Excess Nutrients

John E. Vanderveen*

It is generally conceded today that diet has a profound effect on long-term health (Surgeon Gen. Report on Nutrition and Health, 1988). The life expectancy in western countries has risen constantly during this century; this has been largely attributed to improved nutrition, especially during early childhood, and improved medical care. As late as the 1930's, nutritional deficiencies were common among large segments of the U.S. population and caused both morbidity and mortality. Studies of military service inductees during the early 1940's showed that some young men and women were deficient in one or more nutrients. Today, for the most part, nutritional deficiencies have been eliminated, and the health of the younger population segments has improved substantially in the past 50 years. But as the mean age of our population increases, we have become aware that more individuals are being affected with so-called degenerative diseases which have diminished substantially the quality of life for many in our population. The causes of these diseases, which include coronary heart disease, cancer, stroke, osteoporosis and kidney disease, are multifactorial and diet has been implicated as a significant factor. The observation that all these diseases or even some of these diseases are not observed in all individuals consuming the same diets is explained by the multifactorial nature of the etiology of these diseases.

The term "multifactorial" implies that either more than one condition must be present before the disease is manifested or that one or more conditions can cause manifestation independently. It is the purpose of this presentation to review some of these diet-disease relationships in which excess nutrient consumption is known to be implicated. The term "nutrient" as used in this discussion includes both dietary essential elements and substances as well as other constituents of foods which can be digested, absorbed and metabolized.

It is now recognized that all essential nutrients become harmful if taken at a level some multiples above that of biological need. The tolerance for excess amounts of essential nutrients varies with each nutrient, the age of the individual, nutritional status and other conditions. For example, fat-soluble vitamins A and D become toxic for most individuals at levels of 5 to 10 times the Recommended Dietary Allowance (RDA) established by the National Academy of Sciences (1980), whereas the tolerance for excess amounts of water-soluble vitamins may be more than 100-fold the RDA, as in the case of biotin. However, harmful effects may be lower for some individuals under certain conditions, such as in the case of vitamin A excess during pregnancy (Hathcock et al., 1989). For years it was assumed that water-soluble vitamins such as pyridoxine (vitamin B6) could be consumed at very high levels with no harmful effects. Recently, however, it has been shown that long-term consumption of less than 100-fold can cause numbness in fingers and toes (Schaumberg et al.,1983).

Similarly, for most individuals excess iron intake over long periods at levels two or three times the RDA poses no problem; however, for individuals with the genetic condition known as hemochromatosis, these levels of iron can become life-threatening with time. Fortunately, a diet composed of a variety of foods will not normally contain harmful amounts of essential nutrients. Most instances of harmful effects associated with excess amounts of essential nutrients have been caused by inappropriate use of supplements. However, it is important to realize that foods with high levels of essential nutrients can also cause a problem when such foods are consumed as a major part of a diet. For example, there have been cases of vitamin A toxicity in infants caused by feeding large amounts of chicken liver (Mahoney et al., 1980). In those instances, vitamin A was present naturally. There have also been instances of toxicity caused by over-fortification as well (McCormick, 1988). The addition of excess nicotinic acid to foods is readily apparent because of the immediate appearance of symptoms such as flushing, heart palpitation and intense itching. Although these effects are not considered serious, long-term consumption may cause liver damage. Another example of an instance where fortification resulted in toxicity involved the addition of vitamin D to milk powders (Lightwood et al., 1956). Such an instance was reported to occur in Great Britain in the mid-1950's and resulted in 216 reported cases of infantile hypercalcemia. The infants also had a loss of appetite, failed to thrive and lacked normal activity. These cases of nutrient toxicity are cited for illustrative purposes only and it is not the intent here to provide a full discussion of the toxicological consequences of excess essential nutrient intake. In-depth reviews of nutrient toxicities have been published in the open literature.

For the past two decades, a major focus of nutrition research has been the relationship between nutrient excess and the development of the so-called degenerative diseases. These relationships were first explored using epidemiological techniques which resulted in the establishment of associations between the consumption of certain foods and/or food constituents and the incidence of disease. Such epidemiological studies do not provide proof of a relationship between diet or dietary components and a disease. However, they can be used for the development of hypotheses for experimental research or clinical studies with various levels

*J.E. Vanderveen, Division of Nutrition, Food and Drug Administration, 200 'C' Street, S.W., Washington, DC 20204

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of controls. These controlled studies can provide more substantial evidence for the hypothesis or the null hypothesis. Among the nutrients having the highest association between high levels of intake and the incidence of disease are sodium, total fat, saturated fat and cholesterol (Surgeon Gen. Report 1988). It is important to indicate that there is insufficient data to establish proof that excess levels of these nutrients cause any degenerative diseases in humans. Furthermore, it is likely that proof may never be established for some nutrient-disease relationships because studies cannot be accomplished which will provide the necessary data due to cost, ethics or other considerations. Therefore some lesser standard of association, such as substantial evidence, will have to be used for policy determination. With these considerations in mind, the following comments will indicate the evidence relating high intake levels of sodium, total fat, saturated fat and cholesterol to the incidence of degenerative diseases.

Sodium

Sodium is an essential nutrient with several physiological functions, the most critical of which is its role as the major extracellular cation in the maintenance of extracellular fluid volume. It has been widely demonstrated that sodium balance is readily maintained in healthy individuals over a wide range of intakes. For most individuals, consumption of one gram of sodium per day in temperate climates is adequate to maintain physiological function, (RDA, 1980). However, individuals who are exposed to very hot environments while performing heavy work will require two to three times that level. Many individuals consume as much as 10 grams of sodium per day without disturbing electrolyte balance (FASEB, 1979). What is of concern is that high sodium intakes may predispose some individuals to the development of hypertension. This hypothesis is largely based on epidemiological data which has shown a correlation between the sodium intakes of some populations and the incidence of hypertension (Surgeon Gen. Report, 1988). This hypothesis is strengthened by the fact that for more than 80 years sodium restriction has been found effective in lowering blood pressure of many individuals with hypertension. It is estimated that 30% of the adult population have elevated blood pressure and approximately half of these respond to a reduction of sodium intake. Further evidence for the sodium hypothesis is that studies in rats and chickens have demonstrated that salt loading can cause a rise in blood pressure over time. In addition, studies in rats, pigs and dogs have found that increased sodium can increase hypertension induced by mineralocorticoids (FASEB, 1979).

It is important to point out that other dietary and non-dietary factors are also associated with hypertension. These factors have given rise to new hypotheses concerning the etiology of hypertension. Nevertheless, it is prudent to consider the potential benefits and drawbacks of reducing the intake of sodium in the American diet. Most Americans take far more than the recommended 3 grams of sodium recommended as the upper limit of the safe and adequate range established by the National Academy of Sciences (Pennington et al., 1986). Therefore, a reduction in sodium intake for those individuals consuming more than 3 grams of sodium down to 3 grams would have no risk from a physiological perspective. Sodium in the form of sodium chloride (salt) is added to processed meats and some other foods to aid in preservation by lowering the water activity. Complete removal of salt from these foods may increase the risk of harmful microorganisms contaminating these foods. However, some substitution with other substances which lower water activity is possible, and many foods have far more salt than is necessary to bring water activity into a safe range (Sebranek et al., 1983). Looking at the positive aspects, a reduction in sodium intake would benefit millions of hypertensive individuals who are salt-sensitive. Furthermore, if the hypothesis is correct that a high sodium intake is a risk factor for developing hypertension, then a reduction in sodium intake could potentially lower the risk of onset of hypertension in some individuals.

Total Dietary Fat, Saturated Fat and Cholesterol

A strong association exists between the level of total dietary fat intake and the risk for obesity, some forms of cancer, and gallbladder disease (Surgeon Gen. Report, 1988). Fat contributes twice as many calories per unit weight than either protein or carbohydrates. In addition, foods high in fat frequently are preferred to low-fat foods. It stands to reason that eating a high-fat diet will contribute to consumption of more calories than are being expended and, therefore, will contribute to obesity. Animal studies support epidemiological observations which show an association between high-fat diets and cancer, especially breast and colon cancer. It is not clear if this association is related to higher calorie intake, since it is known that obesity is also a risk factor for these forms of cancer (Surgeon Gen. Report, 1988).

Epidemiological studies as well as clinical studies provide consistent evidence that a high intake of saturated fat is associated with high blood cholesterol and increased risk for coronary heart disease (Surgeon Gen. Report, 1988). Conversely, lowering saturated fat levels reduces the level of blood cholesterol and reduces the risk of coronary heart disease. It is now believed that a more important indicator of risk of coronary heart disease is the ratio of high-density lipoprotein (HDL) to low-density lipoprotein (LDL) in the blood. HDL contains approximately 50% protein and less than 25% cholesterol. The amounts of HDL found in the blood are negatively correlated with the risk of developing atherosclerosis. LDL contains approximately 25% protein and over 50% cholesterol. LDL is the major cholesterol transport substance in the blood and the level is positively correlated with the risk of developing atherosclerosis (Surgeon Gen. Report, 1988). There has been extensive research in recent years on the effects of dietary saturated, monounsaturated and polyunsaturated fatty acids on the levels of HDL and LDL in blood. The results of these studies do not provide a clear understanding of the effects of the dietary levels of these three types of fatty acids on HDL and LDL blood levels nor has there been consensus on the effects of the individual fatty acids which compose these three groups. While dietary polyunsaturated fatty acids have been shown to reduce total blood cholesterol levels, the reduction of HDL cholesterol in some studies has been

greater than that of LDL cholesterol, (Kris-Etherton et al., 1988). On the other hand, studies on the effects of some dietary saturated fatty acids have been shown to increase the total blood cholesterol levels, but the increases were higher for HDL cholesterol. The picture is even more confusing in that, in one recent study, a diet high in stearic acid was shown to decrease total cholesterol and LDL cholesterol when compared with diets high in other saturated fatty acids (Bonanome and Grundy, 1988). High saturated fat diets have been shown to decrease hepatic LDL receptor activity.

Data on the impact of dietary cholesterol on blood cholesterol levels provide further complexity to the situation. Increased dietary cholesterol has been shown to increase blood cholesterol levels in some, but not all, individuals (Gordon et al., 1982). Decreased dietary cholesterol stimulates LDL cholesterol synthesis in the body and an increase in dietary cholesterol lowers the LDL cholesterol synthesis in some individuals (Linscheer, Vergroesen, 1988). Consequently, a diet high in saturated fat and low in cholesterol promotes high LDL cholesterol blood levels.

Considering the knowledge accumulated to date, the recommendations relative to dietary fat contained in the Dietary Guidelines adopted by the Departments of Health and Human Services (DHHS) and Agriculture (USDA) in 1985 continue to be prudent advice. These include a recommendation to avoid too much fat, saturated fat and cholesterol. This recommendation was carefully worded to be relevant to the entire population, and it draws attention to the reality that diets high in fat increase risk of disease. However, it lacks the quantification which consumers need for implementation. The lack of specific values is an indicator that more knowledge is needed before these two departments become satisfied that more specific guidance can be given to individuals at various levels of risk for developing degenerative diseases. Currently, part of this knowledge base is being assessed by the National Cholesterol Education Program (NCEP) (Ernst et al., 1988), which was created to assist in the prevention of coronary heart disease by reducing the prevalence of high blood cholesterol levels. The NCEP recommends that adults with blood LDL cholesterol levels above 130 mg per deciliter consume a diet that contains less than 30% of total calories from fat, less than 10% of total calories from saturated fat and less than 300 mg of cholesterol per day. For individuals with blood LDL cholesterol levels above 160 mg per deciliter, the recommendations are that the total dietary fat be less than 30% of calories, saturated fat less than 7% of calories and total cholesterol be less than 200 mg per day.

The implications of the relationship between dietary fat levels and the development of degenerative diseases to the meat industry are clear. Meat, poultry and dairy products provide the largest amount of the total fat and cholesterol in the American food supply. Animal-derived foods also contain large amounts of saturated fat and are the major sources of these fats in diets of many Americans. Although some vegetable oils, such as palm oil, contain a high percentage of saturated fats, the total consumption of these oils is very small compared to those fats from animal sources. Data from recent studies confirm earlier research findings that all saturated fatty acids are not equal in raising levels of serum cholesterol. These data indicate that stearic acid found in large amounts in red meats and dairy products is rapidly converted to a monounsaturated fatty acid once it is absorbed (Bonanome, Grundy 1988). It is important to recognize, however, that other saturated fatty acids are also found in high levels in foods derived from animals.

If Americans follow the advice to lower intakes of total fat saturated fat and cholesterol, it follows that animal products high in these constituents would be selected less frequently and portion sizes would be reduced. Such practices are not without other nutrition and health consequences. Animal products are important to the American diet in providing high-quality protein and many micronutrients. In particular, milk and other dairy products are the major source of bioavailable calcium. Red meats provide significant bioavailable iron as well as many other trace elements and vitamins. It is important, therefore, in maintaining the nutritional quality of the American food supply, to seek alternative approaches in lowering the total fat, saturated fat and cholesterol in these animal-derived products. The report of the Committee on Technological Options to Improve the Nutritional Attributes of Animal Products, Board of Agriculture of the National Research Council (1988), includes a thorough review of current approaches which are being studied. Many of these concepts clearly need more research, development and testing. However, implementation of proven options will mark the critical phase in maintaining and improving the nutritional quality of the food supply.

In keeping with recommendations made by the White House Conference on Food, Nutrition and Health (1969) and the recent National Research Council report, the Food and Drug Administration has continued to permit the marketing of foods which have been modified to lower fat, sodium and/or calories without requiring imitation labeling. Such foods are considered to be nutritionally equivalent to traditional foods provided they contain equal or greater amounts of all nutrients found in the traditional foods (Vanderveen, 1987). Currently, many substitute dairy and egg products which have lower fat, sodium and/or calories can be found in the marketplace.

Educational efforts by government, professional societies, public interest groups, and civic organizations have created strong interest on the part of consumers for products lower in fat, lower in saturated fat, lower in cholesterol and lower in sodium. Food manufacturers and retailers have found in recent years that claims for lower amounts of these nutrients in their products were effective in promoting sales. Consequently, efforts have been made to make sure that such information is not misleading to consumers and promotes honesty and fair dealing in the marketplace. The FDA has, therefore, strived to encourage the presentation of accurate information about the nutrient content of foods on the food label through the use of nutrition labeling and by defining adjectival descriptors for the levels of these substances in foods. In 1978, regulations were published which defined terms for calorie content of foods (Federal Register, 1978). In 1984, regulations were finalized which defined terms for the sodium content of foods regulated by the FDA (Fed. Register). In 1986, the Agency proposed definitions for terms used to describe cholesterol content in foods and the final regulation is expected to be published in the Federal Register in the near future. These descriptors are summarized in Table 1. Currently, proposed regulations on terms for fat content of

Table 1. Adjectival Descriptors Approved For Use in Food Labeling

Term	*Requirement*
Low calorie	No more than 40 calories per serving and less than 0.4 calories per gram.
Reduced calorie	At least one-third reduction in calories per serving.
Sodium free	Less than 5 milligrams per serving.
Very low sodium	140 milligrams or less sodium per serving.
Low sodium	140 milligrams or less sodium per serving.
Reduced sodium	At least a 75% reduction.
Cholesterol free*	Less than 2 milligrams cholesterol per serving.
Low cholesterol*	Less than 20 milligrams cholesterol per serving.
Cholesterol reduced*	At least 75% reduction.

*Terms proposed and not finalized.

foods are being drafted for consideration.

For years since the passage of the amendment to the Food, Drug and Cosmetic Act in 1938, the FDA has prohibited explicit health messages on food labeling. In 1984, a food manufacturer challenged Agency regulations, claiming that the consumer should be aware of information about food products which may affect their health. After careful consideration, the Agency published a proposal to permit truthful health messages about foods which are not misleading to consumers. This proposal received considerable comment from consumers, health professionals and industry. Their comments were both critical of the proposal and supportive of the potential benefits of providing consumers with needed information. The FDA has considered these comments and is preparing a final regulation.

Summary

In summary, it is clear that excess amounts of nutrients can have an impact on the long-term health of humans. Although much of the data which has been developed to support specific hypotheses of mechanisms for the impact of excess nutrients on health has been derived from epidemiological studies, prospective clinical studies have been supportive of these hypotheses. Products derived from animals are among the foods which contribute to excess nutrient consumption. These products also make valuable contributions to the nutritional quality of the American food supply. It is important, therefore, that efforts be undertaken to reduce the levels of such nutrients as total fat, saturated fat, cholesterol and sodium so that the quality of the food supply can be further improved.

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