VITAMINS AND THEIR OCCURRENCE IN FOODS

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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

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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 includes 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, and 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 two 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 which 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 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, vitamin B_1, 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 and 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 treatments 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

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 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 and 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 which contains a higher proportion of caro-

[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 rôle 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.

tene 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 values. 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, although 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 per cent 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)

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 ex-

[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 ap-

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pressed by a definite percentage but is more a matter of rate of 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 per cent 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 per cent 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 per cent.

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)

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 in-

proximated 30 per cent 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.

crease 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, and turnips and rutabagas also contain large amounts. Vitamin C occurs in fairly high concentration in all leaves such as spinach, collards, turnip greens, and watercress.

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 for 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 on a dozen oranges examined individually. These oranges were of uniform size and appearance and were purchased at one time and came 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 per cent 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 inactivation 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 they 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 per cent while 30 to 40 per cent 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 bead 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; but 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

Properties. At least ten different substances are known to have vitamin D activity but 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, and 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 to any extent commercially.

Riboflavin (Vitamin G)

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 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 food is 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 per cent 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 per cent. When the mixture was made only slightly alkaline, the rate of destruction reached 30 to 40 per cent for one hour of heating. This is 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 per cent.

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)

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. No consistent effort has been made to determine the nicotinic acid content of foods accurately. Most of the studies along this line have been concerned with determination of pellagra-preventing value directly. Some of these studies have been made with dogs as subjects and some with human beings. It is difficult to correlate the two kinds of data. 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; and 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.

Vitamin K (The Antihemorrhagic Vitamin)

Properties. Vitamin K is one of the newer vitamins. It 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

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 oil, 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

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 butterfat; beef fat; meats; and fish. Most vegetables and fruits are poor sources.

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. 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. Dried foods are not especially recommended for vitamin value.

8. 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.

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

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 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 1 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 1 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 1 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 1 International unit (I.U.) of vitamin D.

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 which have been derived from Sherman unit values by use of conversion factors cannot be considered more than rough approximations. International unit values so obtained should be clearly designated if presented with other material. 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 1 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, 1 Sherman unit of vitamin A = 0.7 International unit.

Vitamin B_1. Sherman unit values of vitamin B_1 corresponding to 1 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 1 Sherman unit equivalent to 1 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.

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 median 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 the table presented here, which is offered as an aid to those who must use single values expressive of vitamin content, were selected on this basis. The selections were made from a summary of all of the data that could be obtained in the literature or elsewhere up to July 1, 1940. Careful consideration was given to the methods of analysis used and the nature of the food material studied. The values given should be taken as applying to foods that are reasonably fresh and of good quality. This is especially important to keep in mind relative to 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 being applied are not strictly fresh.

Some values in the table may differ materially from corresponding ones in other summaries. Too much concern should not be felt over such discrepancies, perhaps, since all values of this kind are, as explained, arbitrarily selected and their approximation to actual fact is problematical in any case. If specific information about a food is available, other values might be selected as more suitable.

Table 1. Values selected as representative of the vitamin A, vitamin B_1, vitamin C, vitamin D, and riboflavin content of common foods. Unless otherwise stated, the values given are for the edible portion of the fresh food.

Food Material	Vitamin A	Vitamin B_1	Vitamin C	Vitamin D	Riboflavin Vitamin G
	Units per 100 Grams[1]				
	Int.	Int.[2]	Int.[3]	Int.	Sherman[4]
Alfalfa leaf meal, dried	8,000				500
Almond	75	75			200
Apple	75	15	(30–400) Av. 100		10
Apricot, fresh	4,000	10	100		17
Apricot, dried	5,000	30	60		35
Artichoke, Globe	200	60	175		Fair
Artichoke, Jerusalem		50	115		
Asparagus, green	700	70	700		40
Asparagus, bleached	0–50	50	650		Fair
Avocado	100	30	400		30
Banana	300	15	200		30
Barley	0	120	0		3
Beans, snap					
Green	1,000	25	300		40
Wax	0	25	300		40
Beans, shelled					
Lima	500	115	600		100
Runner	1,000	100	500		
Soy bean	200	175	800		100
Beans, shelled, dried					
Lima	100	175	0		300
Navy	0	170	0		
Red Kidney		150	0		
Soy bean	100	400			300
Beef, lean	50	40	0		75
Beet	0	15	100		10
Beet Tops	Excellent		1,000		150
Blackberry	150	15	140		

Food Material	Vitamin A	Vitamin B_1	Vitamin C	Vitamin D	Riboflavin Vitamin G
	Units per 100 Grams[1]				
	Int.	Int.[2]	Int.[3]	Int.	Sherman[4]
Black-Eyed Peas—*see* Cowpeas					
Blueberry	100	15			
High bush			120		
Low bush			90		
Brazil Nut	10	350			
Bread					
White	Trace	20	0		0
Whole Wheat	Trace	100	0		30
Rye	Trace	70	0		
Broccoli, entire plant	9,000	37	1,400		75
Flower	5,000	45	2,000		80
Leaf	16,000	45	2,500		150
Stem	1,000	25			
Brussel Sprouts	200	60	1,500		
Buckwheat		150	0		
Butter, average	2,400		0	80	
From cows on dry feed	1,200		0	40	
From cows on green feed	4,000		0	150	
Cabbage, head					
Young, partly green	100	25	1,200		30
Mature, bleached	0	25	1,200		15
Red			1,200		
Chinese	2,000	25	800		15
Cantaloupe	300	20	600		20
Carrot	2,100	20	100		20
Cauliflower	30	50	1,500		35
Celery Stalks					
Green	1,000	10	100		10
Bleached	10	10	100		
Chard	9,000	Fair	750		30
Cheese					
Cheddar	2,000	15	0		250
Cottage	500		0		Good
Cream	2,100		0		60
Cherry	15–550 Av. 200	15	200		
Chicken, Muscle					
Dark		50			Excellent
Light		30			Excellent
Clam	14	7			
Codfish	5	30	0		Good
Cod Liver Oil	*	0	0	*	0
Collards	7,000	50	800		100
Corn, Sweet					
White	0–50	45	200		
Yellow	500	45	200		20
Corn, dried					
White	0	100	0		Fair
Yellow	550	100	0		Fair
Corn Oil, refined	0	0	0		0
Cottonseed Oil, refined	0	0	0	0	0
Cowpea, fresh			130		
Dried	50	300			100

Food Material	Vitamin A	Vitamin B1	Vitamin C	Vitamin D	Riboflavin Vitamin G
	Units per 100 Grams[1]				
	Int.	Int.[2]	Int.[3]	Int.	Sherman[4]
Cranberry	20		225	0	0
Cream, 20 per cent	600	10		Traces	
Cucumber	20	15	200		8
Currant, Black	400	10	3,000		
Red		15	900		
Dandelion	12,000		2,000		Good
Dates, cured	150	25	0		15
Dock, leaves	14,000				Good
Egg, whole	1,000	50	0		110
White	0	0	0		100
Yolk	2,800	140	0		115
Eggplant	35	15	200		10
Endive (Escarole)	15,000	28	400		40
French	Good	25			20
Fig, Fresh	50	25	30		15
Dried	60	22	0		25
Flour					
White, patent	0	30	0		
Whole Wheat		160			Fair
Garden Cress	Excellent	30			
Gooseberry			500		
Grape	Trace	15	60		8
Grape Juice			30		
Grapefruit	0	23	850		Trace
Juice	0	25	900		Trace
Canned	0	25	800		Trace
Guava	200	14	1,500		3
Haddock	5	5	0		Good
Halibut		30			
Hazelnut	100	220			
Heart					
Beef	Trace	200			300
Lamb	Trace	200			
Pork		180			
Honey	0	0	0	0	0
Horseradish			2,000		
Huckleberry			800		
Kale	20,000	50	2,500		200
Kidney, beef or veal	1,000	60			700
Lamb	1,000	75			
Pork		150			
Kohlrabi		20	1,200		
Lamb, muscle, lean		80			70
Lard	4	0		0	0
Leek	Fair	50	400		Fair
Lemon Juice	0	10	900		Trace
Lentils, dried	Trace	170	0		105
Lettuce, green	4,000	25	250		75
Bleached	100	25	250		15
Romaine or Cos	800				30
Lime Juice			750		
Liver, Beef	9,000	75	Fresh 750	45	600

Food Material	Vitamin A	Vitamin B1	Vitamin C	Vitamin D	Riboflavin Vitamin G
	Units per 100 Grams[1]				
	Int.	Int.[2]	Int.[3]	Int.	Sherman[4]
Liver, Calf	7,000	70	Fresh 650	15	550
Chicken	Excellent	75	Fresh 450	50	Excellent
Lamb	Excellent	75	Fresh 750	20	550
Pig	Excellent	100	Fresh 525	45	600
Mango	1,500	30	600		20
Milk			Raw 40		
Whole Fresh, average market	110	20	Past. 25	2	75
From cows on dry feed	55	20	Raw 30	1	60
From cows on pasture	175	20	Raw 50	3	80
Whole Dried					
Average	875	120	0	16	500
From cows on dry feed	450		0	8	
From cows on pasture	1,400		0	24	
Skim	2	15	0		Excellent
Skim, dried	20	120	0		600
Molasses	0	0	0		
Mushrooms	0	30	Trace		
Mustard Greens	Excellent	45	2,500		Excellent
Oats (rolled or Oatmeal)	Trace	180	0	0	35
Okra	400	40	400		Fair
Olive, canned					
Green	190		0		
Ripe	125	2	0	0	0
Olive Oil, refined	0			0	
Onion, green	Fair		275		
Mature	0	10	160		30
Orange Juice	45–350	30	450–1,200 Av. 900		5
Oyster	140		5		
Papaya	2,500	25	900		60
Parsley	30,000		2,000		
Parsnip	Trace	40	450		
Pea, green, fresh	1,000	140	500		65
Green, dried	1,200	175			100
Peach, White	5	10	200		
Yellow	1,000	10	200		20
Yellow, dried	3,000		0		
Peanut, Jumbo	0	320			Good
Roasted		90			
Spanish		300			250
Spanish, roasted		60			
Pear	10	15	50		20
Pecan	400	350			100
Pepper, Green	5,000	10	2,500		40
Red	5,000	10	3,000		
Pineapple	90	25	500		12
Juice, fresh		30	600		
Juice, canned		25	300		

Food Material	Vitamin A	Vitamin B_1	Vitamin C	Vitamin D	Riboflavin Vitamin G
	Units per 100 Grams[1]				
	Int.	Int.[2]	Int.[3]	Int.	Sherman[4]
Plum		35	100		15
Pork muscle, lean	Trace	400			75
Potato, average	30	40	250		15
New			350		
Stored, old			100		
Prune, fresh	1,500	20			
Dried	2,500	50	50		Good
Pumpkin	2,500	15	60		15
Quince			250		
Radish	Trace	20	400		10
Raisin	50	30	0		
Raspberry		10	600		
Rhubarb	Trace		400		
Rice, Brown	Trace	75	0		50
Polished	0	10	0		Trace
Roe	2,000	30	100		Fair
Rutabaga, White	0	15	400		
Yellow	25	15	400		
Rye	0	140	0		Fair
Salmon, canned					
Chum	30			225	
Chinook	750			275	
Pink	100			625	
Red	325	Trace	0	800	75
Sardine		10		Good	Good
Soy bean—*see under* Bean					
Spinach	25,000	40	1,500		125
Squash, Summer	1,000	15			15
Winter	4,000	15	100		25
Strawberry	Trace	Trace	1,000		Trace
Sweet Potato	3,500	30	400		30
Tangerine		30	700		10
Tomato, mature, Green	700	23	260–600 Av. 450		15
Ripe	1,000	25	260–600 Av. 450		20
Juice, fresh	1,000	25	Av. 450		
Juice, canned commercial			150–575 Av. 375		
Turnip, White	0	12	600		12
Yellow	20	12	600		12
Turnip Greens	10,000	40	3,000		120
Walnuts, Black	130	110			
English	100	150			
Watercress	4,000	40	1,500		90
Watermelon	Trace	20	150	0	10
Wheat	Trace	180	0		35

[1] Where there are no values, data were not available for making estimates. One hundred grams is approximately 3.5 ounces.

[2] International units of vitamin B_1 multiplied by 3 give micrograms of thiamin.

[3] International units of Vitamin C multiplied by 0.05 give milligrams of ascorbic acid.

[4] For the calculations made in this table, the relation of one Sherman unit equivalent to 3.0 micrograms (0.003 milligrams) of riboflavin was used. Sherman units multiplied by 3 give micrograms of riboflavin.

* For vitamins A and D use values given on the container.

SELECTING FOODS TO MEET VITAMIN REQUIREMENTS

In planning or assessing diets for adequacy in vitamin content, it is obviously necessary to have information as to the quantities of each of the vitamins needed in the daily diet. Suggested values for vitamins A, B_1, C, D, and riboflavin are summarized in Table 2.

At the present time considerable interest is being shown in studies to determine the requirement of the various vitamins known to be essential in the diet of man. The main problem has been the development of methods giving results that could be interpreted in relation to nutritional well-being. The first knowledge of the requirement of any vitamin came as a result of determining the quantity required to cure or prevent the disease associated with that vitamin. Such quantities have usually been referred to as mini-

Table 2.[1] Values suggested as expressive of the daily requirement for vitamins A, B_1, C, D, and riboflavin.

Vitamin	For the Average Adult Under Average Conditions			During Pregnancy and Lactation	For Growing Children and Adolescents
	Absolute Minimum	Adequate	Optimum		
A	2,000 I.U.	3,000 to 5,000 I.U.	6,000 to 8,000 I.U.	more	8,000 to 10,000 I.U.
B_1 (thiamin)	200 I.U. *or* 0.6 mg.	300 to 400 I.U. *or* 0.9 to 1.2 mg.	500 to 600 I.U. *or* 1.5 to 1.8 mg.	several times allowance for average adult	considerably more in proportion to their weight than adults
C (ascorbic acid)	20 to 25 mg. *or* 400 to 500 I.U.	40 to 60 mg. *or* 800 to 1,200 I.U.	80 mg. *or* 1,600 I.U.	twice that for the average adult	only slightly less than that for adults
D	not known			800 I.U. suggested as adequate	300 to 400 I.U. suggested as adequate for protection against rickets; 675 I.U. suggested for optimum growth
Riboflavin (vitamin G)	approximately 600 Sherman-Bourquin units or 2 milligrams				at least 400 Sherman-Bourquin units

[1] Previously published. Munsell, Hazel E.: Planning the Day's Diet for Vitamin Content. *Journal of the American Dietetic Association*, October, 1939, 15, p. 639.

mum protective quantities. It soon became apparent that the quantity needed for normal nutrition was considerably in excess of the minimum protective quantity. As information and experience accumulated the aim has been to obtain values of vitamin requirements that apply more nearly to normal nutrition.

In summarizing data on vitamin requirements, it seems desirable to give the quantities determined as minimum as well as those considered adequate. In some instances data have been obtained indicating that nutritional well-being is enhanced by a diet supplying quantities of a vitamin in excess of that considered adequate. Such quantities have been designated as optimum.

Studies to determine the requirement 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.

The material offered in Table 2 should be used with certain considerations in mind. With the exception of vitamin D the values for the requirement of each of the vitamins represent quantities that may be supplied readily by the use of natural foods. These quantities indicate the *daily* requirement of the *normal* individual with no allowance made for variation in the vitamin value in different foods or losses that may occur from cooking or other processes to which the food may be subjected.

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.