.29 (2)	1.12 (2)	55 (0)
Pink, raw	76.4 (141)	3.45 (144)	0.10 (1)	0.59 (1)	52 (0)
Pink, canned	70.5 (41)	4.83 (41)	0.11 (37)	0.69 (37)	82 (37)
Red, raw	70.2 (48)	8.56 (48)	0.04 (3)	0.65 (3)	62 (11)
Red, canned	67.5 (25)	7.31 (1689)	0.15 (22)	0.88 (22)	44 (3)

[1]EPA = Eicosapentaenoic Acid
[2]DHA = Docosahexaenoic Acid
[3]Number of samples analyzed

Table 6: Moisture, niacin, and vitamin B_{12} in 10 forms of salmon. The highest levels of niacin occurred in the two AN smoked red salmon (13.1 and 22.0 mg/100g). The raw and R canned salmon had niacin values ranging between 5.8 and 8.4 mg/100g. Vitamin B_{12} was higher in the AN raw salmon (7.4 and 8.5 mcg/100g) than in the R raw salmon samples (2.8 – 5.0). The AN smoked red salmon had the highest value (14.3 mcg/100g). The R canned salmon values for vitamin B_{12} (5.0 and 5.5 mcg/100g) were closer in line with the high end of the range for R raw salmon.

Table 6. Moisture, niacin, and vitamin B_{12} in selected NFNAP salmon samples

Salmon Species/form	Moisture (g/100g)	Niacin (mg/100g)	Vitamin B_{12} (mcg/100g)
Source: Alaska, native			
King, raw	66.0 (2)[1]	8.4 (2)	7.4 (1)
Coho, raw	69.4 (1)	7.9 (1)	8.5 (1)
Red, smoked	26.9 (1)	22.0 (1)	14.3 (1)
Red, canned, smoked	56.5 (1)	13.1 (1)	7.4 (1)
Retail			
Atlantic, farmed, raw	68.9 (2)	7.5 (2)	2.8 (2)
Atlantic, wild, raw	68.5 (21)	7.9 (13)	3.2 (10)
Pink, raw	76.4 (141)	7.0 (0)	3.0 (0)
Pink, canned	70.5 (41)	7.4 (15)	5.0 (15)
Red, raw	70.2 (48)	5.8 (11)	5.0 (1)
Red, canned	67.5 (25)	7.6 (12)	5.5 (12)

[1]Number of samples analyzed

Discussion

As shown in Table 3, the level of protein in raw salmon species is relatively consistent at about 20 g/100g. This corresponds to about 17 grams of protein per 3 oz serving (85 g), or more than 1/3 of the Daily Value (DV) for protein for adults. The much higher level of protein in the AN smoked red salmon (48.4 g/3 oz) is due to the drying that occurs during the smoking process and is reflected in the much lower moisture content. Using 5 grams of fat per 100 grams of fish as a cut-off between low fat and high fat fish, most of the species can be considered high fat fish. There is a relatively narrow range of values for the sum of moisture and fat between 75 and 80 g/100g. Ash, not shown, is about 1.2 g/100g for most of the samples.

Based on the data for calcium given in Table 4, canned salmon with bones provided between 19 and 24% of the DV for calcium. The intermediate values for the other processed forms of salmon are about five times higher than values for raw salmon. This might be explained by some of the calcium being leached from the bones into the flesh during the processing procedures or by the presence of some small pieces of bone in the edible portion.

As shown in Table 5, the level of DHA is consistently higher than the level of EPA up to more than 10 times for the lowest levels of EPA. However, there does not appear to be any consistent relationship between the amount of total lipid and the amount of DHA in the reported samples. The lowest level of DHA in AN raw chum salmon corresponds to a low total lipid level in the same sample; however, the high level of DHA in raw samples of AN coho and R raw, farmed Atlantic salmon correspond to total lipid values of 5.6 g/100g and 10.8 g/100g, respectively. Some of this variability is due to species differences, and some is probably due to the limited number of samples that were analyzed.

With a DV of 300 mg for cholesterol, a 3 oz serving of raw salmon provides about 18% of the DV. Even the highest value in AN smoked red salmon is only 40% of the DV (120 mg/3 oz). It isn't clear why there is such a difference between the cholesterol content in the red and the pink canned salmon samples. It may be due to species differences and/or it may be due to the limited number of analytical values.

Based on the data given in Table 6, the highest levels of niacin in the two AN smoked red salmon samples may be related to the loss of moisture during processing. Applying this reason to the highest value of vitamin B_{12} in the AN smoked red salmon does not hold given the value of 7.4 ug/100g for the AN canned smoked red salmon. A 3 oz serving of AN smoked red salmon provides 94% of the DV for niacin and twice the DV for vitamin B_{12}. Averaging the values in the raw salmon samples provides 32% of the DV for niacin and 50% of the DVfor vitamin B_{12} per serving. The average value of niacin in the two retail canned red salmon also provides 32% of the RDI for niacin in a 3 oz. serving, but the average value of vitamin B_{12} in the same two retail canned red salmon provides 74% of the RDI for vitamin B_{12} in a 3 oz. serving. It appears that salmon is a better source of vitamin B_{12} than of niacin.

Conclusions

A variety of species and forms of salmon are available in the American diet and are important to the diet of Alaska Natives. Besides the availability of different species and wild and farmed sources for some, there are also smoked, canned and smoked, and canned (some with bone and some without) forms. This variety allows the consumer a wide range of choices that contain reasonable and significant levels of important nutrients. The recently published report from the Institute of Medicine of the National Academies on balancing the benefits and risks in choosing seafood ranked salmon high as a good choice.[4] The data presented here clearly support that decision.

References

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[3]Phillips, KM, Patterson, KY, Rasor, AS, Exler, J, Haytowitz, DB, Holden, JM and Pehrsson, PR 2006. Quality-control Materials in the USDA National Food and Nutrient Analysis Program (NFNAP). Anal. Bioanal. Chem. 384(6): 1341-1355.

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