Vitamins and Their Occurrence in Foods[1]

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INTRODUCTION

THE FIRST VITAMINS were discovered less than three decades ago but since then an almost phenomenal number of substances has been classified in this nutritionally important group. A complete listing at the present time would include as many as forty or more and there are indications of the existence of still others.

The presence of vitamins in foods was recognized from observations of the almost spectacular effect certain foods have on growth, function, and general well-being of the body. For centuries it had been known that the juice of limes or lemons would prevent or cure scurvy, but there had never been an adequate explanation of this relation. When it was demonstrated that a substance in the outer coating of the whole rice grain would cure or prevent the disease known as beriberi, and that butter and egg yolk contained a substance required for growth and for the prevention of a peculiar type of inflammation of the eye, it became apparent that foods contain certain substances other than protein, carbohydrate, fats, and minerals which are likewise essential for normal nutrition.

The substances in foods credited with these properties were distinguished by descriptive terms as the antiscorbutic, antiberiberi, and antiophthalmic factors, respectively, or on the basis of their solubility, as water-soluble C, water-soluble B, and fat-soluble A. When the name vitamin, from the term "vitamine" originally used for the antiberiberi substance, was suggested for them as a group they were designated vitamin C, vitamin B, and vitamin A. Since the chemical composition of the vitamins became known several of them have received names related to their chemical structure. Thus, vitamin C is now known as ascorbic acid, vitamin B_1 as thiamin, vitamin G or B_2 as riboflavin, and vitamin B_6 as pyridoxine.

For various reasons a number of the water-soluble vitamins have been grouped together as the vitamin-B-complex. Vitamin B_1 and vitamin G were the original members of this group which now in-

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cludes nicotinic acid and vitamin B_6 as well as five or six other factors not mentioned in this discussion.

The number of vitamins actually known to be essential in human nutrition is relatively small. The importance of vitamins A, B_1, and C in the diet is now well known. It is certain that vitamin D is a requirement of children; while it may be needed by adults as well, perhaps in lesser amounts, this is yet to be demonstrated. Evidence of the significance of riboflavin (vitamin G) in the diet of man has been obtained within the last few years, and we now have a clear picture of the external symptoms that follow the use of a diet deficient in this factor. Since the announcement in 1937 of the value of nicotinic acid in the cure of the disease in animals that is comparable to pellagra in man, considerable information has accumulated to establish the value of this substance as a pellagra-preventive. There is still some question as to whether nicotinic acid and/or nicotinamide can unreservedly be designated the pellagra-preventing or P–P factor or factors, but there can be no doubt that they are specific in their effect on certain symptoms of pellagra. The substance in foods, which is referred to as vitamin K, helps promote the clotting of blood, and the supposition now is that it functions in man, as well as in animals, in maintaining a normal level of prothrombin in the blood. An anemia which occurs in chicks given a diet deficient in vitamin K responds to treatment with extracts containing this vitamin.

These are the vitamins definitely known to be required by man. There is also considerable evidence in favor of two others, vitamin E and vitamin B_6. Vitamin E (alpha-tocopherol) has been shown to be important for normal reproduction in several species of animals and it may be required for successful reproduction in the human species as well. Both vitamin E and vitamin B_6 or pyridoxine are being actively investigated at the present time.

The importance of the vitamins to normal nutrition is now fully recognized although there is still a great deal to learn about these substances. In planning foods for the day it is essential to know how to select them for vitamin values as well as for their content of protein, carbohydrate, fat, and minerals. The purpose of this article is to give a brief and not too technical presentation of our knowledge of the properties and food sources of these vitamins. A brief description of the method of quantitative expression used for them and a table of values for vitamin A, Thiamin or vitamin B_1, Ascorbic Acid or vitamin C, and riboflavin content of common foods is also included.

PROPERTIES AND FOOD SOURCES

General Considerations

The most distinctive common characteristic of the vitamins is the fact that they occur in foods in almost infinitesimal quantities and are effective in the body in similarly small amounts. Beyond this they have little in common since they differ markedly both in their physical and chemical properties. Some are soluble in water while others dissolve only in fats and fat-solvents. Some are easily destroyed, especially at high temperatures and when oxygen is present, as when foods are heated in air. Others are fairly resistant to destruction by heat, even when heated for several hours at temperatures well above the boiling point of water. In the case of nearly all of them, however, destruction takes place more rapidly in alkaline than in acid solution.

In estimating the vitamin value of foods in the diet, it is essential to know and keep in mind the properties of the various vitamins in order to be able to take account of possible losses. Consideration of changes that occur in the vitamin content of foods during processes connected with preservation and preparation, such as storage, freezing, cooking, canning, and drying, is of as much importance as consideration of the vitamin content of the fresh or untreated food. A food which, in its original state, is a perfectly good source of one or more of the vitamins may have its content of one or all of these factors reduced to insignificance as a result of the treatment it undergoes during preparation for consumption. Loss of vitamin value may be brought about not only as a result of inactivation or destruction of the vitamins but also through their mechanical removal by solution, the vitamin passing out of the food material into the surrounding liquid.

While vitamins are found in foods of both plant and animal origin, plants—generally speaking—should be considered the primary sources, since animals depend upon plants for their supply of most of the vitamins. This does not mean that the substance responsible for vitamin value in plant tissue is always the same as that having a similar function in animal tissue. Vitamin A, for instance, does not occur in plants, the vitamin-A value of plants being due to certain orange-yellow substances called carotenoids. These are broken down in the liver of the animal so that vitamin A is derived from them, and for this reason the carotenoids are sometimes called the "precursors" of vitamin A.

It is now well known that foods show marked differences both in the kinds and amounts of vitamins they supply. Differences in the vitamin values of different foods do not constitute the only problem of variation that must be considered, however. There is the equally important matter of variation from sample to sample of a single food item. While it may generally be taken for granted that samples of a given food, selected at different times, will contain the same kind, or kinds, of vitamins, it does not necessarily follow that they will contain equal quantities of any kind. The idea must not be held with respect to any natural food—that it has a definite and fixed content of any vitamin—unless, perchance, it is zero.

The problem of sample variation in vitamin content of foods is responsible for some of the newer phases of vitamin research, especially in connection with studies related to food production. Some of the factors associated with this variation have been identified but there is still much to be learned. In foods of plant origin, variety in a given kind is very often an important factor in relation to vitamin content. Age and maturity of the product, its size, the amount and kind of fertilizer used in cultivation, the amount of moisture present in the soil, and the degree of exposure to sunlight may also have considerable influence. In foods of animal origin the breed of the animal from which the food comes, as well as its age and physical condition, is sometimes of significance, but the most important factors are the vitamin content of the animal's food and, in the case of vitamin-D value, the length of time the animal was exposed to sunshine. This sums up to the conclusion that values for vitamin content can in no sense be considered exact unless correlated with an adequate knowledge of the conditions that might have had an influence on them.

A point of considerable practical importance in dealing with vitamin values for foods is the fact that relative vitamin potency may easily be discussed by reference to food groups or food types. A diet can be planned on the basis of food groups rather than individual foods, thus lessening the tendency to place undue emphasis on one food that may have been shown to be very rich in a particular vitamin.

VITAMIN A

Functions. Vitamin A is essential to the normal structure of the epithelial tissue. This is the tissue of the skin. It also forms the lining membrane of the respiratory passages, the stomach and intestines, and other parts of the digestive tract, glands and ducts of glands. The cornea of the eyes and enamel of teeth also have their origin in this tissue. When the intake of vitamin A has been inadequate for some time, a change takes place in the structure of the epithelial tissue. The normal cells lose their property to secrete the substance that keeps the epithelium moist and the tissue becomes hard or keratinized. Fissuring presents areas for the lodgment and growth of bacteria.

Vitamin A is also needed for the formation of a pigment in the eye called visual purple. Visual purple is essential for vision in dim light and, when there is an insufficient amount of vitamin A in the eye for its formation, a person is unable to see readily when passing from bright light to dim light. This condition is called "night-blindness." Many traffic accidents are attributed to this nutritional defect which comes from the use of a diet that does not contain enough vitamin A for good nutrition. Because of this and in line with other defense measures relating to nutrition, aviators are given carotene, or other source of vitamin A, before going out on night flights.

Properties. Vitamin A belongs to the group of fat-soluble vitamins and is practically insoluble in water. The pure vitamin, prepared by freezing it out of solution, is a pale yellow, viscous, oily substance. It is not readily broken down by heat but is inactivated by oxidation, especially when heated in a medium where there is free access of oxygen.

As already explained, the vitamin-A value of foods of plant origin is due not to vitamin A, since this substance does not occur in plants, but to the presence of orange-yellow pigments called carotenoids—"precursors" of vitamin A. There are four of these substances: alpha, beta, and gamma-carotene, and cryptoxanthin. Beta-carotene is by far the most important and most widely distributed in natural food products. Cryptoxanthin occurs in only a few foods.

The carotenoids, like vitamin A, are soluble in fats and fat-solvents and are not readily inactivated by heat except as oxygen is present.

Food sources. The vitamin-A precursors may occur in any part of a plant-root, stem, leaf, flower, fruit, and seed. There is considerable variation, however, in the amounts present in foods of plant origin. Many contain them in abundance, and some carry only small amounts or none at all.

An orange-yellow color in foods of plant origin indicates the presence of one or all of the plant carotenoids from which vitamin A may be derived and furnishes a rough index of vitamin-A potency in many vegetables as well as in fruits. Carrots and sweet potatoes are outstanding examples of this relationship. This index holds good where there are yellow and white varieties of a given product. Yellow turnips, yellow peaches, yellow corn, and yellow tomatoes are sources of vitamin A, whereas the corresponding white varieties are not. To avoid confusion as to the application of these findings a word of caution seems advisable here. The fact of the presence of vitamin A in yellow varieties of foods is no reason for ignoring the white varieties. They may have values the yellow ones do not have. There is a place in the diet for all types of foods and there is little or no reason for consistently using certain ones and excluding others. Care should be taken to avoid applying factual information on food values in a fanatical way.

A yellow color is not invariably associated with vitamin-A potency, for there are yellow plant-pigments that do not yield vitamin A. A red color has no relation to vitamin-A value and is not indicative of it except that in some foods a red color may mask the orange-yellow of carotene. An example is the red-fleshed tomato containing carotene either in the flesh or the skin.

Experience has led to the recognition that a green color[2] in plants indicates vitamin-A value. Green leaves, and more especially thin green leaves like those of spinach, kale, dandelion, and leaf lettuce, are among the richest sources of vitamin A. Other green foods that are notable in this respect are green string beans and green peppers. The stems of asparagus, celery, and broccoli, and many other plants, may be appraised for vitamin-A value on the basis of greenness. Bleached parts of plants that would normally be green but do not have the green color, either because the chlorophyll never developed or because it was destroyed as in the case of winter cabbage, the inner leaves of lettuce, and the bleached stems of asparagus and celery have practically no vitamin-A value.

In general, roots and tubers may be accepted as low in vitamin-A value with the exception of carrots and sweet potatoes, as noted above. Seeds, including nuts, cereal grains, and legumes (peas and beans), are on the whole low in, or totally devoid of, vitamin-A value

2. Chlorophyll, the green coloring matter of plants, does not itself form any part of vitamin A, but the high concentration of this vitamin in parts of the plant where chlorophyll functions has led to the suggestion that it may play a role in the formation of the vitamin. Vitamin-A potency in other parts of the plant would in that case be due to substances transported to them for storage.

unless they have some green or yellow color as peas and yellow corn.

Vegetable oils contain little or no vitamin A.

Among the foods of animal origin, eggs and milk are important sources. The hen and the cow do not convert all of the carotene obtained from their feed into vitamin A hence eggs and milk contain both vitamin A and carotene. In both cases the proportion of vitamin A is much higher than that of carotene. The ratio between the quantities of these two substances in milk from different breeds of cows may be significantly different, some breeds, for instance, consistently giving milk that contains a higher proportion of carotene than others. Since vitamin A is soluble in fat and only slightly, if at all, soluble in water, the vitamin-A value of the egg is in the yolk and that of milk is in the cream. Butter is an important source of vitamin A, and other milk products, such as cheese, contain it in proportion to the quantity of milk-fat present.

Eggs and milk show wide variations in vitamin-A value. The total quantities of both vitamin A and carotene in eggs and milk are influenced by the quantities present in the feed of the respective animals producing these foods. During the summer months, when green feed is available, milk and eggs may show radically higher values than during other months of the year. However, present-day feeding practices, by the use of feeds of high vitamin-A value throughout the year, tend to eliminate seasonal variation.

In contrast to its precursors, the carotenoids, vitamin A has very little color. Inasmuch as milk and eggs contain both carotene and vitamin A, color is of little value in judging their vitamin-A potency. This is especially true of eggs. If the hen derived vitamin-A value from green feed or products rich in carotene, the yolk of the eggs will be deep yellow in color and will have a high vitamin-A value. If the hen did not have access to green feed or other highly colored food, but was given feed containing cod-liver oil, which contains vitamin A but not carotene, then the yolk of the eggs will be very light in color and still will be rich in vitamin A.

Meats vary considerably in their vitamin-A value since much more of this factor is stored by some tissues than by others. Liver, especially, retains large amounts of it when there is an abundance of the vitamin in the diet, which makes it a rich food-source, but from the standpoint of cost it can hardly be considered an important one. Glandular organs, other than liver, contain fairly large amounts of the vitamin but, like liver, they are available in limited quantities. Lean muscle meats contain only small quantities of vitamin A.

Losses of Vitamin-A Value. Vitamin A and its precursors are not greatly affected by any of the processes connected with food preservation and preparation unless there is considerable chance for oxidation. Foods that are stored show a loss only after prolonged storage. This is greatest in foods that have been dried preparatory to storing, such as dried grasses and dried fruits. Even though such foods were good sources to begin with, they may lose as much as 50 percent of their vitamin-A value in a few months' time. Boiling and steaming cause practically no diminution in vitamin-A content. Losses have been noted as a result of baking but they are not serious; in roasting, destruction of vitamin A is appreciable.

As would be expected, there is little or no loss of vitamin A when foods are canned. During storage the vitamin-A content of canned foods may decrease but this change takes place gradually and usually is not appreciable up to nine months.

VITAMIN B_1 (THIAMIN)

Functions. Vitamin B_1 prevents and cures beriberi or polyneuritis—a condition thought to be due to changes in the nerve tissue. Vitamin B_1 also functions as the active part of an enzyme which enables the body to obtain energy from carbohydrates, starches and sugars. The body is unable to break down the carbohydrates completely and thus obtain energy from them unless it has vitamin B_1 in adequate amounts. Without sufficient amounts of vitamin B_1 there is an accumulation of pyruvic acid, one of the products of carbohydrate metabolism, in the tissues, especially brain tissue, which may account for some of the symptoms in vitamin B_1 deficiency. The amount of vitamin B_1 required for good nutrition is thus related to energy expenditure or the work a person does and to the relative proportion of carbohydrate and fat in the diet serving as the source of energy.

An adequate supply of vitamin B_1 for the mother is very important both before the birth of her baby and while she is nursing him.

Properties. Vitamin B_1 is a white crystalline material that is soluble in water. In plants it seems to exist in relatively simple combination and may be removed fairly easily by extraction with water. In animal tissue it is present in more complex form combined with phosphate.

Vitamin B_1 is described as heat labile—that is, unstable when heated. Inactivation depends entirely, however, upon conditions under which it is treated. In acid solution it is relatively stable but in neutral or alkaline solution it is readily broken down, the rate of destruction being higher with increase in alkalinity, temperature, and time of heating. The rate of destruction of the vitamin is also higher, when it is heated in solution or in mixtures that are moist, than when heated in dry mixtures.

Food Sources. Vitamin B_1 occurs in practically all foods derived from plants with the exception of fats and oils, but there are very few concentrated sources. Vitamin B_1 values of foods seem to be less subject to the influence of conditions of production and are therefore somewhat more constant than other vitamin values.

The relatively low concentration of vitamin B_1 in foods, and the lack of sensitivity of the methods for measuring it, have not made it possible to determine its distribution in the different parts of plants as closely as in the case of some other vitamins. Seeds, including grains, nuts, and legumes, are known to be among the richest sources. In grains, the vitamin is concentrated in the embryo and outer covering. In the process of refining, these parts are largely removed, hence the importance in the diet of whole grain breads and cereals from the standpoint of vitamin B_1.

All fruits and vegetables contain some vitamin B_1. Although none of them is a rich source, they should be considered important sources since they comprise a part of all diets and are usually eaten in relatively large amounts. Potatoes should be considered especially in this respect.

Milk is a good source of vitamin B_1 in that it is generally consumed without having been subjected to treatment other than pasteurization which entails little loss of the vitamin. Eggs are also a good source, the vitamin being in the yolk.

Meats should probably be rated as good sources of vitamin B_1, although information concerning this is not very complete. For reasons not yet determined pork has a vitamin-B_1 content two or three times greater than other meats, and the dark meat of chicken may be richer than the light meat. Glandular organs, liver and kidney for example, are somewhat richer than muscle meats.

Fats and oils do not contain vitamin B_1.

Losses of Vitamin B_1. In considering loss of vitamin B_1 in foods it is essential to keep certain facts clearly in mind: (1) the vitamin is soluble in water; (2) it exists in foods in different combinations which may have a bearing on the ease of removal and also on its destruction; and (3) inactivation of the vitamin depends upon conditions,[3] and the quantity destroyed cannot very well be expressed by a definite percentage but is more a matter of rate or destruction.

When foods are cooked by boiling, the proportion of vitamin B_1 destroyed is relatively small up to cooking periods as long as one hour, and generally does not exceed 10 to 15 percent unless the food is distinctly alkaline or has been made so by the addition of soda. The loss by solution, on the other hand, may be considerable, depending, in addition to other factors noted, upon the proportion of water used. Larger amounts of water remove more of the vitamin. The proportion of vitamin B_1 found in water in which food has been cooked has been reported as high as 50 percent of that originally present in the food. If this water is used, there will be little loss of the vitamin.

Baking causes only slight, if any, destruction of vitamin B_1, but the higher temperature and longer time required for roasting results in appreciable destruction.

In canning there is apparently no loss of vitamin B_1 from processing, the greatest loss taking place during blanching or other procedures where there is a chance for solution. There are very few data to support a statement concerning the effect of storage on vitamin B_1 in canned foods. Losses noted were determined after about six months' storage and ranged around 40 percent.

Practical information on the inactivation of vitamin B_1 in foods during drying is almost entirely lacking. The vitamin seems to be retained fairly well by foods dried at a temperature of 60° C. but at higher temperatures destruction is probably considerable.

VITAMIN C (ASCORBIC ACID)

Functions. Vitamin C prevents scurvy. In this nutritional deficiency disease there is a failure in the cementing substance of the connective tissue which holds parts of structures together. The walls of the blood vessels become thin and fragile. This is evidenced by gums that bleed easily and in severe deficiency, hemorrhages may occur in muscles and joints, especially in areas close to the skin. The teeth also become fragile and are loose and easily removed from their sockets.

3. Acid solutions containing vitamin B_1 have been heated as long as one hour at 120° C. without appreciable deterioration of the vitamin. In slightly alkaline solutions losses approximated 30 percent during one hour of heating at the boiling point of water. Dry mixtures containing vitamin B_1 have been heated at 100° C. for as long as forty-eight hours and have shown no detectable change in their vitamin-B_1 content.

Vitamin C is not stored to any great extent in the body, hence an adequate supply in the diet every day is essential.

Properties. Vitamin C in its pure form is a white-crystalline material with an acid taste and is readily soluble in water. It is inactivated by oxidation and the rate of destruction increases rapidly with increase in temperature. The degree of acidity of the mixture also has a marked influence on the stability of vitamin C. In an acid mixture like tomato juice it is destroyed only slowly, but in less acid solution the rate of destruction is much more rapid.

Inactivation of vitamin C by oxidation proceeds in two steps. By mild oxidative processes a substance called dehydro-ascorbic acid is formed. This substance, which functions in the animal body as vitamin C but does not respond to the usual chemical test, may be reduced to ascorbic acid. Under more drastic conditions of oxidation the vitamin is completely inactivated and its activity may not be restored.

Food Sources. Vitamin C may well be called the vitamin of fresh foods. This does not mean fresh from the market, but fresh from the plant or animal that produced the food. One authority has said, "with the exception of ripe seeds, practically all fresh foods of either plant or animal origin contain generous amounts of vitamin C."

Fruits and vegetables are, on the whole, the richest sources of vitamin C. There is a tendency, however, to limit the emphasis to fruits and vegetables that can be eaten raw, and more especially to the citrus fruits and tomatoes. Since these specific products are not only outstandingly rich sources of the vitamin but also retain their potency remarkably well during the various treatments to which they may be subjected, they have come to be considered almost essential in the diet. This tendency should probably not be encouraged to the extent of diverting attention from other fruits and vegetables that are equally important for vitamin C. In some localities, and at certain times of the year, other fruits and vegetables, if handled so as to conserve their vitamin-C value, might be more economical than citrus fruits or tomatoes.

Other fruits that may be considered important from the standpoint of vitamin-C content are strawberries, blueberries, and cranberries. Among the vegetables, peppers are outstanding in the quantity of vitamin C they contain. Cabbage and other members of the cabbage family, cauliflower and Brussels sprouts, turnips and rutabagas also contain large amounts. Vitamin C occurs in fairly

high concentration in all leaves such as spinach, collards, turnip greens, and water cress.

Variation in vitamin content according to variety has been studied more extensively with respect to vitamin C than for any of the other vitamins. Rather wide varietal differences have been shown for apples, tomatoes, oranges, and cabbage. In the case of oranges several other factors are known to influence vitamin-C content, making varietal differences as studied of lesser importance. Fully ripe fruit contains more of the vitamin than partially ripe fruit, and that exposed to sunlight is richer than that from the shaded side of the tree. The vitamin-C content of a given variety of orange decreases progressively as the season advances, although this change is less pronounced in some varieties than others. Conditions of cultivation also have an influence, but these are not as well defined as other factors. The extent of differences that exist in the vitamin-C content of oranges may be illustrated by values obtained in the Bureau of Home Economics, U. S. Department of Agriculture, Washington, D. C., on a dozen oranges examined individually. These oranges were of uniform size and appearance and were purchased at one time from a single bin in a store in Washington, D. C. The vitamin-C content ranged from 24 to 60 milligrams of ascorbic acid per 100 milliliters of juice.

Factors other than variety that may influence vitamin-C content have also been studied with apples and tomatoes. With apples, size is significant. In this fruit the vitamin is concentrated in the skin and in the flesh just under the skin. Since the proportion of skin to flesh is greater in small than in large apples, a small apple contains more vitamin C in proportion to its weight than a large one. In tomatoes there is a gradual increase in vitamin-C content as the fruit matures while, during the actual process of ripening, there may be a decrease.

Milk and meats should not be considered significant sources of vitamin C. Milk as it comes from the cow contains an appreciable amount, but this is inactivated rapidly as the milk stands. Meats are not important sources because whatever vitamin C they contain is destroyed during cooking. Eggs do not contain vitamin C.

Vitamin C is not present in fats and oils since it is soluble in water and not in fats.

Losses of Vitamin C. Loss of vitamin-C value from foods may occur as a result of inactivation by oxidation or removal of the vitamin by solution.

Consideration of losses from oxidation require mention, at least, of factors pertaining especially to this vitamin. Some fruits and vegetables contain substances called oxidases that accelerate the rate of inactivation of vitamin C by oxidation. These substances in turn are inactivated by heat and are destroyed in a short time when kept at the boiling point of water. Small amounts of copper coming from utensils and containers also catalyze, or hasten the oxidation of vitamin C. Some foods also contain within their tissues an amount of oxygen sufficient to be a factor in the oxidation process.

Deterioration of vitamin C begins in all foods as soon as they are removed from the environment in which they were produced. This is the reason for indicating carefully what is meant by "fresh foods" from the standpoint of vitamin-C content. The rate of inactivation of vitamin C in fruits and vegetables that are allowed to stand seems to depend upon their physical characteristics. Thin leaves like spinach lose vitamin C rapidly and may retain no more than 50 percent after standing two or three days. Peppers having a smooth compact outer covering show little loss. In apples the loss is gradual, and ripe tomatoes may be stored as long as ten days without detectable change in vitamin-C content. Rate of inaction in all such products increases with increase in temperature so that loss is less when they are kept under refrigeration.

In plant products inactivation is more rapid when the plant cells have been opened up so that the vitamin is exposed to oxygen. Decrease in vitamin-C content takes place in vegetables that are prepared for cooking or canning and then allowed to stand. Foods that are chopped or crushed lose vitamin C rapidly and may contain appreciably less of the vitamin after standing only a few hours. The rate of destruction of the vitamin is less, however, at low temperatures in such cases. Expressed juices like orange juice and tomato juice may be stored in covered containers at household refrigerator temperatures for as long as twenty-four hours with no detectable change in vitamin-C content. Rate of destruction after that time depends upon whether the oxidases have been previously destroyed by heating. Canned tomato juice, after the can is opened, shows little change in vitamin-C content after several days' storage in a refrigerator.

Heat markedly accelerates the rate of destruction of vitamin C and cooked foods are not dependable sources of this vitamin. Tomatoes are a notable exception since they are rich sources to begin with and, due to their high acidity, show loss of the vitamin only after

prolonged heating. In foods that contain oxidases, destruction of vitamin C during cooking is very rapid at first or until the temperature is reached at which the oxidase is destroyed, when it proceeds at a much slower rate. To preserve vitamin-C content during cooking, foods should be cooked quickly. They should also be served immediately since cooked foods lose vitamin C more rapidly when allowed to stand than do raw ones.

When foods are boiled, some of the vitamin C they contain may dissolve in the cooking water. This dissolved vitamin may be conserved, obviously, by using the water. The proportion of vitamin C destroyed in foods that are boiled averages 20 to 25 percent while 30 to 40 percent may be present in the cooking water, depending upon the amount used.

Foods that must be cooked at temperatures higher than that of boiling water do not retain enough vitamin C to require consideration.

Reduction in vitamin-C content from canning is less than in foods cooked by other methods since air is largely excluded during processing. Decrease in vitamin-C content is greater in foods that are preheated in an open kettle before they are put into the can than in those canned by the cold-pack method. Blanching may cause some loss of vitamin C through solution, but this procedure at the same time effects inactivation of any ascorbic acid oxidase present.

Canned foods may be stored several months without showing serious decrease in vitamin-C content, but when deterioration once begins it proceeds rapidly. Inactivation of vitamin C in canned goods is directly and specifically related to the size of the head space, hence, this should be kept as small as possible. Conditions of storage do not seem to be closely related to rate of loss of vitamin C in canned foods. The question as to whether loss is greater in foods canned in tin or in glass is still in the controversial stage.

In considering canned foods as sources of vitamin C, one important point must be kept in mind. Such foods have been cooked at a fairly high temperature and the cellular structure is largely broken down. If they are allowed to stand after removal from the can, or are heated and then allowed to stand, they will not have very much vitamin C. Tomatoes are an exception since they retain vitamin C well under most conditions because of their high acidity.

Drying of foods is very destructive of vitamin C. Some dried products—fruits—have been reported as containing small quantities, and sulphured foods are supposed to contain more than others.

The amounts left even in foods that have just been dried are so small that it seems safer on the whole to disregard dried foods as probable sources of this vitamin.

VITAMIN D

Functions. Vitamin D is essential in the growth of the skeletal structures, including the teeth as well as the bones. It functions in building calcium and phosphorus into these structures. When children have too little calcium or phosphorus along with too little vitamin D, either because of a poor diet or through lack of exposure of their bodies to sunshine, they have a disease called rickets. In this disease the bones are soft, especially the ends of the long bones, so that children with rickets show bowed legs and crooked arms as well as other bony deformities.

Adults probably need some vitamin D although they do not require as much as children.

Properties. At least ten different substances are known to have vitamin D activity; only two of these are of practical importance. They are vitamin D_2 or activated ergosterol, known also as calciferol, and vitamin D_3 or activated 7-dehydro-cholesterol. Ergosterol which is found only in plant tissue, and 7-dehydro-cholesterol, which is associated with cholesterol, the sterol in animal fats, are often called provitamins. Under the influence of ultraviolet light (irradiation) they are changed into active forms of vitamin D. The commercial preparation known as Viosterol is a solution of activated ergosterol in oil.

The relative activity of these two forms of vitamin D is different for different species of animals. A preparation of vitamin D_2 or calciferol, judged by tests with rats to have the same activity as a given preparation of vitamin D_3, will be judged to be considerably less potent when examined by tests with chicks. Thus, while, for a given effect, chicks may require the same amount of vitamin D_3, they will require more vitamin D_2.

Vitamin D (D_2 and D_3) is soluble in fats and is not affected by heat or oxidation.

Food Sources. Vitamin D does not occur to any extent, if at all, in foods of plant origin, but plants do contain the provitamin, ergosterol. Dried plant tissue containing ergosterol acquires properties of vitamin D on exposure to ultraviolet light. Yeast contains large amounts of ergosterol and irradiated dried yeast is an important source of vitamin D.

The only significant natural sources of vitamin D are among the foods of animal origin. These include milk, eggs, liver, and fish that are rich in oil, like salmon and herring. The value of these foods as sources of vitamin D may well be questioned, however. The quantities of the vitamin that they contain are so small compared to the quantities needed by children for protection against rickets as to be of little practical value in this respect; if adults require vitamin D it is difficult to believe that the quantity is as small as that ordinarily supplied by the use of these foods. This statement does not apply to fish-liver oil, which is the richest natural source of vitamin D. Since foods of animal origin are the only ones that contain vitamin D naturally, and they contain only vitamin D_3, this form of the vitamin is sometimes referred to as natural vitamin D.

The vitamin-D content of milk and eggs may be increased by feeding the animals producing these foods some rich source of the vitamin. Cows may be given irradiated yeast. "Metabolized" vitamin-D milk is produced in this way. The greater proportion of the vitamin D in such milk will be vitamin D_2 with the small quantity of natural vitamin D normally present. Eggs of high vitamin-D activity are obtained by including cod-liver oil in the hen's feed so that eggs generally contain only natural vitamin D.

Milk may also be enriched in vitamin D by irradiating the cow, by irradiating the milk, or by adding concentrates of the vitamin directly to the milk. Only the last two methods have been used commercially to any extent.

RIBOFLAVIN (VITAMIN G OR B_2)

Functions. The symptoms, following the use of a diet containing too little riboflavin to maintain normal body function, have been described only recently. One of the early signs is an inflamed and roughened appearance of the skin in certain areas. In the acute stage there is reddening of the lips and tongue and fissuring at the angles of the mouth—a condition called cheilosis. There are also changes in the cornea of the eye, evidenced by the infiltration of blood vessels. In subacute, but not total deficiency extending for a period of time, opacity of the cornea may develop. There is also some evidence that riboflavin deficiency may give rise to neuropathological symptoms.

Riboflavin like vitamin B_1 functions as the active constituent of an enzyme—tissue respiratory enzyme—which operates in the complicated system for the gradual release of energy to tissues.

Properties. Pure riboflavin is a yellow crystalline material readily soluble in water, giving a yellow-green fluorescent solution. Riboflavin is not readily destroyed by heating but is destroyed by light and is less stable in alkaline than in acid solution.

As it occurs in nature, riboflavin forms part of a protein phosphoric acid complex that must be broken down before the pure vitamin can be obtained.

Food Sources. Food sources of riboflavin are less completely known than are sources of the other vitamins so far discussed. This is due partly to its later discovery but largely to the lack of a satisfactory method of measurement.

Milk, eggs, and lean meats are the richest sources. The yolk and the white of eggs contain it in about the same concentration. As riboflavin occurs associated with protein, it is present in milk in the skimmed milk and not in the butter fat.

In plants, riboflavin seems to be concentrated in the green parts. Thin green leaves are especially rich sources. Green stems are much richer than the flower or the root. Although the vitamin is more concentrated in the green parts, the bleached parts of plants are not devoid of it, as they are of vitamin A. Most root vegetables and tubers contain some riboflavin. In fact, riboflavin is present in practically all vegetables of one sort or another.

Seeds vary considerably in the amounts of riboflavin they contain. Legumes, peas, beans, and especially soy beans are good sources, while nuts and cereal grains are not so rich. The germ portion of the seed usually contains a high concentration of riboflavin, as it does of vitamin B_1.

In general, fruits are low in their content of riboflavin. The majority can be rated only fair and some fruits such as grapes, lemons, oranges, and grapefruit, contain little more than a trace. If there is a basis for classifying fruits as to riboflavin content, it is not apparent in the few data now available.

Fats and oils have already been described as not containing the water-soluble vitamins B_1 and C. They are also about the only foods that do not contain at least traces of riboflavin.

Losses of Riboflavin. There is not a great deal of information available on losses of riboflavin in foods. From the fact that the vitamin is soluble in water it might be anticipated that there would be loss during boiling or any process where foods are kept in contact with water for any length of time. It will be remembered, however, that in foods riboflavin is combined with other substances. The difficulty experienced in removing the vitamin from foods by those who have undertaken quantitative estimation by chemical tests indicates that probably no great amount would be removed during boiling, blanching, or soaking.

Riboflavin is described as heat stable, which again might lead one to think that losses during cooking would be small. Milk whey, having an acidity comparable to that of tomato juice, was found to lose only 10 percent of its riboflavin value when heated at the boiling point of water for one hour, and four hours of heating was required to reduce the original value by 30 percent. When the mixture was made only slightly alkaline, the rate of destruction reached 30 to 40 percent for one hour of heating. This a clear indication that conditions within the medium influence inactivation of riboflavin as they do inactivation of vitamin B_1. Under similar conditions, in a liquid medium the rate of destruction of riboflavin was found to be slightly less than the rate of destruction of vitamin B_1. This relieves the situation relative to lack of specific information on loss of riboflavin in foods, since any measures designed to reduce losses of vitamin B_1 during boiling apparently would also operate to protect against losses of riboflavin.

In contrast to vitamin B_1, riboflavin is less stable when heated in a dry mixture than in one that is watery or even only moist. This may afford partial explanation of the fact that the most extensive losses noted have been in the baking, roasting, and frying of meats. These ranged from 30 to 60 percent.

Riboflavin is sensitive to light; data have been obtained indicating that foods exposed to light, especially during cooking, may show an appreciable decrease in riboflavin content.

There is no indication that storage causes loss of riboflavin irrespective of whether foods are fresh, canned, or dried. Canning *per se* does not seem to reduce the riboflavin content of foods or at least not significantly. Information on the effect of drying is not available.

NICOTINIC ACID (PELLAGRA-PREVENTING FACTOR)

Functions. Nicotinic acid is now known to be the substance needed for the cure and prevention of pellagra. This deficiency disease comes about through the use of diets that do not supply milk, eggs, green vegetables, meats or other food containing nicotinic acid in appreciable amounts. The disease is all too common among low-income groups. The early signs are weakness, lack of appetite and indigestion. In the acute stage there is soreness of the mouth and tongue, diarrhea and the characteristic skin changes that appear bisymmetrically on the back of the hands and along the arms and on the top of the feet.

In the body nicotinic acid occurs as a constituent of two coenzymes both of which, like the enzyme with riboflavin, are concerned in tissue respiration.

Properties. Nicotinic acid is a white crystalline substance soluble in water and fairly resistant to heat. The amide, nicotinamide, is also effective as a pellagra preventive. Like some of the other vitamins discussed, nicotinic acid as present in foods is combined with other substances and is not easily removed until these complex compounds are broken up.

Food Sources. Prior to 1938 most of the studies made to determine the nicotinic acid content of foods were concerned with determination of pellagra-preventing value directly. Some of these studies were made with dogs as subjects and some with human beings. It is difficult to correlate the two kinds of data. Nicotinic acid may now be determined directly by chemical or other methods, and considerable data are at hand on the nicotinic acid content of a fair variety of foods. Appraisal of pellagra-preventing value of foods on the basis of content of nicotinic acid depends upon the quantity of this substance required for the cure and prevention of pellagra; this has not yet been definitely determined, although it can be stated approximately.

Milk, lean meats, eggs, fish, liver, and some vegetables have long been known to be valuable in the cure and prevention of pellagra. Among the vegetables, green leaves are especially effective, and the legumes (peas and beans) and tomatoes have some value.

Losses of Nicotinic Acid. The pellagra-preventing value of foods is not reduced easily. Foods have been heated in an autoclave or pressure cooker as long as six hours without showing a decrease in effectiveness. Canned foods seem to be equally as good as the corresponding fresh ones. Meats retain a high percent—85 to 90—of their original nicotinic acid content during cooking even at the high temperatures required for roasting and boiling. Losses are greatest during braising. Losses during cooking of vegetables vary from 8 to 22 percent depending upon the type of material. The loss is greatest in leafy plants and least in fresh legumes, roots, and tubers. The cooking water may contain an average of 12 percent of the vitamin.

VITAMIN K (THE ANTIHEMORRHAGIC VITAMIN)

Functions. Vitamin K is the newest of the vitamins to be added to the list of those essential in human nutrition. It functions in conjunction with the bile salts and aids in the formation of the substance—prothrombin—responsible for the clotting of blood. It has been studied extensively in the treatment of hemorrhage and has been found useful in treating hemorrhage of obstructive jaundice and of the newborn.

Properties. Vitamin K is a colorless or slightly yellowish crystalline substance soluble in fats but not in water. It seems to be resistant to heat but is destroyed by alkalies and certain substances that bring about oxidation.

Food Sources. Vitamin K is fairly widely distributed in foods. It occurs abundantly in green leaves, alfalfa having been one of the chief sources from which concentrates have been prepared. Flowers, roots, and stems of plants contain less than leaves. The vitamin is present in soy bean oil and some other vegetable oils and in tomatoes. It is not present in fish-liver oils, but decomposed fish meal has been the source of a substance having vitamin K activity, differing slightly from the vitamin K of alfalfa. A number of compounds are known to have properties ascribed to vitamin K but how many of these occur naturally is not known.

VITAMIN E

Functions. The functions of vitamin E have been studied largely with animals. This vitamin is essential for the normal progress of the reproductive cycle in some animals notably the rat. Whether it plays any part in human pregnancy remains to be proved. It has been studied most extensively as a preventive of abortion and in the treatment of muscular dystrophy.

Properties. Vitamin E activity is shown by several substances. The one of most importance from the standpoint of its natural occurrence is alpha-tocopherol. This has been separated from wheat germ oil and cotton seed oil as a light yellow viscous oil.

Food Sources. Vitamin E occurs in many of the various types of foods considered essential in a well-balanced diet and it is not difficult to obtain an adequate supply. Foods known to contain vitamin E in abundance are milk, meat, eggs; whole seeds, including both cereal grains and legumes, and lettuce. It is also present in many vegetable oils including, in addition to the two already mentioned, corn oil, rice, and Red Palm oil.

Losses of Vitamin E. Vitamin E is soluble in fat and occurs associated with oils. It is stable toward heat but is inactivated when oils containing it become rancid—presumably because of oxidation.

VITAMIN B_6 OR PYRIDOXINE

Functions. Vitamin B_6 is definitely known to be essential for the good nutrition of several species of animals. The evidence for listing it as an essential in the diet of man is still tentative. A group of pellagrims that were treated with thiamine, riboflavin, and nicotinic acid, on being given vitamin B_6, showed further improvement, while a parallel group that did not receive vitamin B_6 developed symptoms of extreme nervousness, insomnia, abdominal pain, weakness and difficulty in walking.

Properties. Vitamin B_6 is a white crystalline substance and is soluble in water. It is stable toward heat even in alkaline solution, but is destroyed by long exposure to light.

Food Sources. Vitamin B_6 is found in seeds, in some vegetable fats and oils such as linseed oil, peanut oil, rice oil, soy bean oil, cotton seed oil, corn oil, and wheat germ oil, and in butter fat, beef fat, meats, and fish. Most vegetables and fruits are poor sources.

VITAMIN VALUES

As soon as the existence of any one of the vitamins was recognized, it became a matter of concern to know not only in what foods it occurred but also in what quantities. The development of methods of measurement was, therefore, of considerable importance. Chemical identification of the vitamins has usually not been made until some time after their discovery and for this reason development of chemical or physical methods of measurement proceeded uncertainly.

Many of the studies on the physiological effects of the vitamins have been made with laboratory animals. It was natural in some of these studies for information to be obtained on the relation between the quantity which an animal ate of a food known to contain a particular vitamin and the response of that animal in terms of growth or cure or prevention of the disease associated with the vitamin. As these observations were made, consideration was given to the possibility of using a relationship of this kind as the basis of a quantitative method of measurement for the vitamin concerned. Methods of determination in which the reactions of animals are used are called biological methods.

To determine actual vitamin content by a biological method it is necessary to carry out a test in comparison with a substance containing a known amount of the vitamin in question. When the biological methods were first suggested, this condition could not be met because the chemically pure vitamins had not yet been prepared and natural products vary too much to be used as reference materials. As a result of this situation, it became the custom to express content with respect to a particular vitamin in terms of the quantity required to produce a given response in the animal used and under the conditions specified for the test. Such a quantity was known as a "unit." Several of these biological units have been defined and used, but the best known are probably the Sherman units for vitamins A, B_1, and C, and vitamin G or B_2 (riboflavin).

As interest in the importance of the vitamins increased, attempts were made to devise more satisfactory methods of evaluating them. A committee appointed by the Health Organization of the League of Nations has established standards of reference called International Standards of Reference for vitamins A, B_1, C, and D to be used in determining the content of these vitamins in foods and other materials. A Standard for vitamin E was added recently. A definite *quantity* of each standard was specified as the International unit in terms of which the content of the respective vitamin was to be expressed.

Definitions of the International Units for Vitamins A, B_1, C, and D

Vitamin A. The International unit of vitamin A is the vitamin-A activity of 0.6 microgram (0.0006 milligram) of the International Standard Beta carotene. One U.S.P. (United States Pharmacopoeia) unit of vitamin A presumably has the same value as one International unit (I.U.) of vitamin A.

Vitamin B_1. The International unit of vitamin B_1 is the vitamin-B_1 activity of 3.0 micrograms (0.003 milligram) of the International Standard crystalline thiamin chloride (vitamin B_1). One U.S.P. (United States Pharmacopoeia) unit of vitamin B_1 has the same value as one International unit (I.U.) of vitamin B_1.

Vitamin C. The International unit of vitamin C is the vitamin-C activity of 0.05 milligram of the International Standard crystalline ascorbic acid (vitamin C). One U.S.P. (United States Pharmacopoeia) unit of vitamin C has the same value as one International unit (I.U.) of vitamin C.

Vitamin D. The International unit of vitamin D is the vitamin-D activity of the International Standard solution of irradiated ergosterol in oil. One U.S.P. (United States Pharmacopoeia) unit of vitamin D presumably has the same value as one International unit (I.U.) of vitamin D.

Vitamin E. The International unit for vitamin E is the vitamin-E activity of one milligram of the International Standard preparation of synthetic racemic tocopheryl acetate. This is distributed as a solution in olive oil of the strength of 0.1 gram containing one International unit.

Enumeration of vitamin potency in terms of International units is now the accepted mode of expression. As more satisfactory chemical and physical methods of measuring vitamin content are developed, this somewhat cumbersome device will doubtless be abandoned for the more usual procedure of giving composition on the basis of weight of chemical substance. This is already the case with vitamin C where values are given more often in terms of milligrams of ascorbic acid per gram, or per 100 grams of material, than in terms of International units.

No International Standard for riboflavin has been established. The Sherman or Sherman-Bourquin unit is frequently used for denoting vitamin-G potency, otherwise riboflavin is given directly as milligrams or micrograms of riboflavin.

Values for vitamin-A, vitamin-B_1, and vitamin-C content of foods and other materials determined prior to the adoption of the International Standards of Reference are for the most part expressed in terms of the Sherman units. For some foods the only values available are expressed in these units and, for this reason, attempts have been made to derive factors showing the relation between the Sherman and the International units. Since there has been some divided opinion as to what these should be, it seems well to reemphasize the fact that a biological unit does not have an exact value. These units are defined in terms of animal behavior which, however well controlled, is certain to vary. This simply means that the ratio between an International unit and the corresponding biological unit varies according to conditions, and a fixed figure cannot be established for it. Values expressed in International units and derived from Sherman unit values by use of conversion factors cannot be considered more than rough approximations. International unit values obtained by the use of conversion factors should be clearly designated if they are included among values determined directly in terms of International units. The ratios given below for these two units represent general experience with comparative values.

Suggested Interrelation of Sherman Units for Vitamins A, B_1, C, and G and the Corresponding International Units

Vitamin A. Sherman units of vitamin A corresponding to one International unit of vitamin A have been found to vary from 0.8 to 2.5. The ratio of 1.5 is suggested as most representative, that is, one Sherman unit of vitamin A = 0.7 International unit.

Vitamin B_1. Sherman unit values of vitamin B_1 corresponding to one International unit of vitamin B_1 have been found to vary from 0.7 to 4 or 6 Sherman units. The most general relation for the majority of values obtained by the Sherman technique is suggested as one Sherman unit equivalent to one International unit.

Vitamin C. One Sherman unit of vitamin C is generally considered equivalent to 10 International units.

Riboflavin. One Sherman-Bourquin unit of vitamin G is equivalent to 3.0 to 3.5 micrograms of riboflavin.

VITAMIN REQUIREMENTS

At the present time considerable interest is being shown in determinations of the quantities of the various vitamins needed in the diet each day. The first knowledge regarding the requirement of any vitamin has come through determining the quantity needed to cure or prevent the disease associated with a dietary deficiency of that vitamin. Such quantities have usually been described as minimum protective quantities. It soon became apparent in each case that the quantity needed to insure normal or good nutrition was considerably in excess of the minimum protective quantity. The main problem, therefore, has been to develop methods giving values that could be interpreted in relation to normal nutrition, that is, amounts that could be considered *adequate* to good nutrition.

In some instances data have been obtained indicating that nutritional well being is enhanced by a diet supplying an amount of a vitamin in excess of that considered adequate. Such quantities have been designed as optimal.

In summarizing data on vitamin requirement, it seems desirable to give the quantities determined as minimum as well as those considered for an adequate diet. Table 1 presents the values selected and accepted in 1941 by the Committee on Food and Nutrition of the National Research Council, Washington, D. C., and recently

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	Calories	Protein grams	Calcium grams	Iron mgm.	Vitamin A[b] I.U.	Thiamin (B_1)[c] mgm.	Riboflavin mgm.	(Nicotinic acid) mgm.	Ascorbic acid mgm.[d]	Vitamin D I.U.
Man (70 kgm.)										
Sedentary	2,500	—	—	—	—	1.5	2.2	15	—	—
Moderately active	3,000	70	0.8	12	5,000	1.8	2.7	18	75	[g]
Very active	4,500	—	—	—	—	2.3	3.3	23	—	—
Woman (56 kgm.)										
Sedentary	2,100	—	—	—	—	1.2	1.8	12	—	—
Moderately active	2,500	60	0.8	12	5,000	1.5	2.2	15	70	[g]
Very active	3,000	—	—	—	—	1.8	2.7	18	—	—
Pregnancy (latter half)	2,500	85	1.5	15	6,000	1.8	2.5	18	100	400–800
Lactation	3,000	100	2.0	15	8,000	2.3	3.0	23	150	400–800
Children up to 12 years										
Under 1 year[e]	100/kgm.	3–9/kgm.	1.0	6	1,500	0.4	0.6	4	30	400–800
1–3 years[f]	1,200	40	1.0	7	2,000	0.6	0.9	6	35	[g]
4–6 "	1,600	50	1.0	8	2,500	0.8	1.2	8	50	—
7–9 "	2,000	60	1.0	10	3,500	1.0	1.5	10	60	—
10–12 "	2,500	70	1.2	12	4,500	1.2	1.8	12	75	—
Children over 12 years										
Girls, 13–15 years	2,800	80	1.3	15	5,000	1.4	2.0	14	80	[g]
16–20 "	2,400	75	1.0	15	5,000	1.2	1.8	12	80	—
Boys, 13–15 years	3,200	85	1.4	15	5,000	1.6	2.4	16	90	[g]
16–20 "	3,800	100	1.4	15	6,000	2.0	3.0	20	100	—

[a] Tentative goal toward which to aim in planning practical dietaries; can be met by a good diet of natural food. Such a diet will also provide other minerals and vitamins, the requirements for which are less well known.

[b] Requirements may be less if provided as Vitamin A; greater if provided chiefly as the pro-vitamin carotene.

[c] One milligram thiamin equals 333 I.U.

[d] One milligram ascorbic acid equals 20 I.U.

[e] Needs of infants increase from month to month. The amounts given are for approximately 6–8 months. The amounts of protein and calcium needed are less if derived from human milk.

[f] Allowances are based on needs for the middle year in each group (as 2, 5, 8, etc.) and for moderate activity.

[g] Vitamin D is undoubtedly necessary for older children and adults. When not available from sunshine, it should be provided probably up to the minimum amounts recommended for infants.

Further recommendations, adopted 1942:

The requirement for iodine is small; probably about 0.002 to 0.004 milligram a day for each kilogram of body weight. This amounts to about 0.15 to 0.30 milligram daily for the adult. This need is easily met by the regular use of iodized salt; its use is especially important in adolescence and pregnancy.

The requirement for copper for adults is in the neighborhood of 1.0 to 2.0 milligrams a day. Infants and children require approximately 0.05 per kilogram of body weight. The requirement for copper is approximately one-tenth of that for iron.

The requirement for vitamin K is usually satisfied by any good diet. Special consideration needs to be given to new-born infants. Physicians commonly give vitamin K either to the mother before delivery or to the infant immediately after birth.

revised and brought up to date by the Food and Nutrition Board of that same organization. Table 2 presents a summary of the Minimum Daily Requirements for labeling Special Purpose Foods as set up by the Food and Drug Administration of the Federal Security Agency of the Government of the United States (Federal Register Nov. 22, 1941).

TABLE 2

Minimum Daily Requirements for Labeling Special Purpose Foods

(Food and Drug Administration Federal Register, No. 22, 1941)

	Vitamins					Minerals			
	A I.U.	B_1 mgm.	C mgm.	D U.S.P. units	Riboflavin mgm.	Calcium mgm.	Phosphorus mgm.	Iron mgm.	Iodine mgm.
Infants	1,500	.25	10	400 for any person irrespective of age except as noted for milk[a]	.5	Not practical to establish			
Children 1–6	3,000	.5	20		not	750	750	7.5	0.1
6–12	3,000	.75	20		known	750	750	10.0	0.1
Adults	4,000	1.0	30		"	750	750	10.0	0.1
Pregnancy and Lactation					2.0	1,500	1,500	15.0	0.1

[a] Vitamin D consumed in milk is more efficacious but minimum daily requirements have not been established.

Cow's milk containing 135 units per quart will usually prevent clinical rickets.

Evaporated milk containing 7.5 units per ounce will usually prevent rickets in normal children.

Milk with increased vitamin D is usually marketed at levels of 400 and 135 U.S.P. units per quart. Evaporated milk at 22.2 or 7.5 U.S.P. units per quart.

Milk containing increased vitamin D to less than 135 U.S.P. units per quart will carry statement that additional vitamin D is needed.

Milk substitutes for infant feeding must contain per 100 calories at least 30 U.S.P. units of vitamin C, 50 U.S.P. units vitamin D and .75 mgm. iron.

When milk contains at least 135 U.S.P. units vitamin D per quart and evaporated milk 7.6 U.S.P. units per ounce, it is not necessary to say that vitamin D should be supplied from other sources.

Studies to determine the requirement of each of the various vitamins are still in the preliminary stage. It is problematical whether the requirement of any vitamin can ever be expressed with precision. Many factors operate to influence the quantity of each that is needed. Data already at hand indicate that the requirements may vary from individual to individual according to sex, age, size, and activity, and vary in the same individual from day to day, depending upon the physiological condition, activity, or environment.

There is no evidence of harm from the ingestion of vitamins, as they occur in foods, in quantities considerably in excess of those given as requirements. In planning diets, the aim should be to provide foods that will supply at least as much and, preferably more, than the adequate allowance of each vitamin and several times this allowance in cases where there is indication of a greater need.

THINGS TO REMEMBER

The array of information relating to the vitamins is extensive and complex. Unless one is making almost constant use of it, it is next to impossible to keep even the essential details in mind, and very few people wish to be hampered by the need of a pocket handbook in order to remember their vitamins. In the selection and preparation of foods for a diet adequate in vitamin content a few rules or summary statements are usually sufficient. Those given below are suggested as helpful and others may be formulated if need requires.

1. Use a variety of all types of foods giving especial attention to the use of milk, eggs, green leafy vegetables, *fresh* fruits and vegetables, lean meats, and whole grain cereals and breads.

2. To avoid loss of vitamin value in cooking:

Cook foods as quickly as possible.

Use small amounts of water and use any that is left. Special utensils are not necessary for so-called waterless cookery.

Steaming is an excellent way to cook many vegetables and some other foods.

Do not peel vegetables or fruits and cut them up and then let them stand before cooking. Cooking them whole and with the outer covering on helps preserve vitamin content.

Never add soda to vegetables during cooking. It serves no useful purpose and makes for destruction of vitamins. Cook green vegetables in an open kettle and they will stay green.

Serve foods as soon as possible after they are cooked.

Do not fry foods if they can be cooked in some other way. Frying and roasting are very destructive of vitamins.

3. Give very careful attention to sources of vitamin B_1 in the diet. It is more difficult to obtain an adequate amount of this vitamin than any of the others. It is probably the one in which American diets are most deficient. Take special care to conserve the vitamin B_1 in foods during cooking. Many of the foods that contain an abundance of vitamin B_1 are cooked before being eaten and next to vitamin C, vitamin B_1 is the vitamin most likely to be lost when foods are cooked or canned. The precautions necessary to conserve vitamin B_1 will conserve other vitamins as well.

4. Store foods at low temperatures and in closed containers.

5. Do not chop or crush fresh fruits and vegetables and allow them to stand. They lose vitamin C rapidly.

6. Frozen foods have practically the same vitamin content as fresh ones, but care must be taken to conserve it during preparation for serving. Do not defrost and then allow to stand. If frozen foods are to be cooked put them on to cook while they are still frozen and use all of the liquid.

7. Canned foods retain vitamin value well, with the possible exception of vitamin C, provided they have not been stored too long. To obtain full value, use the entire contents of the can. Canned foods are cooked foods and should be treated accordingly.

8. In canning foods observe the same precautions for conserving vitamin content as suggested for cooking.

VALUES FOR THE VITAMIN CONTENT OF FOODS

For some purposes, and especially for dietary calculations, it is desirable to have a set of values showing the quantities of the various vitamins in different foods. In the general discussion of food sources of the vitamins it was made clear that no food has a fixed and invariable content of any vitamin. Values for different samples of any food may vary over wide ranges depending upon the factors that influence the content of the vitamins it contains. The derivation of average values, in the strict sense of this term, is not possible without using an unreasonable amount of descriptive material concerning each individual food item. In lieu of this it might seem advisable to indicate a range in place of a single value. The difficulty in that case is that anyone requiring a single value will use the medium of the range which may not be in any sense the best value to use. This reduces the problem to one of arbitrarily selecting what are considered the most representative values.

The values in Table 3, which is offered as an aid to those who must use single values expressive of vitamin content, were selected as explained above. A compilation was made of all data on vitamin content that could be obtained from the literature or elsewhere through July 1, 1942. From a consideration of all data showing the content of a vitamin in a food, a value was selected as "representative." This designation is intended to make clear that the values presented are not averages but were selected according to the best judgment of the author as being most generally applicable. In the appraisal, attention was given to the method of analysis used, but there was no general discrimination against data on this basis. This policy was followed from the viewpoint that it is a fallacy to discount data absolutely because they were determined by methods now out-moded when careful appraisal shows that they are more consistent than data obtained by a more recently developed method that has not been perfected to the point of strict reliability.

The nature and type of each food material was also taken into account. The values should be taken as applying to the edible portion of foods that are reasonably fresh and of good quality. This is especially important to keep in mind for vitamin-C values. "Market fresh" vegetables are often far from "fresh" as far as vitamin-C content is concerned. Adjustments should be made in the vitamin-C values for fruits and vegetables, especially leafy vegetables, when the products to which they are applied are not strictly fresh. No attempt has been made to give summarizing statements for treated foods since the appraisal of such data seemed beyond the scope of this discussion.

TABLE 3

The Vitamin A, Vitamin B_1 or Thiamin, Vitamin C, or Ascorbic Acid, and Riboflavin Content of Common Foods

	Vitamin A	*Thiamin*	*Ascorbic Acid*	*Riboflavin*
	Values per 100 Grams Edible Portion			
	I.U.	*Micrograms*	*Milligrams*	*Micrograms*
Alfalfa Leaf Meal, Dried	8,000			1,500
Almond	75	225		300
Apple	75	35	.5-20 Av. 6	10
Apricot, Fresh	4,000	45	7	
Dried	6,000	90	2	100
Artichoke, Globe (Cynara Scolymus)	200	75	9	30
Artichoke, Jerusalem (Helianthus Tuberosus)		60	7	
Asparagus, Green	900	180	40	120
Bleached	0-50	180	30	
Avocado	125	90	10	90
Banana	350	50	10	75
Barley	0	500	0	120
Beans, Snap				
Green	1,000	75	25	110
Wax	300	75	25	100
Beans, Shelled, Fresh				
Lima	300	300	30	175
Runner	500	300	25	
Soybean	200	500	40	300
Beans, Shelled, Dried				
Lima	100	525	0	750
Navy	0	510	0	325
Red Kidney		450	0	
Soybean	100	1,200	0	750
Beef, Lean	20	125	0	225
Beet	0	30	15	50
Beet Tops	15,000		50	300
Blackberry	75	30	7	
Black-Eyed Peas—*see* Cowpeas				
Blueberry	50	30	Av. 10	
Brazil Nut	10	500		
Bread, White 6% Milk Solids		65	0	130
Whole Wheat 6% Milk Solids		210	0	180
Rye		210	0	
Broccoli, Entire Plant	9,000	111	65	225
Flower	3,000	135	65	240
Leaf	12,000	135	70	450
Stem	1,000	75		
Brussel Sprouts	500	150	65	
Buckwheat		450	0	
Butter, Average	2,700		0	
From Cows on Dry Feed	2,000		0	
From Cows on Green Feed	5,000		0	
Cabbage, Head,				
Young, Partly Green	150	30	60	50
Mature, Bleached	0	30	60	25
Red			60	
Chinese	9,000	30	45	45
Cantaloupe	1,000	50	30	60
Carrot	10,000	60	10	60
Cauliflower	50	150	75	105
Celery Stalks				
Green	1,000	30	5	100
Bleached (Hearts)	10	30	5	35

TABLE 3—*Continued*

	Vitamin A	*Thiamin*	*Ascorbic Acid*	*Riboflavin*
	Values per 100 Grams Edible Portion			
	I.U.	*Micrograms*	*Milligrams*	*Micrograms*
Chard	10,000		35	125
Cheese				
Cheddar	1,500	24	0	550
Cottage	175		0	280
Cream	2,000			
Cherry	15-800 Av. 150	45	8	
Chicken, Muscle				
Dark		150		260
Light		90		70
Clam	200	25		
Cod Fish	0	90	0	
Cod-Liver Oil	*	0	0	
Collards	12,000	80	60	300
Corn, Sweet				
White	0-50	135	10	
Yellow	600	135	10	60
Corn, Dried				
White	0	450	0	130
Yellow (Whole Grain Cornmeal)	750	450	0	130
Corn Oil, Refined	0	0	0	0
Cottonseed Oil, Refined	0	0	0	0
Cowpea, Fresh			5	
Dried	30	500	0	300
Cranberry	50		12	0
Cream, 20 Percent	650	35		
Cucumber	20	30	9	25
Currant, Black	400	30	150	
Red		45	45	
Dandelion	12,000		100	
Dates, Cured	300	75	0	45
Dock Leaves	14,000			
Egg, Whole, Average	1,000	150	0	250
White	0	0	0	230
Yolk	2,800	420	0	285
Eggplant	100	45	10	30
Endive, Escarole	10,000	50	15	200
French		75	20	60
Fig, Fresh	10	60	2	5
Dried	60	60	0	45
Flour, White, Patent	0	75	0	40
Whole Wheat		450		100
Garden Cress		90		
Gooseberry			25	
Grape	0	50	4	15
Grape Juice			2	
Grapefruit	0	40	43	
Grapefruit Juice	0	45	45	12
Canned	0	45	40	
Guava	200	45	225	10
Haddock	0	15	0	
Halibut		90		
Hazelnut	100	400		
Heart				
Beef	200	600		900
Lamb	trace	600		
Pork		600		900
Honey	0	0	0	0

* Use value given on the container.

TABLE 3—*Continued*

	Vitamin A	*Thiamin*	*Ascorbic Acid*	*Riboflavin*
	Values per 100 Grams Edible Portion			
	I.U.	*Micrograms*	*Milligrams*	*Micrograms*
Horseradish			100	
Huckleberry			30	
Kale	16,000	150	100	400
Kidney				
Beef or Veal	1,000	250		2,100
Lamb	1,000	300		2,000
Pork		500		2,100
Kohlrabi		50	60	
Lamb Muscle, Lean	trace	200	0	250
Lard	5	0		
Leek	1,000	80	15	
Lemon Juice	0	30	45	0
Lentils, Dried	50	500	0	315
Lettuce				
Green	5,000	75	15	150
Bleached, Head	100	75	15	45
Romaine or Cos	1,000			100
Lime Juice		30	37	
Liver, Beef	30,000	400	fresh 37	3,000
Calf	27,000	400	fresh 32	3,300
Chicken	24,000	400	fresh 35	2,500
Lamb	27,000	400	fresh 37	3,300
Pig	27,000	425	fresh 27	2,700
Mango	1,000	60	60	50
Milk				
Whole, Fresh, Average Market	120	42	fresh 2.2; pasteurized 1.3	195
From Cows on Dry Feed	60	42	1.5	160
From Cows on Pasture	180	42	1.5	210
Whole Dried, Average	960	250	0	1,500
From Cows on Dry Feed	480		0	
From Cows on Pasture	1,440		0	
Skim	10	45	0	200
Skim, Dried	100	320	0	1,600
†Milk, Whole, Evaporated	400	53	1.2	390
Molasses	0	0	0	
Mushrooms	0	60	1	5
Mustard Greens	10,000	100	120	
Oats, Rolled or Oatmeal	0	540	0	100
Okra	2,000	120	20	
Olive, Canned, Green	200		0	
Ripe	125	6	0	0
Olive Oil, Refined	0			
Onion, Green	5,000		30	
Mature	0	30	15	50
Orange Juice	150	70	45	15
Oyster	200	300		
Papaya Green	2,500	50	45	180
Parsley	18,000		100	
Parsnip	0	80	22	
Pea, Green, Fresh	1,000	400	25	200
Dried	750	525	0	300
Peach				
White	100	40	10	
Yellow	2,000	40	10	60
Yellow, Dried	3,000		0	

† Values should be considered tentative until more reliable values are available.

TABLE 3—*Continued*

	Vitamin A	*Thiamin*	*Ascorbic Acid*	*Riboflavin*
	Values per 100 Grams Edible Portion			
	I U.	*Micrograms*	*Milligrams*	*Micrograms*
Peanut, Jumbo	0	900		500
Roasted	0	200	0	
Spanish	0	900		500
Roasted		200		
Pear	30	40	7	20
Pecan	300	500		300
Pepper, Green	3,000	30	125	50
Red	2,000	30	150	
Pineapple, Whole	150	50	20	5
Juice, Fresh	125	65	25	
Juice, Canned	100	50	20	
Plum	350	50	7	45
Pork Muscle, Lean	0	1,200		225
Potato, White, Average	30	100	10	40
New			15	
Old			9	
Prune, Fresh	1,500	50		
Dried	2,500	125	0.5	50
Pumpkin	2,000	45	5	45
Quince			8	
Radish	25	60	25	30
Raisin, Seedless	0	100	0	
Raspberry, Red	150	30	25	
Rhubarb	100	15	20	
Rice, Brown	0	225	0	80
Polished	0	30	0	0
Roe	2,000	1,000	5	100
Rutabaga, White	0	70	45	
Yellow	25	70	45	
Rye	0	500	0	140
Salmon, Canned				
Chum	30	30		
Chinook	750	30		
Pink	100	30		
Red	325	30	0	225
Sardine	150	50		
Soybean—*see* Bean				
Spinach	18,000	100	50	400
Squash, Summer	750	45		50
Winter	4,000	45	5	50
Strawberry	50	25	50	
Sweet Potato	3,500	90	20	75
Tangerine		70	35	20
Tomato, Mature Green	800	70	22	45
Ripe	1,000	75	22	45
Tomato Juice, Fresh	1,000	75	22	45
Commercial Canned			8-29 Av. 18	
Turnip, White	0	30	30	30
Yellow	20	30	30	35
Turnip, Greens	18,000	100	100	350
Walnuts, Black	70	330	0	
English	50	450	0	
Watercress	4,000	100	75	270
Watermelon	50	30	7	15
Wheat, Hard	0	525	0	100
Soft	0	350	0	100