THE NUTRITIONAL VALUE OF SHELLFISH

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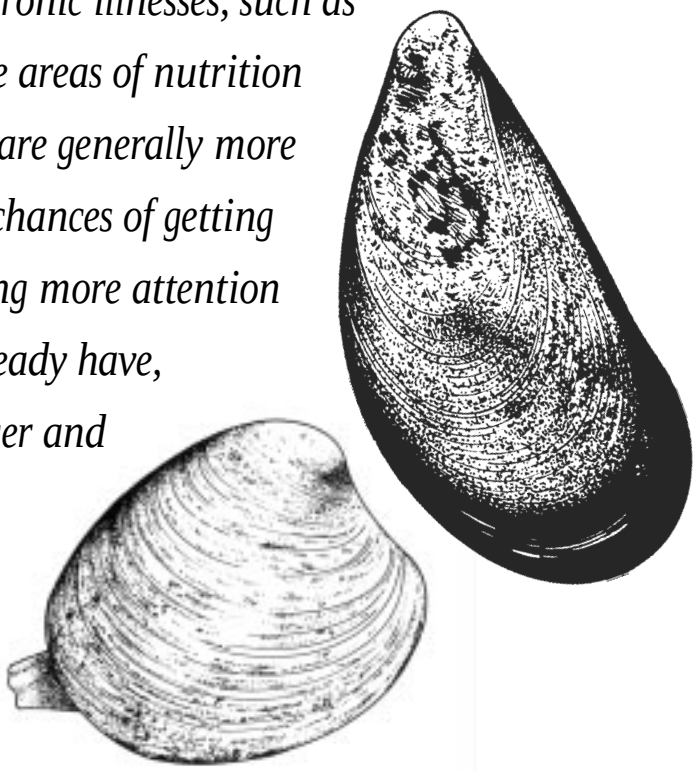
Maintaining good health and a sense of well-being are top priorities for many people today. Both health and well-being are strongly related to diet. The relationship of diet to overall health and the effect of diet on the incidence of certain chronic illnesses, such as heart disease and cancer, continue to be active areas of nutrition research. Compared to the past, people today are generally more careful in managing their diets to reduce the chances of getting life-threatening diseases. People are also paying more attention to better managing any diseases they may already have, and to changing their lifestyles to sustain longer and healthier lives. Based on current dietary recommendations, this paper examines whether shellfish should be included in a healthful diet.



CURRENT DIETARY RECOMMENDATIONS

The traditional definition of "good health" was merely the absence of disease and of any physical symptoms of nutritional deficiencies. This has been replaced by the current definition: a state of well-being and increased resistance to chronic diseases. Americans are experiencing a high incidence of several chronic diseases, many of which can have negative physical, emotional, financial, psychological, and social impacts on their lives. These diseases, which include heart disease, hypertension, cancer, diabetes, and obesity, are multifactorial in nature and are usually affected by several lifestyle habits, genetic predispositions, and environmental factors, in addition to diet.

Dietary recommendations have been published most recently by the U.S. Department of Agriculture, (Dietary Guidelines for Americans 2000) and the Nutrition Committee of the American Heart Association (AHA Dietary Guidelines Revision 2000). Both publications state that individuals should maintain an appropriate, healthy body weight; consume a variety of fruits, vegetables, and grains daily; and limit the intake of foods that are high in saturated fat and cholesterol. As a substitute for foods with high cholesterol and saturated fat, the publications recommend that people consume unsaturated fat from vegetables, legumes, nuts—and fish. Dietary Guidelines for Americans (2000) specifically recommends choosing 2 to 3 servings daily of lean poultry, other lean meats, beans, nuts—or, again, fish and shellfish.

General dietary guidelines recommended by many nutrition experts are to consume 50 percent to 60 percent of total calories from complex carbohydrates, such as whole grains, fruits, and vegetables; 10 percent to 20 percent from protein obtained from food sources that, together, provide high quality protein; and less than 30 percent of the calories from fat (Table 1). Experts further recommended that less than 10 percent of the calories from fat consist of saturated fats (such as those found in untrimmed red meat). Up to 10 percent of the calories from fat should come from polyunsaturated fats (such as those found in vegetable oils and marine fish oils), and 10 percent to 15 percent from monounsaturated fats (such as those found in olive oil, peanut oil, walnuts, and avocados).

Although the typical consumer tends to be more conscious of the cholesterol content of foods, it is the level of saturated fat intake that should be scrutinized and monitored closely. Both biochemical and clinical evidence support a close relationship between high dietary saturated fat intake and elevated blood cholesterol levels, which can put a person at higher risk for heart disease. However, a strong relationship between dietary cholesterol intake and blood cholesterol levels in the general population has not been established.

Table 1. Recommended diet

• Total fat	less than 30% of total calories
–Saturated	less than 10% of total calories
–Polyunsaturated	up to 10% of total calories
–Monounsaturated	10% - 15% of total calories
• Carbohydrate	50% - 60% of total calories
• Protein	10% – 20% of total calories
• Cholesterol	less than 300 mg/day
• Total calories	to achieve and maintain ideal body weight

SHELLFISH: A HEALTHFUL ADDITION TO A BALANCED, LOW-FAT DIET

Both the amount of fat and the proportions of saturated, monounsaturated, and polyunsaturated fat in shellfish contribute to a healthful diet. Beef and pork can contain over 40 percent of the calories from fat. Shellfish such as shrimp, clam, scallop, lobster, crab, and abalone contain 15 percent or fewer calories from fat (Figure 1). Even oyster, mussel, and geoduck meats contain approximately 20 percent to 28 percent calories from fat. The types of fat in shellfish are also favorable.

Although most foods contain some saturated, monounsaturated, and polyunsaturated fat, the proportions of these fats may differ (Figure 2). The fat in land animal meats, such as beef, lamb, and pork, and also the fat in some tropical oils, including coconut oil, contain high levels of saturated fat. Other foods, such as salmon and shellfish, usually contain high levels of polyunsaturated fat. If the fats from chicken, beef, oyster, and clam meats are compared, it is apparent that the proportions of polyunsaturated fat are higher and the proportions of saturated fat are lower in shellfish than in beef and chicken.

Shellfish also provide high quality protein with all the dietary essential amino acids for maintenance and growth of the human body. For this reason, shellfish should be considered a low-fat, high-protein food—one that can be included in a low-fat diet.

Figure 1. Percent calories from fat

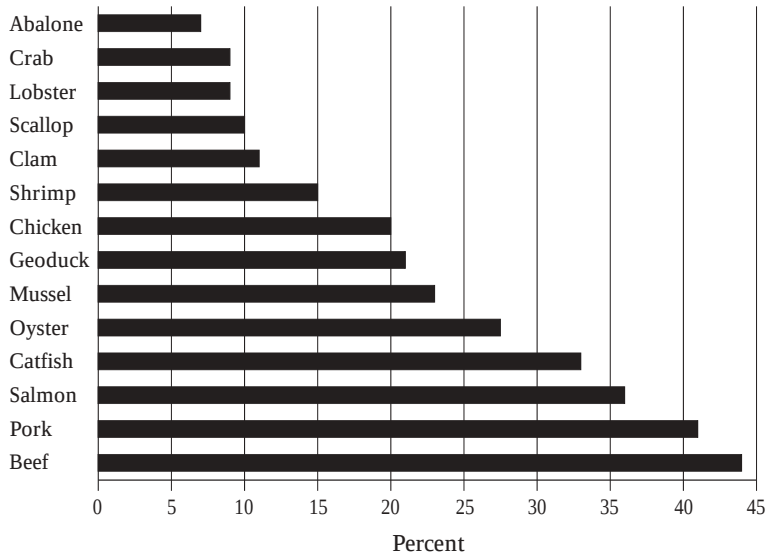
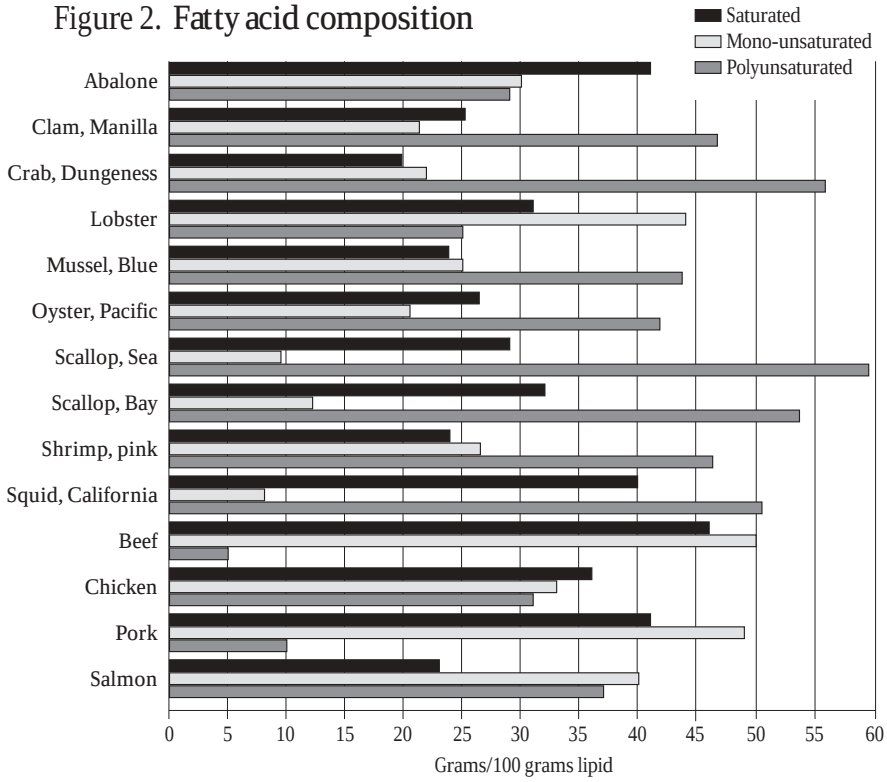


Figure 2. Fatty acid composition



From King et al. (1990) and USDA website (see references)

SHELLFISH HAVE SOME OF THE "GOOD" FATS

Salmon and other fatty fish are rich sources of the "good" fats called omega-3 fatty acids. Shellfish also contain significant amounts of these fats. The interest in omega 3-fatty acids grew in the early 1970's, after studies of the Greenland Inuit people were published. The studies reported that compared to Danes, the Greenland Inuit had a healthier clinical profile: a much lower incidence of heart disease, lower total plasma cholesterol, lower low density (bad) lipoprotein (LDL) in the blood, higher high density (good) lipoprotein (HDL) in the blood, and lower plasma triglycerides (Nettleton 1995). Studies reported that the Greenland diet was very high in omega-3 fatty acids (Figure 3), and, since then, research has reported that these fatty acids appear to have a wide range of functions (Table 2). A diet low in both total fat (less than 30 percent of total calories from fat) and saturated fat combined with regular consumption of fish can contribute to improving the blood lipid profile, reducing the risk of blood clots and lowering blood pressure, especially in people with hypertension or atherosclerosis (Whitney and Rolfes 1999).

Although salmon is one of the richest sources of omega-3 fatty acids, even the lower levels in shellfish (Table 3) will contribute to the overall recommended intake of approximately 2 grams of omega-3 fatty acids per day (the Canadian Recommended Nutrient Intakes is 0.5 percent of total calories; Whitney and Rolfes 1999). The omega-3 fatty acid contribution of seafood is in contrast to beef, chicken, and pork which have undetectable levels of omega-3 fatty acids. If the shellfish is cooked until done but not overcooked, then omega-3 fatty acids are usually preserved.

Table 2. Functions of omega-3 fatty acids

- Aids in the development and function of brain, retina, sperm
- Aids in the formation of compounds that have hormone-like properties
- Plays a role in inflammation, blood pressure maintenance, blood clotting

Figure 3. Structures of two common omega-3 fatty acids

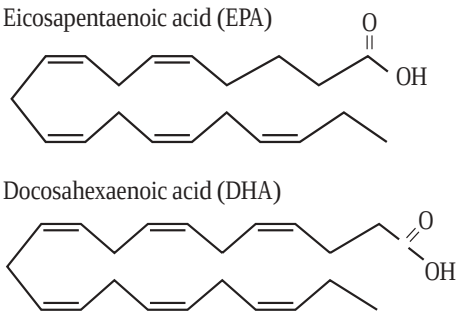


Table 3. Concentrations of EPA and DHA

	grams/100 grams edible portion
Salmon, sockeye	1.17
Mussel, blue	0.84
Clam, Manila	0.67
Oyster, Pacific	0.60
Squid, California	0.52
Crab, blue	0.40
Crab, Dungeness	0.38
Shrimp, pink	0.36
Snapper, mixed species	0.31
Catfish, channel	0.27
Scallop, bay	0.27
Scallop, sea	0.23
Lobster, northern	0.20

Sources: King et al. (1990), Raper et al. (1992), USDA web site www.nal.usda.gov/fnic/foodcomp/

WHAT ABOUT THE CHOLESTEROL IN SHELLFISH?

Cholesterol is essential in the body because it is used to make important compounds such as bile acids (which help to digest fat in the intestine), sex hormones, and vitamin D. The liver in the human body makes about three to four times as much cholesterol (approximately 1,500 milligrams per day) than is consumed in the typical American diet (approximately 400 milligrams per day; Whitney and Rolfes 1999). Dietary cholesterol can increase blood LDL cholesterol levels, although to a much lesser extent than dietary saturated fat. The responses of blood lipids to either dietary saturated fat or dietary cholesterol vary widely among individuals. Although most animal products high in saturated fats are also sources of dietary cholesterol, there are some foods like squid and egg yolk that are low in saturated fat but have a fair amount of cholesterol. In general, consumers should be advised to concentrate more on reducing *total* and *saturated* fat in the diet, rather than focusing only on reducing the amount of dietary cholesterol, because saturated fats contribute the most to increases in blood cholesterol and, hence, to increased risk of heart disease (Sizer and Whitney 2000).

When examining the cholesterol content of shellfish, it is important to also measure the other sterols that may be present. Shellfish in general are low in fat, and some, notably squid, contain a high concentration of cholesterol. However, non-cholesterol sterols (also known as plant sterols or phytosterols) are found in herbivorous mollusca, such as clams and scallops (Table 4). These non-cholesterol compounds are absorbed from the intestine, and can actually decrease the absorption of cholesterol in humans (Childs et al. 1987), and therefore can have a positive effect on health. Previously it was thought that shellfish contained high levels of cholesterol because the non-cholesterol sterols could not be differentiated from cholesterol. With a new laboratory technique called gas chromatography, the different types of sterols can now be identified and the amounts measured. Aside from shrimp and squid, the shellfish in Table 4 have cholesterol concentrations of less than 80 milligrams per 100 grams (edible portion) and, therefore, can be consumed by people trying to limit their dietary cholesterol intakes. It should be noted that shellfish are low in fat, including saturated fat, and can contribute significantly to a low-fat diet.

Table 4. Types of sterols in shellfish

milligrams/100 grams shellfish

Item	Cholesterol	C-26 sterol	Brassicasterol	7-dehydrocholesterol	Campesterol	Stigmasterol	β-sitosterol	TOTAL
Clam, Manila	36	25	47	33	8	3	3	155
Crab, Dungeness	72	—	6	—	—	—	—	78
Mussel, blue	37	21	18	16	8	3	4	107
Oyster, Pacific	48	12	19	—	31	6	8	124
Scallop, sea	27	12	21	25	4	—	8	97
Scallop, bay	37	13	20	19	4	4	10	107
Shrimp, pink	147	—	10	—	—	—	—	157
Squid, California	231	—	—	—	—	—	—	231

From King et al. (1990)

DO SHELLFISH CONTRIBUTE MINERALS AND VITAMINS TO THE DIET?

Shellfish are rich in several nutrients that are needed in the body. Iron is a dietary essential mineral in the heme molecule of hemoglobin, the component of the red blood cell that carries oxygen in the bloodstream. People who do not eat enough iron can suffer from iron-deficiency anemia. Worldwide, iron-deficiency anemia is the most common nutritional deficiency (Centers for Disease Control and Prevention 1998). In developing countries, about 33 percent of children and women of childbearing age have iron-deficiency anemia (West 1996). Iron-deficiency anemia is less prevalent in the United States, affecting about 10 percent of toddlers, adolescent girls, and women of childbearing age (Centers for Disease Control and Prevention 1998; Whitney and Rolfes 1999). Several kinds of shellfish are rich sources of iron (Table 5): clams in particular have enough iron in 100 grams to almost meet the recommended daily intake for women and exceeds that for men. Oysters, mussels, abalone, and shrimp also contribute significant amounts. Although beef and other red meats are often touted as rich iron sources because of the presence of heme iron, it is reasonable to assume that the iron in shellfish should also be easily absorbed.

Zinc is also necessary for a healthy diet. This mineral helps with immune function and is essential for healing of wounds, sperm production, taste perception, fetal development, growth and development of children, and to make heme for hemoglobin (Whitney and Rolfes 1999). A recent government survey showed that nearly 2 in 3 women ages 60 years and older get less than 75 percent of the recommended intake of zinc, and more than 1 in 4 women gets less than 50 percent of the recommended intake (Tufts Newsletter 2000). An examination of the zinc content in shellfish reveals that oyster meat is a very rich source. A 100-gram serving will provide more than the recommended daily zinc intake for both men and women (Table 6).

Copper is also an essential mineral in the diet because it helps to form hemoglobin and collagen (a ubiquitous protein in the body) and assists in reactions that lead to the release of energy by the body (Whitney and Rolfes 1999). The copper concentrations in shellfish (Table 7) indicate that the meats of squid, lobster, oyster, and several other shellfish are excellent dietary sources of copper.

Table 5. Iron concentrations
(milligrams/100 grams)

Clam	14.0
Oyster	5.1
Mussel	4.0
Abalone	3.2
Shrimp	2.4
Beef	2.0
Chicken	0.7
Salmon	0.6

Recommended daily intake:
Females–15 milligrams
Males–10 milligrams

Table 6. Zinc concentrations
(milligrams/100 grams)

Oyster	16.6
Crab	4.3
Beef	4.1
Lobster	3.0
Mussel	1.6
Squid	1.5
Clam	1.4
Shrimp	1.1
Chicken	0.8

Recommended daily intake:
Females–12 milligrams
Males–15 milligrams

Table 7. Copper concentrations
(milligrams/100 grams)

Squid	1.9
Lobster	1.7
Oyster	1.6
Crab	0.7
Clam	0.3
Shrimp	0.3
Abalone	0.2
Mussel	0.1

Recommended daily intake:
1.5 – 3.0 milligrams

Vitamin B_{12} helps the body to maintain sheathes around nerve fibers and to make red blood cells. It is found exclusively in animal products and in vitamin B_{12}-fortified plant products, such as meat replacements (Whitney and Rolfes 1999). Generally, it is not difficult to get enough vitamin B_{12} in the diet. Typically, B_{12} deficiencies are observed among vegetarians who avoid all animal products and don't take vitamin B_{12} supplements. Vitamin B_{12} deficiencies are also observed among the elderly, who may not have enough acid in their stomachs to release vitamin B_{12} from food and allow it to bind to the carrier that aids in absorption of the vitamin (Whitney and Rolfes 1999). A 100-gram serving of clam, oyster, mussel, crab, and several other shellfish meats will provide more than the recommended daily intake of this vitamin (Table 8).

Table 8. Vitamin B_{12} concentrations

(micrograms /100 grams)

Clam	49.0
Oyster	16.0
Mussel	12.0
Crab	9.0
Salmon	4.0
Beef	2.1
Scallop	1.5
Squid	1.3
Shrimp	1.2
Chicken	0.4

Recommended daily intake: 2.4 micrograms

Table 9. Benefits of shellfish in the diet

- Low in saturated fat
- Contain omega-3 fatty acids
- Especially good sources of
  – High-quality protein
  – Minerals: iron, zinc, copper
  – Vitamin B_{12}

SUMMARY

Increased intake of a variety of shellfish should be encouraged to provide a healthy diet (Table 9). Shellfish are low in fat, especially low in saturated fat, contain the omega-3 fatty acids, are excellent protein sources, and are especially good sources of iron, zinc, copper, and vitamin B_{12}.

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REFERENCES

AHA Dietary Guidelines. Revision 2000. A Statement for Healthcare Professionals from the Nutrition Committee of the American Heart Association. Ronald M. Krauss, Chair, AHA Dietary Guidelines Committee; Robert H. Eckel, Chair, Nutrition Committee. *Circulation* 102 (18): 2284.

Centers for Disease Control and Prevention. Recommendations to prevent and control iron deficiency in the United States. 1998. Morbidity and Mortality Weekly Report (April supplement) 47:3.

Childs, M.T., C.S. Dorsett, A. Failor, L.Roidt, and G.S. Omenn, 1987. Effects of shellfish consumption on cholesterol absorption in normolipidemic men. *Metabolism* 36: 31.

Dietary Guidelines for Americans. 2000. U.S. Department of Agriculture, Fifth Edition, 2000. *Home and Garden Bulletin* No. 232. 39 pp.

King, I., M. T. Childs, C. Dorsett, J. G. Ostrander, and E. R. Monsen. 1990. Shellfish: proximate composition, minerals, fatty acids, and sterols. *J. Am. Diet. Assoc.* 90: 677.

Nettleton, J.A. 1995. *Omega-3 Fatty Acids and Health*. Chapman and Hall, New York. 359 pp.

Raper, N.R., , F. J. Cronin, and J. Exler. 1992. Omega-3 fatty acid content of the U.S. food supply. *J. Am. College Nutr.* 11(3): 304.

Sizer, F. and E. Whitney. 2000. *Nutrition, Concepts and Controversies*. Eighth edition. Wadsworth/Thomson Learning, Belmont, CA. 567 pp.

Tufts Newsletter. Jan. 2000.

USDA. United States Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory, www.nal.usda.gov/fnic/foodcomp/

West, C.E. 1996. Strategies to control nutritional anemia. *Am. J. Clin. Nutr.* 64: 789.

Whitney, E.N. and S. R. Rolfes. 1999. *Understanding Nutrition*. Eighth edition. West/Wadsworth, Belmont, CA. 647 pp.

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