(2.32%) and lower lysine (0.77%), arginine (1.15%), and proline (0.77%) content in the American pepper.

The amino acid content of the pericarp of the "sweet" fruit in this study was generally lower than in the pericarp of the Italian variety *Corno di due* (Bottazi et al., 1968) which is similar in the shape and size of the fruit. Exceptions were histidine, proline, alanine, methionine, and isoleucine, which were higher in our samples. These differences could be due to climatic and cultivating conditions since, among other factors, fertilizing influences the amino acid composition of *Capsicum* (Tsonev and Chalukova, 1969, 1972).

Finally, we wish to report three unidentified yet reproducible peaks with maximum absorbance higher at 440 nm than at 570 nm. Their positions were before hydroxyproline (aspartic acid) or between cysteic acid and hydroxyproline in the peroxidized samples. Unidentified peaks with maximum absorbance at 440 nm, before aspartic acid, were also observed for several plant hydrolysates (Van Etten et al., 1963). A possible attribution of such peaks to breakdown products of carbohydrate content (Ewart, 1967) is not likely in the present case, as the size of these peaks was not related to the sugar content of the samples (Tsatsaronis and Kehayoglou, 1964). To indicate the relative sizes of these peaks they were integrated and computed as proline. Thus, the following mean values (g/100 g of dry sample) for both "sweet" and "hot" species were obtained: 0.30, 0.27, 0.09 for red peppers; 0.31, 0.34, 0.26 for pericarps; 0.28, 0.27, 0.06 for seeds; and 0.56, 0.33, 0.26 for stems. These peaks, however, were disregarded in the results given in Tables I and II since the peaks have not yet been identified.

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Mineral and Proximate Composition of Pacific Coast Fish

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The mineral and proximate composition of 14 marine species from the Pacific Coast Fishery and as going into the human food chain were determined. Mineral analysis was accomplished by atomic absorption spectrometry for K, Ca, Mg, Na, Fe, Cu, Zn, and Mn. Phosphorus levels were determined by emission spectroscopy and S gravimetrically after sample combustion in an oxygen bomb. Mean Na and K levels found in white flesh finfish were, respectively, 52 ± 15 mg/100 g and 348 ± 47 mg/100 g wet weight. Magnesium, P, and S levels in finfish, mollusks, and crustaceans were determined to be fairly constant, averaging, respectively, 25 ± 4 mg/100 g, 177 ± 47 mg/100 g, and 225 ± 43 mg/100 g. The only other mineral displaying such uniformity between species was Mn at 22 ± 9 μg/100 g. Oysters were the exception and were found to contain on the average of 643 μg/100 g. Much lower iron levels, 0.31 ± 0.08 mg/100 g were found in white flesh finfish than previously reported. Copper and Zn averaged, respectively, 29 ± 8 μg/100 g and 0.28 ± 0.04 mg/100 g in finfish with higher amounts in mollusks and crustaceans. Calcium is very low in finfish and oysters, 8 ± 2 mg/100 g, two to three times higher in crustaceans, and extremely high in canned salmon, 251 mg/100 g.

Seafoods do not play a major role in the dietary habits of Americans based on a 5.5 kg per capita consumption (National Marine Fisheries Service, 1975). The extent to which this figure is underestimated in selected geographical regions is unknown. In line with this lack of a more thorough detailing of seafood consumption is the lack of nutritional information on the mineral composition of finfish, mollusks, and crustaceans. This is evidenced by the blanks existing in Agriculture Handbook No. 8 (Watt and Merrill, 1963) on minerals in seafoods. While current reviews have brought together a magnitude of information on the proximate composition (Stansby and Hall, 1967; Sidwell et al., 1974; Stansby, 1976) and fatty acid composition (Exler et al., 1975; Exler and Weihrauch, 1976) of marine foods, reported mineral levels are only for two or three elements on a very select species basis; the work of Thurston (1958, 1960) on Na and K levels not withstanding. Nilson and Coulson (1939) published the latest comprehensive study on six minerals, Ca, Mg, P, Fe, Cu,

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and I, but on a more geographically disbursed sampling of 18 species.

The purpose of this investigation was to determine, for human nutrition purposes, the mineral composition of selected seafoods common to the Pacific Coast. Species analyzed represent 35% of the food fish harvested yearly (Fishery Statistics of the United States, 1973) in the Pacific Coast Fishery. Reported values are for products, some of which receive secondary processing, going directly into the food chain and available to the consumer.

While the principal purpose of this investigation was to determine the mineral composition of seafoods, the inclusion of proximate composition values is believed to be an important criteria in helping provide a more complete nutritional profile.

MATERIAL AND METHODS

Samples. Information on the source and general characteristics of the samples analyzed is in Table I. All finfish samples, except sockeye salmon, were obtained from local fishermen through processors, 24-h postharvest, and prior to filleting in the laboratory. Samples were all obtained unfrozen and stored on ice, except the sockeye salmon (termed fresh), and the tuna and sockeye salmon subsequently canned. Fresh cooked and canned shrimp, canned tuna, canned sockeye salmon, and fresh cooked Dungeness crab were commercially processed. For comparative purposes, a single sample of beef, round steak, from which all visible fat was removed and reported to be from a grass fed (range) animal, was carried through the entire sequence of analyses. Two sample lots of oysters were also analyzed for comparative purposes.

Sample Preparation and Proximate Determination. Three homogenized composites of each sample were made for subsequent moisture determination according to the AOAC procedure (1975c) in duplicate. Sections of six finfish were used to obtain composites and 200-g amounts of shrimp meat, crab body, and crab leg were used in preparing these composites. The drained contents of three cans of shrimp, tuna, and salmon were homogenized together, each being one composite sample. Six oysters each were used to make a composite.

Remaining sample material for each specie was immediately vacuum sealed in moisture vapor-proof packaging material and held at −30 °C prior to being freeze-dried by Oregon Freeze Dry Foods, Inc., Albany, Ore.

Freeze-dried samples were ground in a Thomas Wiley Mill again to obtain composite samples of no less than 12 individual fillets, mollusks, crustacea, or the contents of 12 canned items. When number of fish or sample size permitted (Table I), four freeze-dried ground composite samples composed of 12 individual samples were prepared. In those cases where less than 48 individual samples were available, the freeze-dried material was divided into four approximately equal amounts and then ground. Protein (total N × 6.25), ash, and moisture were determined on the composite using AOAC procedures (1975a,b,c, respectively). Lipid content of three composites were determined by the method of Folch et al. (1957).

The original mean total solid content of each sample lot was used in calculating mean protein, lipid, and ash content on a wet weight basis.

Mineral Analysis. From 1 to 2 g of each composite freeze-dried sample was initially digested in 15 mL of HNO_3. After the addition of 1.5 mL of $HClO_3$, the digestion was continued until colorless and the samples were made up to 25 mL with distilled water. Direct analysis for K, Na, Fe, Cu, Zn, and Mn were made by atomic absorption spectrometry (AAS) using a Perkin-Elmer Model 403 spectrophotometer. For Ca and Mg determinations, digested samples were adjusted to a final concentration of 1000 ppm lanthanium with lanthanium oxide making only a 1% volume dilution. A standard air acetylene burner and single element hollow cathode lamp were used for each element. Instrumental settings were those described by the manufacturer (Perkin-Elmer Corporation, 1973). Standards were obtained from Harleco, Philadelphia, Pa.

A fraction of one composite of each species sample was forwarded to the WARF Institute, Inc., Madison, Wis., for analysis of P using direct reading emission spectroscopy (Christensen et al., 1968).

Three composites of each sample lot were combusted in a Parr Model 1242 adiabatic calorimeter for determination of S by gravimetric analysis using the procedure outlined by the manufacturer (Parr Instrument Co., 1975).

RESULTS AND DISCUSSION

The levels of macro and micro minerals found in the freeze-dried composite seafood samples, on a dry matter basis, are indicated in Tables II and III, respectively. The proximate composition of freeze-dried composite samples is shown in Table IV.

The first eight species listed in all tables are commonly referred to as "groundfish", and since their composition does appear to be similar, mean levels will be discussed for these specific finfish as a group.

Freeze-drying affords the advantage of evaluating a large number of whole fish (edible portions), preservation of original nutrient composition, and ease of handling in forming representative subsamples. The analysis of whole fish is important since the composition of a fillet is known to be variable in different sections of the musculature (Love, 1970). Conventional drying (hot air oven) is not conducive to handling large quantities without some loss of the sarcoplasmic fraction of a wet sample (Thompson, 1964) leading to lower nutrient levels. The opposite is true of initial milling of wet samples followed by drying with a double-drum drier which may increase the level of certain minerals, i.e., Fe and Cu (Crawford et al., 1972; Adu, 1975). Mineral analysis of wet seafood samples was found to have the added disadvantage of requiring a large sample size requiring a dilution to a small volume. This is necessary to reach the threshold of detection for most of the trace elements using conventional methods of analysis.

Preliminary investigation on the mineral composition of seafoods led to the selection of the HNO_3–$HClO_3$ wet digestion techniques over dry ashing based on a higher degree of accuracy. Lower values for K, Na, and possibly inaccurate Fe levels were found employing the dry ash method, and this has previously been reported for K determination in seafoods (Thompson, 1964). Due to the rather conflicting information available on the mineral composition of seafoods, concurrent analysis of the National Bureau of Standards, Standard Reference Material, SRM 1577, bovine liver was performed to check the reliability and accuracy of the wet digestion and subsequent AAS quantitation. Comparison of determined levels to those reported in SRM 1577 (Table V) appear to strengthen the accuracy of observed values.

In addition to the single observation for P (Table II) obtained on one composite sample forwarded to the WARF Institute, information was also provided on Al, Ba, Sr, B, and Cr. The levels of these five elements are summarized on a dry weight basis, and like P were determined by emission spectroscopy. Aluminum levels in all samples were less than 10 μg/g with the exception of the two oyster samples which were 93.2 μg/g (sample I) and 97.9 μg/g

Table I. Summary of Samples Analyzed

Sample (date harvested)	Species	Product description	Origin of sample	No. of fish or sample size	Av wt, kg	Av length, cm
Pacific cod (6/26/75)	*Gadus macrocephalus*	Fillet	No. of Astoria canyon, 80 fathoms (F)	33	2.2	56
Dover sole (7/17/75)	*Microstomus pacificus*	Fillet	So. of Astoria canyon, 50 F	100	0.5	39
Rockfish, black (8/5/75)	*Sebastodes melanops*	Fillet	No. of Astoria canyon, 25 F	24	1.7	50
Rockfish, orange (8/20/75)	*Sebastodes pinniger*	Fillet	No. of Astoria canyon, 70 F	31	1.8	50
Ling cod (8/20/75)	*Ophiodon elongatus*	Fillet	No. of Astoria canyon, 50 F	26	4.0	70
Petrale sole (9/22/75)	*Eopsetta jordani*	Fillet	No. of Astoria canyon, 60 F	160	0.6	37
English sole (7/28/75)	*Parophrys vetulus*	Fillet	No. of Astoria canyon, 30 F	125	0.3	33
Pacific hake (5/27/75)	*Merluccius productus*	Fillet	Mouth of Columbia river	18	1.1	42
Pacific shrimp, fresh (9/28/75)	*Pandalus jordani*	Fully processed (PCA peeler) ready to eat, salted used in processing	Off Newport, Ore. coast	9.2 kg final product	Raw count, 220–280/kg	
Pacific shrimp, canned (9/27/75)	*Pandalus jordani*	Drained solids, (Model A peeler) salt added[a]	Southern Wash. coast	65 each, 128 g[b] cans	Raw count, 350–440/kg	
Albacore tuna, canned (9/75)	*Thunnus alalunga*	Drained solids, salt added[c]	Northern Ore. coast	70 each, 199 g cans		
Sockeye salmon, fresh (7/16/75)	*Oncorhynchus nerka*	Fillet	Bristol Bay, Alaska, mouth of Naknek river	12	3.9[d]	80
Sockeye salmon, canned (7/16/75)	*Oncorhynchus nerka*	Drained solids, salt added.	Bristol Bay, Alaska, mouth of Naknek river	20 each, 440 g[b] cans		
American shad (6/3/75)	*Alosa sapidissima*	Fillet	Columbia River, Zone 5, below Bonneville Dam	12	1.7	61
Oysters, sample I (10/16/75)	*Crassostrea gigas*	Whole	Willapa Bay, Wash.	13 kg	Raw count, 32/kg	
Oysters, sample II (1/15/76)	*Crassostrea gigas*	Whole	Willapa Bay, Wash.	5 kg	Raw count, 40/kg	
Dungeness crab, body (12/22/75)	*Cancer magister*	Picked body meat, salt used in processing	Off the mouth of the Columbia river	36 each, 6.5 kg	1.0	
Dungeness crab, leg (12/22/75)	*Cancer magister*	Picked leg meat, salt used in processing	Off the mouth of the Columbia river	36 each, 6.5 kg picked meat	1.0	
Round steak, all visible fat removed (10/24/75)		Section of round from one animal	Local abattoir	8 kg		

[a] 2.85 g of NaCl and 0.27 g of citric acid added to can. [b] Drained weight. [c] Albacore in water seasoned with vegetable broth, 1.2 g of salt and 0.5 g of sodium acid pyrophosphate added to can, pressed weight. [d] Eviscerated.

Table II. Macromineral Content of Pacific Coast Fish (Dry Weight)[a]

Sample	Percent					
	P[b]	K[c]	Ca[c]	Mg[c]	Na[c]	S[d]
Pacific cod	0.958	2.032 ± 0.133	0.040 ± 0.002	0.134 ± 0.008	0.355 ± 0.020	1.17 ± 0.09
Dover sole	0.877	1.915 ± 0.080	0.045 ± 0.001	0.126 ± 0.008	0.481 ± 0.009	0.97 ± 0.02
Rockfish, black	0.865	1.776 ± 0.138	0.023 ± 0.002	0.145 ± 0.031	0.148 ± 0.034	0.95 ± 0.15
Rockfish, orange	0.871	1.726 ± 0.222	0.045 ± 0.003	0.129 ± 0.018	0.179 ± 0.033	1.18 ± 0.18
Ling cod	1.000	2.159 ± 0.177	0.069 ± 0.002	0.131 ± 0.020	0.209 ± 0.057	1.07 ± 0.02
Petrale sole	0.878	1.607 ± 0.087	0.052 ± 0.001	0.142 ± 0.008	0.224 ± 0.022	1.02 ± 0.16
English sole	0.899	1.687 ± 0.163	0.052 ± 0.006	0.119 ± 0.015	0.275 ± 0.031	1.17 ± 0.27
Pacific hake	0.969	1.967 ± 0.150	0.052 ± 0.001	0.142 ± 0.011	0.397 ± 0.048	0.91 ± 0.14
Pacific shrimp, fresh[e]	0.638	0.533 ± 0.038	0.183 ± 0.021	0.157 ± 0.012	2.240 ± 0.298	0.95 ± 0.03
Pacific shrimp, canned[e]	0.523	0.328 ± 0.035	0.127 ± 0.012	0.091 ± 0.013	2.299 ± 0.229	0.96 ± 0.02
Albacore tuna, canned[e]	0.745	0.900 ± 0.070	0.007 ± 0.002	0.097 ± 0.005	1.247 ± 0.130	1.02 ± 0.10
Sockeye salmon, fresh	0.667	1.143 ± 0.042	0.021 ± 0.002	0.092 ± 0.006	0.103 ± 0.009	0.69 ± 0.08
Sockeye salmon, canned[e]	0.878	0.836 ± 0.109	0.753 ± 0.048	0.086 ± 0.010	1.436 ± 0.168	0.86 ± 0.03
American shad	0.796	1.278 ± 0.186	0.138 ± 0.013	0.088 ± 0.003	0.143 ± 0.014	0.71 ± 0.03
Oysters, sample I	1.042	1.031 ± 0.161	0.044 ± 0.010	0.128 ± 0.017	0.771 ± 0.236	1.60 ± 0.09
Oysters, sample II	0.856	0.949 ± 0.196	0.055 ± 0.012	0.137 ± 0.012	0.453 ± 0.200	1.47 ± 0.14
Dungeness crab, body[e]	0.564	0.549 ± 0.083	0.090 ± 0.004	0.085 ± 0.011	4.418 ± 0.358	1.13 ± 0.03
Dungeness crab, leg[e]	0.603	0.728 ± 0.173	0.119 ± 0.005	0.099 ± 0.008	3.816 ± 0.255	1.20 ± 0.02
Round steak	0.753	1.620 ± 0.070	0.014 ± 0.002	0.099 ± 0.012	0.204 ± 0.029	1.05 ± 0.03

[a] Freeze-dried composite sample, see Material and Methods section. [b] One composite sample, $n = 1$. [c] Mean ± SD, $n = 4$. [d] Mean ± SD, $n = 3$. [e] Salt added during processing.

Table III. Micromineral Content of Pacific Coast Fish (Dry Weight)[a]

Sample	μg/g			
	Fe[b]	Cu[b]	Zn[b]	Mn[b]
Pacific cod	13.7 ± 1.6	1.11 ± 0.30	15.74 ± 0.28	0.67 ± 0.008
Dover sole	14.7 ± 1.2	1.46 ± 0.71	13.48 ± 1.80	0.74 ± 0.13
Rockfish, black	15.1 ± 1.0	1.50 ± 0.50	10.53 ± 2.74	1.60 ± 0.29
Rockfish, orange	21.3 ± 2.6	2.19 ± 0.75	13.47 ± 1.35	0.78 ± 0.07
Ling cod	15.7 ± 2.2	1.62 ± 0.46	15.14 ± 3.09	0.97 ± 0.13
Petrale sole	9.1 ± 1.0	1.39 ± 0.49	14.94 ± 1.06	0.81 ± 0.15
English sole	16.6 ± 2.1	1.33 ± 0.39	18.80 ± 1.52	1.41 ± 0.27
Pacific hake	24.3 ± 3.0	1.62 ± 0.58	15.56 ± 2.08	0.86 ± 0.16
Pacific shrimp, fresh	13.1 ± 0.6	9.03 ± 2.21	43.36 ± 2.35	1.58 ± 0.19
Pacific shrimp, canned	12.6 ± 1.1	7.28 ± 0.93	47.4 ± 6.12	1.23 ± 0.17
Albacore tuna, canned	16.7 ± 3.6	0.92 ± 0.27	13.50 ± 1.33	0.52 ± 0.16
Sockeye salmon, fresh	23.9 ± 4.6	1.87 ± 0.33	10.08 ± 2.03	0.53 ± 0.13
Sockeye salmon, canned	29.3 ± 3.0	3.46 ± 1.03	22.85 ± 1.23	1.01 ± 0.37
American shad	28.1 ± 1.0	2.30 ± 0.31	7.85 ± 1.84	1.23 ± 0.06
Oysters, sample I	441 ± 22	65.6 ± 7.3	804.8 ± 17.4	42.18 ± 4.83
Oysters, sample II	358 ± 27	57.2 ± 7.5	782.0 ± 36.56	32.97 ± 5.74
Dungeness crab, body	17.4 ± 3.7	18.42 ± 2.08	200.8 ± 17.63	0.90 ± 0.16
Dungeness crab, leg	16.8 ± 1.3	22.61 ± 5.01	200.67 ± 38.42	0.81 ± 0.14
Round steak	105 ± 3	3.04 ± 0.48	172.5 ± 2.95	0.98 ± 0.15

[a] Freeze-dried composite sample, see Materials and Methods section. [b] Mean ± SD of four composite samples.

(sample II) and canned sockeye salmon with 17.3 μg/g. Barium could not be detected in any sample above the 2 μg/g level. Groundfish were found to contain 1.43 ± 0.51 μg/g strontium, shrimp 32 μg/g, canned salmon 28 μg/g, oysters 5 μg/g, crab body 18 μg/g, and crab leg 36 μg/g and could not be detected above 1 μg/g in the remaining samples. The boron content of all samples was 2.7 ± 0.8 μg/g except for oysters which was higher at 8.6 μg/g (sample I) and 12.8 μg/g (sample II). Chromium could not be detected in any sample above the 3 μg/g level, but this might be due to volatilization resulting from the dry ashing technique.

Results of mineral and proximate analyses are reported for freeze-dried samples in Tables II, III, and IV. Discussion, however, will focus on mean wet weight values as reported in Table VI. Transformation of information into a wet weight basis, per 100 g of edible portions, is more useful in discussing the nutrient profile of foods and more easily evaluated against existing but limited information.

All samples not subjected to secondary processing have a P level of 190 ± 44 mg/100 g. Those undergoing a peeling and washing operation, shrimp and crab, contain 126 ± 10 mg/100 g. The value of 221 ± 33 mg/100 g reported by Sidwell et al. (1973) in crustacea appear to support the suggestion that processing has an effect on P levels. It would also appear that processing of shrimp and crab has a tendency to reduce K levels from those expected or observed in other seafoods. Other minerals do not appear to fluctuate with secondary processing.

Thurston (1961a,b,c) has previously examined many of the species of groundfish investigated herein for Na and K. Use of flame photometry–emission spectroscopy (Bowen, 1967) is believed to account for his slightly higher observed Na levels, 76 ± 21 mg/100 g, than found in this study, 52 ± 15 mg/100 g. There is good agreement between the mean value for K found in groundfish 348 ± 47 mg/100 g and that reported earlier 367 ± 41 mg/100 g (Thurston, 1961a,b,c). Even with the degree of variation existing in seafoods with added salt (Table II), Na levels are very high in these foods. Individuals on a Na regulated diet need to be alerted to this high Na content.

Calcium levels are extremely low in finfish and oysters, 8 ± 2 mg/100 g, while being higher in crustaceans, 28 ± 9 mg/100 g. Observed Ca levels are lower than previously reported (Sidwell et al., 1973) in finfish, 52 ± 33 mg/100 g, and crustaceans, 62 ± 20 mg/100 g.

Table IV. Proximate Composition of Freeze-Dried[a] Pacific Coast Fish

Sample	Percent			
	Protein[b]	Lipid	Ash	Carbohydrate[c]
Pacific cod	94.17 ± 1.32 [d]	4.28 ± 0.23[e]	5.85 ± 0.02[f]	
Dover sole	94.36 ± 0.86	5.19 ± 0.50	5.98 ± 0.16	
Rockfish, black	88.04 ± 0.54	10.54 ± 0.38	5.14 ± 0.24	
Rockfish, orange	89.33 ± 0.92	9.01 ± 0.06	5.10 ± 0.20	
Ling cod	89.98 ± 0.77	7.04 ± 0.43	6.05 ± 0.12	
Petrale sole	91.00 ± 0.85	6.83 ± 0.47	5.06 ± 0.08	
English sole	88.95 ± 0.14	7.76 ± 0.04	5.95 ± 0.06	
Pacific hake	94.30 ± 0.43	8.61 ± 0.33	5.77 ± 0.28	
Pacific shrimp, fresh[g]	87.95 ± 0.82	7.24 ± 0.26	8.66 ± 0.20	
Pacific shrimp, canned[g]	88.14 ± 0.56	7.73 ± 0.10	8.36 ± 0.09	
Albacore tuna, canned[g]	94.45 ± 0.41	4.14 ± 0.38	5.03 ± 0.21	
Sockeye salmon, fresh	75.66 ± 0.97	29.73 ± 0.42	3.77 ± 0.37	
Sockeye salmon, canned[g]	78.83 ± 0.20	24.05 ± 0.46	7.65 ± 0.23	
American shad	60.69 ± 0.73	38.03 ± 1.17	4.35 ± 0.05	
Oysters, sample I	57.12 ± 0.77	17.63 ± 0.07	6.45 ± 0.45	19.22
Oysters, sample II	49.40 ± 0.57	17.00 ± 0.54	5.25 ± 0.05	28.86
Dungeness crab, body[g]	83.87 ± 0.71	4.00 ± 0.75	12.62 ± 0.06	
Dungeness crab, leg[g]	86.45 ± 1.01	3.72 ± 0.55	11.51 ± 0.05	
Round steak	91.03 ± 1.00	6.75 ± 0.50	4.57 ± 0.10	

[a] Values for freeze-dried samples corrected to zero moisture: mean ± SD of moisture levels in freeze-dried samples 2.06 ± 0.99%. [b] Kjeldahl N × 6.25. [c] By difference. [d] Mean ± SD, n = four composite sample. [e] n = 3. [f] n = 4. [g] Salt added during processing.

Table V. Analysis of U.S. National Bureau of Standards (NBS) Standard Reference Material 1577, Bovine Liver

	NBS[a]	Determined[b]
	Percent	
Nitrogen	10.6 ± 0.6	10.6 ± 0.2
Potassium	0.97 ± 0.06	0.97 ± 0.02
Sodium	0.243 ± 0.013	0.248 ± 0.007
	μg/g	
Iron	270 ± 20	277 ± 6
Copper	193 ± 10	196 ± 3
Zinc	130 ± 10	130 ± 6
Manganese	10.3 ± 1.0	11.1 ± 1.0
Calcium	(123)[c]	105 ± 11
Magnesium	(605)[c]	590 ± 10

[a] Mean ± 95% confidence limits. [b] Mean ± SD of nine replicates. [c] Noncertified values provided by NBS for information.

The somewhat uniform level of Mg in the species investigated, 24 ± 4 mg/100 g, is unique but unexplainable at this time.

Iron levels are substantially lower than previously reported values. While some general reports indicate (Stansby and Hall, 1967; Stansby 1976) finfish may range in iron content from 0.5 to 1.5 mg/100 g, values found in groundfish were 0.31 ± 0.08 mg/100 g. Exceptions to these very low levels were fresh salmon, 0.62 mg/100 g; canned salmon, 0.98 mg/100 g; and American shad, 0.96 mg/100 g. The iron content of seafoods is not considered to increase by canning. However, this may have been true when the iron content was determined in canned shrimp (Watt and Merrill, 1963; Item No. 2045) and reported to be at the level of 3.1 mg/100 g. While the high iron levels in oysters were to be expected, the observed variation between the two sample lots dramatizes the possible effects of seasonal variation known to occur in any compositional analysis of seafoods (Love, 1970). This is further illustrated by comparing the proximate composition of these two samples. The effect of seasonal variation on the mineral composition of any one species remains to be evaluated. The high micromineral content in mollusks is believed due to their close cohabitation with their geochemical environment. Combined with what appears to be a great variation in their own seasonal nutritional and physiological cycle, species of their nature should always be expected to produce a rather large variation in observed nutrients and especially mineral levels. Another consideration is that the nature of the iron in oysters, along with its other minerals, has not been defined and its resulting biological availability unknown. Among finfish of the Pacific Coast at least, there appears to be some uniformity in mineral composition, allowing a certain generalization of compositional data for nutritional planning purposes. However, the reader is reminded that reported results are for particular samples analyzed and should not be construed as the best estimate of proximate or mineral composition of any one species. Variation due to size, geographical location, and season should be taken into consideration for average results.

Copper levels averaged 29 ± 8 μg/g in groundfish, with even higher levels in shrimp and Dungeness crab. The higher content of copper in crustaceans is believed to be due to its association with the highly active polyphenoloxidase system in these animals, which at times can lead to an undesirable blueing discoloration (Babbitt et al., 1973). Nilson and Coulson reported 317 μg/100 g of Cu in shrimp meat (*Peneus brasiliensis*) and 1582 μg/100 g in the white meat of blue crab (*Callincectes sapidus*) and 368 μg/100 g in the claw meat. Babbitt et al. (1973) determined the level in Dungeness crab (*Cancer magister*) to be 31 μg/g on a dry weight basis (Table III).

With the increased attention given today to the role of zinc in human nutrition (Burch et al., 1975), groundfish appear to provide about 2% of the U.S. RDA (15 mg/day) for this mineral per 100-g portion. As with copper, higher Zn levels are observed in crustaceans but its possible biochemical or physiological significance is unknown. A sample of freeze-dried albacore tuna, under investigation by the National Bureau of Standards, was determined by neutron activation analysis to contain 13.4 ± 0.5 μg/g (Orvini, 1974).

Manganese levels in fish and crab average 18 ± 7 μg/g. Twice this level was observed in salmon and shrimp and extremely higher levels in oysters, >500 μg/g. High Mn levels have previously been reported in other bivalves (Seah and Hobden, 1969).

There appears to be no characteristic pattern concerning the distribution of S in seafoods, with a mean level of 225

Table VI. Proximate and Mineral Composition of Pacific Coast Fish per 100 g of Edible Portions

Sample	Percent					mg							μg	
	Moisture[a]	Protein	Lipid	Ash	Carbohydrate	P	K	Ca	Mg	Na	S	Fe	Zn	Cu	Mn
Pacific cod	81.8 ± 0.1	17.1	0.78	1.06		174	370	7.3	24.3	64.6	213	0.25	0.29	20.2	12.2
Dover sole	84.4 ± 0.6	14.7	0.81	0.93		137	299	7.0	19.7	75.0	151	0.23	0.21	22.8	11.5
Rockfish, black	78.4 ± 0.3	19.0	2.26	1.11		187	384	5.0	31.3	32.0	205	0.33	0.23	32.4	34.6
Rockfish, orange	79.6 ± 0.2	18.2	1.84	1.04		178	352	9.2	26.3	36.5	241	0.43	0.27	44.7	15.9
Ling cod	79.9 ± 0.9	18.1	1.42	1.22		201	434	13.9	26.3	42.0	215	0.32	0.30	32.6	19.5
Petrale sole	79.3 ± 0.2	18.8	1.41	1.05		182	333	10.8	29.3	46.4	211	0.19	0.31	28.8	16.8
English sole	81.9 ± 0.2	16.1	1.40	0.99		163	305	9.4	21.5	49.8	212	0.30	0.34	24.1	25.5
Pacific hake	83.3 ± 0.1	15.7	1.44	0.96		162	328	8.7	23.7	66.3	152	0.41	0.26	27.1	14.4
Pacific shrimp, fresh[b]	78.6 ± 0.2	18.8	1.55	1.85		137	114	39.2	33.6	479.4	203	0.32	0.93	193.2	33.8
Pacific shrimp, canned[b]	75.3 ± 0.1	21.8	1.91	2.06		129	81	31.4	22.5	567.9	237	0.37	1.17	179.8	30.4
Albacore tuna, canned[b]	70.3 ± 0.1	28.1	1.23	1.49		221	267	2.1	28.8	370.4	303	0.49	0.40	27.3	15.4
Sockeye salmon, fresh	73.8 ± 0.3	19.8	7.79	0.99		175	299	5.5	24.1	42.7	181	0.62	0.26	47.0	13.9
Sockeye salmon, canned[b]	66.6 ± 0.2	26.3	8.03	2.56		293	279	251.5	28.7	479.6	287	0.98	0.76	115.6	33.7
American shad	65.8 ± 0.9	20.8	13.00	1.49		272	437	47.2	30.1	48.9	243	0.96	0.27	78.7	42.1
Oysters, sample I	81.4 ± 0.4	10.6	3.21	1.20	3.56	194	192	8.2	23.8	143.4	298	8.20	14.97	1220.2	784.5
Oysters, sample II	84.8 ± 0.5	7.5	2.58	0.80	4.31	130	144	8.4	20.8	68.9	223	5.45	11.89	869.4	501.1
Dungeness crab, body[b]	80.1 ± 0.2	16.7	0.80	2.51		112	109	17.9	16.9	879.2	225	0.35	4.00	366.6	17.9
Dungeness crab, leg[b]	78.9 ± 0.2	18.3	0.78	2.43		127	154	25.1	20.9	805.2	253	0.35	4.23	477.1	17.1
Round steak	75.5 ± 0.2	22.5	1.65	1.12		184	397	3.4	24.3	50.0	257	2.57	4.23	74.5	24.0

[a] Mean ± SD, duplicate determination on three composite samples; see Experimental Section. [b] Salt added during processing.

± 43 mg/100 g in all samples analyzed.

On a mineral basis, and only compared to one sample of red meat, groundfish do not appear to have as favorable a micromineral composition as round steak per 100 g of edible portion. However, with appropriate substitution, equal dietary mineral levels could be obtained from other seafoods.

Variation is to be expected in the continued proximate analysis of any biological sample. Fairly close agreement in observed protein, lipid, and ash levels (Table VI) with past information (Thurston, 1961a,b,c) suggest that even in this area some fairly well supported general statements can be made concerning the nutritional quality of seafoods. This close agreement even indicates that one could go so far as suggesting nutritional labeling values.

The mineral composition of seafoods has been determined on a regional basis for the purpose of providing a better understanding of the role foods from the sea play in human nutrition. This information is also intended as a first step in supplying some of the missing information in nutritional tables. Some previous information might be inaccurate. Along with data on the mineral composition of whole groundfish and fish waste (Crawford et al., 1972) and the generally considered toxic elements Pb and Cd (Childs and Gaffke, 1974) and Hg (Childs, 1973), the reported mineral levels help complete the nutritional profile on this food commodity.

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Rapid Visual Estimation and Spectrophotometric Determination of Tannin Content of Sorghum Grain

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A new technique was developed to quickly distinguish between zero, low, intermediate, and high tannin varieties of sorghum by the development of shades of yellow, green, and blue colors. A spectrophotometric method was developed which detects low concentrations of tannin and other polyphenolics by the formation of the Prussian blue complex. This method plus a rapid extraction procedure enables polyphenol content of grains to be quantitatively compared in 20 min. The vanillin test was shown to give misleading results unless a suggested modification is included in the procedure; of 35 varieties of grain studied, 20 that had been considered low in tannin have no tannin detectable by this test. Some phenolics which are extracted in water are not extracted in 0.2 M NaCl. This suggests a method which may distinguish between tannins and nontannin polyphenols.

In recent years it has been recognized that the tannins present in many varieties of sorghum diminish the nutritional quality of the grain. Several investigators have reported lower weight gains in young rats and chickens fed high tannin grain compared with those fed low tannin varieties. Typically the weight gains are 30–50% less for the high tannin varieties (Armstrong et al., 1973; Jambunathan and Mertz, 1973), though actual weight *loss* has been reported in rats fed one high tannin variety (Jambunathan and Mertz, 1973). Similar results have been reported comparing the effects of high and low tannin beans on weight gain in rats (Ronnenkamp, 1977) and on in vitro dry matter disappearance trials (Bond, 1976). The increasing concern over the nutritionally harmful effects of tannins in sorghum is creating strong pressures for the sorghum industry to provide grain of low tannin content.

However, there are economic incentives for the producers to grow high tannin varieties of sorghum. The presence of tannin makes grain less desirable to depredatory birds, so "bird resistant" (high tannin) varieties can be of great importance in some regions. Estimated losses of 50% in Georgia (Harris, 1969) and 48–72% in Arizona (Voight, 1966) have been reported from bird depredation. Tannin also apparently is associated with decreased susceptibility of the grain to preharvest germination (Harris and Burns, 1970) and seed molding (Harris and Burns, 1973).

This conflict between the benefits of tannin to the grower and the deleterious effects of tannin for the consumer should lead to a reflection of tannin content in the price paid for the grain. However, analytical procedures to quickly and accurately determine tannin content have not been available. The current method of tannin "analysis" used by grain elevators consists of soaking the grain in bleach and alkali to remove the pericarp, so that the testa (if present and colored) becomes visible. If a testa is seen, the grain is assumed to contain high amounts of tannin. The method is subject to error because of interference in some varieties by plant pigments, the color of which may persist through the bleach test and make identification of a testa ambiguous, and because there is not an absolute correlation between the presence of a colored testa and the deleterious nutritional effects ascribed to tannins. For example, the grain of IS 2319 has a clearly identifiable testa, yet results of a feeding trial showed it to be superior to three low tannin varieties without a testa (Oswalt, 1975). The method also is unsatisfactory because it is not quantitative.

The method of quantitative analysis for tannins that has become most widely used for sorghum grain in the laboratory is the vanillin test (Burns, 1971). This test is not convenient for use at the grain elevator because it involves an overnight extraction and at least minimal laboratory facilities.

In this paper, a new analytical procedure is described which can be used, without instrumentation, to provide a rapid and convenient visual estimation of the quantity of tannin present in sorghum grain. In variations of this test, which can be completed in 1–10 min, the yellow color changes to shades of green and blue with increasing tannin content. For more precise determination of tannin content by those without a laboratory, a simplified procedure requiring only a fixed wavelength colorimeter, some basic glassware, a grinder, and reagents has been devised. Several samples can be determined in an hour. An even more precise spectrophotometric procedure is described which requires about 20 min for analysis in the laboratory. A new method is suggested to differentiate between large polymeric tannins and simple flavanoids, anthocyanidins, and small polymers. An essential modification of the

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