Conserving minerals and vitamins in vegetables

Olive Sheets
Conserving Minerals and Vitamins in Vegetables

By

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PRACTICAL APPLICATIONS

It is evident from the information which has been presented that vegetables may be so handled and prepared for eating that much of their nutritive value is lost. Thus, the most nutritious parts of certain vegetables may be thrown away. Through improper handling the vitamin C content of fresh vegetables may be considerably reduced before they are cooked, and the destruction or loss of vitamin C may be almost complete by the time they are eaten. Vitamin B1 may be destroyed by the use of alkali, and much of it may be lost in the cooking water; half or more of the minerals in green vegetables may be discarded with the cooking water. It is very important, therefore, that certain general rules should be followed in the preparation of vegetables if one wishes to conserve their minerals and vitamins.

The following recommended practices are based upon the information which has been given:

Use green vegetables as soon as possible after they have been gathered.

Store green vegetables in a cool, damp place, preferably in a closed container in the refrigerator. Avoid wilting.

Do not throw away the most nutritious parts of vegetables, as the green outside leaves of head lettuce and cabbage.

Use a small amount of water in cooking all vegetables, except the strongly-flavored ones.

Never use soda in cooking green vegetables.

Avoid cooking vegetables (except for canning) in ways that employ high temperatures, as frying and cooking in the pressure cooker. Such methods conserve minerals but destroy vitamins.

Cook vegetables as quickly as possible. Whenever vegetables or the water in which they are cooked are to be used in stews and soup, add them toward the end of the cooking period.

In blanching vegetables for canning or freezing, keep the water boiling and blanch them as quickly as possible.

Do not allow cooked or reheated canned vegetables to stand. Serve them as soon as possible. Left-overs should be stored in the refrigerator in covered containers.

Use the water in which vegetables have been cooked or canned.

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CONSERVING MINERALS AND VITAMINS
IN VEGETABLES

By OLIVE SHEETS, Home Economics Department

The proper preparation of food has a most important place in our programs for adequate nutrition in national defense. It is essential not only that the housewife should know how to plan an adequate diet for her family and to serve palatable food, but also that she should know how to prepare it so that it loses a minimum of the nutrients it originally contained. The lower the income, the more this knowledge is needed, for the lower the income, the more limited the amount and kinds of food which can be purchased.

Even with the best food selection, the diet of low income families is not apt to supply any more than is actually necessary of some of the food essentials. An adequate diet may be made inadequate through methods used in food preparation. Two instances of an outbreak of scurvy, a disease due to lack of vitamin C, are given in the 1931 Report on Vitamins of the British Medical Research Council. The outbreaks occurred on diets which should have contained more than adequate amounts of this vitamin, had the vegetables included in the diet been properly prepared. However, they were cooked in meat stews for so long that most of the vitamin C was destroyed.

It is evident, therefore, that dietary calculations based upon the fresh uncooked food may greatly overestimate the vitamin C content of the food as it is actually eaten. This is true to a less extent of other vitamins and of minerals.

No class of foods suffers greater losses of their nutrients through poor preparation than do fresh vegetables. Yet we rely on these foods to furnish an important share of the minerals and vitamins needed in the diet.

It is the purpose of this bulletin to describe the effects of different methods of preparing, cooking and preserving vegetables on the losses of minerals and vitamins. We shall then be in a position to decide what methods to recommend. The term “preparation” will include handling and getting the vegetables ready for cooking or eating raw. The term “preserving” will include canning, freezing and drying.

LOSSES OF MINERALS IN VEGETABLES

Minerals are lost from vegetables by discarding parts of the vegetables or discarding the water in which they are cooked, since minerals dissolve into the cooking water. From a practical standpoint we need concern ourselves only with minerals which are not always supplied in the diet in sufficient amounts, particularly in the diet of low income families. These minerals are iron, calcium and phosphorus.

Losses in Preparation of Vegetables

Losses of minerals result from the preparation of vegetables, because edible parts are discarded, and because the vegetables are frequently peeled or cut into pieces. It is a common practice to discard certain parts of vegetables, such as the outside green leaves of head lettuce and cabbage, the stems and midribs of leafy vegetables, the green leaves and stalks of celery, the peelings, etc.

The green portions of vegetables are particularly rich in calcium and iron, the green leaves having a much higher calcium and iron content than the bleached leaves. On the other hand, the stems and midribs of leaves contain much less iron, less phosphorus and a lower vitamin content than the leafy portion. They also require longer cooking than the leafy
portion, and longer cooking causes greater losses of nutrients. For these reasons it may be justifiable to discard the stems and midribs of leafy vegetables when ample quantities are available.

In a study made by the Department of Home Economics of the Mississippi Experiment Station on methods used by Mississippi housewives for preparing and cooking vegetables, it was found that the majority of the women did not use the stems and midribs of leafy vegetables, unless they were young and tender. Peeling are usually thrown away, although analyses of different parts of Irish potatoes have shown that the skin and the layer under the skin have a higher mineral content than the inner portions of the potato.

Vegetables which have been peeled lose more minerals in boiling than those left whole, and large losses occur when vegetables are cut into small pieces.

**Losses in Cooking Vegetables**

The losses of minerals resulting from the cooking of vegetables depend upon the methods used. Vegetables may be boiled, steamed, cooked in the pressure cooker, baked, or fried. It is obvious that no minerals are lost in baking, and there is little or no loss in frying, so these methods need not be considered in a discussion of losses of minerals in cooking.

The most common method of cooking vegetables is boiling them, but in general practice the amount of water used and the time of cooking vary. In the study of methods of cooking vegetables used by Mississippi housewives referred to above, it was found that the most usual method of cooking was boiling in at least enough water to cover the vegetable, although the majority cooked mustard in less than enough water to cover it. The time of cooking depended upon the vegetable. Mustard and English peas were cooked an hour or more by 60 percent of the 124 women interviewed; cowpeas (field peas) and butter beans were cooked 1 1/2 hours or more, and string beans were cooked 2 hours or more by 80 percent of the women. Turnip tops and collards were cooked 2 hours or more by 50 and 63 percent of the women. Thus, relatively long cooking periods in at least enough water to cover the vegetables were used by the majority of Mississippi housewives in boiling vegetables. Although this study was made some years ago, and cooking methods have improved as a result of education, recent inquiries have disclosed that many women still boil their vegetables for a relatively long time.

**Losses of Iron**

Iron is an essential part of the hemoglobin, or red coloring matter in the blood, which carries oxygen to the tissues. It is also necessary for the functioning of living cells. Leafy vegetables have a high iron content and the legumes, as peas and beans, are good sources of iron. They contain less iron than leafy vegetables, but more of their iron is available to the body than that which is present in leafy vegetables.

In order to determine the effect of different methods of cooking vegetables on losses of iron, this Department carried out a study in which common southern vegetables of high iron content were cooked. The vegetables selected for study were turnip tops, mustard, collards, string beans, field peas, English peas, and butter beans.

The same general methods of preparation were used in this study as those employed by the Mississippi housewives. The majority of the women did not steam their vegetables, but steaming and cooking in the pressure cooker were included in the methods tested. String beans were broken into pieces before cooking. The stems of the leafy vegetables were discarded. Enough of each vegetable was cooked (2/3 to 1 pound) to make four or five servings. Cooking in smaller quantities, as has often been done in experimental work of this kind, might lead to greater losses of iron and
the results would therefore be misleading. Five different methods of cooking were used, as follows:

1. Boiling in more than enough water to cover the vegetable 1 to 2½ hours.
2. Boiling in more than enough water to cover the vegetable ½ to 1¼ hours.
3. Boiling in ½ to ¾ enough water to cover the vegetable ½ to 1½ hours.
4. Steaming 1 to 1½ hours.
5. Cooking in a pressure cooker at 10 to 15 pounds pressure 8 to 15 minutes.

The amount of water used and the time of cooking varied with the vegetable. Method 1 gives the longest period of time ordinarily used by the women to cook the vegetables; method 2, the shortest time required to get the vegetable tender. The vegetables were put in boiling water when cooked by the first three methods. After cooking, the vegetables were drained from 3 to 5 minutes. The fresh, and cooked, vegetable and the cooking water were analyzed separately for iron.

The losses of iron which resulted when the seven vegetables were cooked by the different methods are shown in Table 1. The greatest losses occurred in all seven vegetables when they were boiled the longest period of time in the largest quantity of water. Collards, string beans and field peas lost from 25 to 29 percent of their iron when cooked in this way.

The loss varied in different vegetables from 9 to 29 percent, mustard losing the least iron. The average loss of iron for the seven vegetables was 20.5 percent, or one fifth of the iron which was present.

When the vegetables were boiled in the same quantity of water as that used in method 1, but a shorter time (method 2), they lost less iron in every instance. The average loss of iron for the second method of cooking was 16.6 percent. Vegetables boiled by the third method, that is, those boiled in the smallest amount of water the shortest time lost an average of only 9.8 percent of their iron, or less than half as much iron as when boiled by the first method. The smallest losses of iron resulted from steaming or cooking in the pressure cooker. An average of 6.9 percent of the iron was lost when the vegetables were steamed and an average of 5 percent when cooked in the pressure cooker. Thus, steaming and cooking in the pressure cooker resulted in the loss of only one third and one fourth as much iron as boiling by the first method.

Graph 1 shows the comparative losses of iron which resulted when the leafy vegetables and the legumes were cooked in three different ways. The legumes included field peas, butter beans, and English peas; but did not include string

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>(1) Boiled in more than enough water to cover, 1 to 2½ hrs.</th>
<th>(2) Boiled in more than enough water to cover, ½ to 1¼ hrs.</th>
<th>(3) Boiled in less than enough water to cover, ½ to 1¼ hrs.</th>
<th>Steamed ½ to 1 1/3 hours</th>
<th>Pressure cooked 8 to 15 min. 10 to 15 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnip tops</td>
<td>18.0</td>
<td>16.1</td>
<td>7.3</td>
<td>7.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Mustard</td>
<td>9.3</td>
<td>8.8</td>
<td>7.0</td>
<td>6.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Collards</td>
<td>29.2</td>
<td>26.2</td>
<td>17.0</td>
<td>10.5</td>
<td>---</td>
</tr>
<tr>
<td>Field peas</td>
<td>25.5</td>
<td>21.6</td>
<td>10.9</td>
<td>7.4</td>
<td>---</td>
</tr>
<tr>
<td>English peas</td>
<td>13.1</td>
<td>10.8</td>
<td>8.0</td>
<td>5.0</td>
<td>7.3</td>
</tr>
<tr>
<td>Butter beans</td>
<td>19.2</td>
<td>11.7</td>
<td>6.2</td>
<td>4.2</td>
<td>4.9</td>
</tr>
<tr>
<td>String beans</td>
<td>29.0</td>
<td>21.3</td>
<td>12.2</td>
<td>6.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Average</td>
<td>20.5</td>
<td>16.6</td>
<td>9.8</td>
<td>6.9</td>
<td>5.0</td>
</tr>
</tbody>
</table>

*(1) and (2) boiled in 1½ c. to 1 qt. of water; (3) boiled in 3/4 c. to 1½ c. of water.
beans, since they are pods, not seeds. As might be expected, the seeds lost less iron than the leafy vegetables for all three methods of cooking, although the difference was small for the method which caused the largest losses of iron.

In general the results obtained by us on losses of iron by the different methods of cooking correspond with those reported by other investigators. Thus, all have found that the amount of water used and the length of time the vegetables are cooked affect the losses of iron, and that the losses increase when the quantity of water and the cooking time are increased. Other workers have also found that steaming and cooking in the pressure cooker caused the smallest losses. If, however, conditions are such within the steamer that water washes down over the vegetables, or the vegetables in the pressure cooker are surrounded with water, large losses of iron may occur.

Peterson and Hoppert reported losses for iron in 16 different vegetables boiled in two ways, steamed and cooked in the pressure cooker. The vegetables included asparagus, string beans, beet greens, cabbage, cauliflower, celery, celery cabbage, spinach, beets, carrots, kohlrabi, onions, parsnips, Irish potatoes, sweet potatoes and rutabagas. The vegetables were cut in small pieces and about 1 to 1 1/2 pounds of each vegetable were cooked. They were boiled in just enough water to cover them, and in twice that amount of water, for about 30 minutes; steamed 40 minutes, and pressure cooked 15 minutes at 15 pounds pressure. The losses of iron varied greatly for different vegetables, but were largest when the vegetables were boiled in the most water; and least when they were steamed or cooked in the pressure cooker. The losses for leafy vegetables were greater than those for roots, tubers and bulbs. Table 2 shows the losses of iron for four of the vegetables.

Peterson and Hoppert reported much larger losses for iron in leafy vegetables than we found. The losses for string beans, except for steaming, are more comparable to ours. The differences in results are doubtless due chiefly to the fact that Peterson and Hoppert cut their vegetables into small pieces whereas ours were left whole with the exception of string beans. Differences in results may also have been due to differences in the nature and composition of the cooking water. The reaction of the water, that is, whether it is acid or alkaline, and the minerals present in the water, are known to affect losses in cooking. Alkali in the water causes increased losses of nutrients, but the vegetables become tender in a shorter time. In the Mississippi study distilled water which is neutral in reaction, and contains no minerals, was used. Peterson and Hoppert do not state what kind of water was used.
Losses in Calcium and Phosphorus

Calcium and phosphorus are both necessary for the building of bones and teeth. Although the bones and teeth contain over 99 percent of the calcium and about 70 percent of the phosphorus of the body, these two elements are essential in the functioning of many kinds of body tissues. Leafy vegetables, especially those of the cabbage family, contain relatively large amounts of calcium, while the leguminous vegetables have a high phosphorus content.

Peterson and Hoppert also determined losses of calcium and phosphorus in the sixteen vegetables which they cooked. The results for four of the vegetables are shown in table 2. In most cases the calcium and phosphorus losses were smaller than those for iron; exceptions were cabbage and sweet potatoes. The trend, however, was the same so far as methods of cooking were concerned. That is, the greatest losses took place when the largest amount of water was used, and the smallest losses occurred when the vegetables were steamed or cooked in the pressure cooker. It will be noted that the calcium losses for beet greens were small. The reason for this is that this vegetable contains an insoluble form of calcium. This calcium cannot be used by the body.

The results of Peterson and Hoppert show that some of the leafy vegetables may lose half or even more of their calcium, phosphorus and iron when they are cooked by certain methods.

We see, therefore, that losses of iron, calcium and phosphorus depend upon a variety of factors, chief of which are the kind of vegetable, the amount and kind of water used, the time of cooking and whether the vegetables are cut up or left whole. Since minerals are not destroyed in cooking, it is obvious that they will not be lost if the cooking water or pot liquor is used.

Losses in Preservation of Vegetables

Canning. The same factors which affect losses of minerals in cooking affect

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Method of cooking</th>
<th>Losses of calcium</th>
<th>Losses of phosphorus</th>
<th>Losses of iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>String beans</td>
<td>Boiled (1)</td>
<td>22.3</td>
<td>21.4</td>
<td>38.1</td>
</tr>
<tr>
<td></td>
<td>Boiled (2)</td>
<td>29.3</td>
<td>27.6</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>Steamed</td>
<td>16.3</td>
<td>18.8</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>Pressure cooker</td>
<td>6.9</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>Boiled (1)</td>
<td>61.6</td>
<td>45.1</td>
<td>56.4</td>
</tr>
<tr>
<td></td>
<td>Boiled (2)</td>
<td>72.3</td>
<td>59.9</td>
<td>66.6</td>
</tr>
<tr>
<td></td>
<td>Steamed</td>
<td>40.2</td>
<td>22.0</td>
<td>34.6</td>
</tr>
<tr>
<td></td>
<td>Pressure cooker</td>
<td>28.7</td>
<td>19.3</td>
<td>23.1</td>
</tr>
<tr>
<td>Beet greens</td>
<td>Boiled (1)</td>
<td>8.6</td>
<td>35.0</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>Boiled (2)</td>
<td>15.9</td>
<td>44.9</td>
<td>43.1</td>
</tr>
<tr>
<td></td>
<td>Steamed</td>
<td>3.8</td>
<td>14.0</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>Pressure cooker</td>
<td>13.9</td>
<td>8.5</td>
<td>8.4</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>Boiled (1)</td>
<td>35.9</td>
<td>33.7</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>Boiled (2)</td>
<td>38.3</td>
<td>44.4</td>
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<tr>
<td></td>
<td>Steamed</td>
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<tr>
<td></td>
<td>Pressure cooker</td>
<td>16.7</td>
<td>8.7</td>
<td>6.4</td>
</tr>
</tbody>
</table>

(1) Boiled with just enough water to cover vegetable.
(2) Boiled with twice as much water as (1).
*Data from Peterson and Hoppert.
losses in canning. Certain methods used in canning, however, may cause additional losses. These are: (1) blanching, and (2) processing the vegetables at a higher temperature than is used in ordinary cooking. Blanching is pre-cooking the vegetable in boiling water before it is placed in the can. Since the time of blanching is short, usually from two to ten minutes, mineral losses are not as great as in cooking.

Losses of phosphorus, varying from 3 percent for carrots, to 12 and 20 percent for English peas and to 48 percent for spinach, have been reported. No information was found on losses of iron. Processing of vegetables at a relatively high temperature as in a pressure cooker causes greater breakdown of the vegetable tissue than occurs in boiling and, therefore, greater losses of minerals when they are surrounded by water. The practice of throwing away the liquor in canned vegetables is, therefore, no more justifiable than throwing away the pot liquor in boiled vegetables.

An interesting finding in connection with the cooking and canning of vegetables is that the amount of calcium in the water used affects the amount of calcium in the cooked or canned vegetable. Vegetables which are cooked, blanched or canned in hard water containing calcium, may absorb considerable calcium instead of losing it.

Freezing. All vegetables which are to be quick-frozen are first blanched for two to three minutes. The losses will of course correspond to those in blanching for canned vegetables. There is some breaking down of the vegetable tissue due to freezing which could cause greater losses of minerals in cooking, but this is probably offset by the smaller losses which would result from the shorter cooking time required for quick-frozen vegetables.

Drying. It is obvious that there is no loss of minerals when fresh vegetables are dried. Losses would occur only when the vegetables are cooked. Since the fresh, succulent vegetables are usually cut up before being dried, and since they must be soaked for several hours before cooking, large losses of minerals will occur, especially if they are not cooked in the water in which they are soaked. These are additional reasons for using the cooking water from dried vegetables.

LOSSES OF VITAMINS IN VEGETABLES

The vitamins with which we are chiefly concerned in the preparation of vegetables are vitamins A, B, and C. Ac-
cording to our present knowledge, it is these three vitamins which are most affected by the various processes to which vegetables may be subjected from the time of harvesting until they are eaten. Moreover, many southern diets have been found to be deficient in one or more of these vitamins, especially vitamin C. Each of these vitamins will be discussed separately. It may be pointed out in general, however, that the same factors which affect losses of minerals also affect losses of vitamins. In addition, there are other factors which bring about losses of vitamins which have little or no effect on mineral losses. Vitamins are not only lost because they are soluble in the cooking water, but they are also lost through destruction by heat and oxidation.

**Vitamin A**

Vitamin A is essential to the normal functioning of the body. It is necessary for growth and for reproduction. It aids in the resistance to infections, in the functioning of the glands, and is necessary for normal eyesight. Thus, persons whose diet contains too little vitamin A are apt to suffer from night blindness.

This vitamin does not exist in plants as such. Their vitamin A value is due to a yellow substance called carotene, which is transformed by the body into vitamin A. For this reason the terms "carotene" and "vitamin A" are often used interchangeably in referring to carotene in plants.

The green leafy vegetables, particularly those with thin leaves, as spinach and turnip greens, are very rich in vitamin A. The yellow vegetables are also good sources of it. In green plants, or parts of plants, vitamin A or carotene is associated with greenness. The yellow color is masked by the green chlorophyll. Thus, the inside bleached leaves of head lettuce and cabbage contain very little vitamin A, while the outside green leaves are rich in it, as has been pointed out in a previous article.* In preparing these and other vegetables, as cauliflower and celery, we should not, therefore, throw away edible green parts.

**Losses in Cooking**

Both vitamin A and carotene are nearly insoluble in water, but are soluble in fats and oils. That is, they will dissolve only slightly in water, but will dissolve in fats and oils. Consequently, they will not be dissolved to any extent in the cooking water unless it contains fat. Also, they are not destroyed by high temperatures if oxygen is not present, but may be destroyed by oxidation. Ordinary cooking will, therefore, cause little loss of vitamin A. Some destruction has been reported when vegetables were boiled as long as an hour. It is probable that slow cooking of green vegetables with fat for two to three hours may cause considerable loss of vitamin A. Some of the vitamin A will be in the cooking water and some will have been destroyed.

**Losses in Preservation**

**Canning.** Destruction of vitamin A in vegetables does not take place to any extent in blanching and canning because there is little opportunity for oxidation to occur. In processing, all or a part of the air is excluded. For this reason, canned green or yellow vegetables may be better sources of vitamin A than the cooked vegetables.

**Freezing.** The processes used in freezing also have little effect on the vitamin A content of vegetables. Zimmerman, Tressler and Maynard found that the freezing of broccoli, spinach, lima beans and asparagus resulted in no loss of their vitamin A value. Storage of the frozen vegetables at 40 degrees for five months also led to no loss of vitamin A.

**Drying.** This is the least desirable

method of preserving vegetables from the standpoint of vitamin A losses, because of the opportunity for destruction through oxidation. Very little information exists on losses of vitamin A in dried vegetables, but it has been found that dried grasses and dried fruits may have lost half or more of their vitamin A value in a few months’ time. In spite of such large losses, leafy vegetables are so rich in vitamin A that they would still be good sources of it. The extent of vitamin A losses will depend upon the temperature and time of drying and storage. Drying at a relatively high temperature, which shortens the time of drying and destroys oxidative substances in the plant, and storing at low temperatures, decrease the loss of vitamin A.

**Vitamin B**

Vitamin B₁, like vitamin A, is an essential constituent of the diet. It also is necessary for growth and for reproduction. It stimulates the appetite and aids in digestion. It is necessary for the normal functioning of the nerves. When this vitamin is almost completely lacking, a disease called “beri-beri” develops, which causes wasting and paralysis. Beriberi is common in the Orient, but not in this country, although many American diets contain insufficient amounts of vitamin B₁.

Vitamin B₁ is soluble in water and exists in plants in a form which is easily extracted by water. It is destroyed by heat in the presence of an alkali, as soda, but not in the presence of acid except at high temperatures.

Like most other foods, vegetables do not have a high vitamin B₁ content, but are important sources of it in the diet because we eat them in fairly large amounts. The seed vegetables, such as cowpeas, soybeans and butter beans, are an exception, for they are rich in vitamin B₁, especially soybeans.

**Losses in Cooking**

Vegetables may be boiled for an hour or longer without destroying more than 10 to 15 percent of their vitamin B₁ content, provided soda has not been added. The addition of soda, however, may cause very extensive destruction of vitamin B₁. Cooking losses in the absence of alkali are brought about mainly by the solution of vitamin B₁ in the cooking water. Half of the vitamin B₁ content of spinach was found to have dissolved out into the cooking water when it was boiled 15 minutes. Other leafy vegetables could be expected to lose comparable amounts. Cutting the vegetables into pieces would increase the cooking losses of vitamin B₁ as it is soluble in water.

Since the seed vegetables, that is, the legumes, are among the few rich sources of vitamin B₁, and since they are an important class of foods, information on the losses of vitamin B₁ in cooking these vegetables is of particular value. Studies have been reported by Kelly and Porter, Aughey and Daniel, and Lantz on cooking losses of vitamin B₁ in several varieties of beans, including two varieties of common bush shell beans, navy beans, and pinto beans.

The two varieties of shell beans and the navy beans did not lose any of their vitamin B₁ content as the result of the cooking processes used, which included soaking, boiling and baking. There was some reduction in the vitamin B₁ content of pinto beans, especially when boiled for a long time in alkaline tap water. Pinto beans boiled six hours were, however, still an excellent source of vitamin B₁. Cooking with soda at high temperatures was found to be very destructive of vitamin B₁.

**Losses in Preservation**

*Canning.* The losses of vitamin B₁ in canning are not due to its destruction, but to its solution. The water used in blanching and the liquor surrounding the vegetable in the can extract the vitamin. It is probable that loss of vitamin
B1 occurs during storage of canned vegetables, but there is very little information on this subject.

Freezing. Vitamin B1 is not affected by the quick-freezing of vegetables, but blanching may cause considerable loss of this vitamin in those vegetables which show a tendency to lose it in cooking. Lima beans and broccoli lost about 50 percent, and asparagus and peas 25 percent of their vitamin B1 content after they had been frozen.

Drying. Little is known about the effect of drying on vitamin B1 in foods. Drying at low temperatures seems to cause little destruction, but at high temperatures the destruction is probably much greater.

Vitamin C

Vitamin C stimulates growth. It is essential for functioning of the glands and other tissues of the body. It favors the development of good teeth and is necessary for healthy gums.

Vitamin C is known as the anti-scorbutic vitamin, because when it is lacking in the diet the disease, scurvy, develops. Soldiers and sailors formerly suffered greatly and many died from this disease because their diet contained no fruits or vegetables. At the present time, scurvy is seldom seen in this country, but many persons consume diets which contain too little vitamin C for good health.

It has been stated that if vitamin C is retained in vegetables, all other nutrients will be retained because vitamin C is the most easily destroyed of all the vitamins. Moreover, no other nutrient, including minerals, is more easily dissolved.

Vitamin C is destroyed by oxidation when foods containing it are exposed to the air. Substances called oxidases, which occur in plants, assist in this process of oxidation. Destruction of vitamin C goes on more rapidly as the temperature increases. Fortunately, the oxidases themselves are quickly destroyed by the boiling temperature.

All fresh vegetables contain vitamin C, but certain vegetables are especially good sources of it. Peppers are particularly rich in this vitamin. Cabbage and other members of the cabbage family, as kale and cauliflower; also turnip greens, mustard greens and other leafy vegetables contain large amounts of it. The tomato, an excellent source of vitamin C, is used as a vegetable, but in reality is a fruit.
Losses in Storage and Preparation

The destruction of vitamin C begins as soon as vegetables are harvested. The rapidity of this destruction depends upon the type of the vegetable and the temperature. Non-acid vegetables and those with thin leaves lose vitamin C more rapidly than other kinds of vegetables. Refrigeration decreases the rate of destruction of vitamin C. Spinach was found to lose half of its vitamin C when left at room temperature for three days, but when stored in the refrigerator at 32-37 degrees F. for the same length of time lost very little. Whole heads of cabbage lost vitamin C slowly when stored, while carrots lost no vitamin C after four months of storage.

The amount of surface exposed by the vegetable, as well as the condition of vegetable tissue, also affects losses of vitamin C. Lima beans left in the pod lost their vitamin C much more slowly than those which were shelled. Any method of preparation which involves grinding, chopping or cutting up the vegetable increases the surface exposed, opens up the plant cells to the air and releases oxidases. This causes a rapid loss of vitamin C, as determined in a number of studies in which vegetables were minced or chopped and allowed to stand at room temperature. Thus, the practice of cutting up vegetables and letting them stand in cold water is not a desirable one from the standpoint of preserving vitamin C.

The question of whether vitamin C could be restored in leafy vegetables which have been allowed to wilt, by refreshing them in cool water was investigated by Mississippi workers.* There was no evidence that vitamin C could be restored in this way.

Losses in Cooking

We have seen that vegetables lose vitamin C in two ways: (1) by destruction of the vitamin, and (2) by its dissolving in water. It has also been stated that the oxidase or enzyme which takes part in this destruction may itself be destroyed by heat. A temperature of 212 degrees F. (boiling temperature) for only one minute will destroy it, but a longer time is needed for the heat to penetrate the vegetable. Studies on cooking losses of vitamins in peas, Swiss chard, carrots and cabbage have shown that most of the destruction of vitamin C takes place in the first two minutes of cooking. However, if vegetables are cooked slowly so that it takes some time for them to reach the boiling point, the enzyme will have a much longer time in which to act and, therefore, will bring about a greater destruction of vitamin C. In boiling, a greater loss of vitamin C is brought about by its solution in the cooking water than by its destruction. From 20 to 66 percent may be lost in this way. The largest losses occurred when the vegetables were shredded.

Baking, steaming, stewing, and frying cause more destruction of vitamin C than boiling because of slow cooking, or high temperatures. In baking and frying the high temperatures are very destructive of vitamin C. Steaming is a slower method of cooking than boiling, but there is very little loss of vitamin C in the water used in steaming. Therefore, the total loss may be less than in boiling. Stewing, because it is a long slow method may bring about almost complete destruction of vitamin C. Therefore, if vegetables are to be added to a stew they should be cooked just long enough to get them tender.

Vitamin C, like vitamin B1, is destroyed by alkali. This is an additional reason for not using soda in cooking vegetables.

Not only do vegetables lose vitamin C in the process of preparation and cooking, but also after they are cooked if they are kept warm or allowed to stand at room temperature. Even when stored
in the refrigerator the loss of vitamin C in most cooked vegetables is considerable. Warmed-over vegetables are, therefore, likely to contain very little vitamin C.

**Losses in Preservation**

Canning. Vegetables usually retain more of their vitamin C when they are canned than when they are cooked by ordinary methods. The principal reasons for this are the blanching of vegetables, which destroys the oxidase, and the removal of air by exhaustion of the cans before they are sealed and processed. Although less vitamin C is destroyed in canning than in ordinary cooking, more vitamin C may go from the vegetable into the liquor when vegetables are canned. The high temperature used in canning breaks down the plant cells, and vitamin C is released.

Acid vegetables lose less vitamin C when canned than non-acid vegetables. It has been reported that tomatoes lost no vitamin C when home canned, either by the cold- or hot-pack method. Care was taken, however, to reduce the head space in the jar to a minimum, for it has been found that the amount of destruction of vitamin C in tomato juice during cooling and storage corresponds to the amount of head space left in the bottle. A great loss of vitamin C occurred during cooling and storage when the bottles were only partially filled with tomato juice. The extent of the loss of vitamin C seemed, therefore, to depend upon the amount of air remaining in the container.

Canned vegetables lose vitamin C slowly, but at varying rates during storage. In the above-mentioned study on home canned tomatoes, from 30 to 50 percent of this vitamin was lost during six months storage. A recent study made by Fellers and Buck on commercially canned vegetables indicates that with improved
commercial methods the destruction of vitamin C during storage may be reduced considerably. Three varieties of strained peas, spinach and tomato juice packed in glass containers and stored for one year at room temperature (70-80 degrees F.) lost only 10 to 25 percent of their vitamin C content. Very little loss occurred after the first two or three months of storage, when the disappearance of oxygen from these foods was complete. Storage of the vegetables at 36 degrees F. for one year reduced the loss of vitamin C to less than 5 percent.

Reheating canned vegetables causes further loss of vitamin C, although the loss is probably small unless they are heated too long, or allowed to stand.

Freezing. When properly blanched, the loss of vitamin C in quick-frozen vegetables is small. The vitamin C content of cooked quick-frozen vegetables is about the same as that of the freshly cooked vegetables if the methods of cooking are comparable.

Drying. In general drying is very destructive of vitamin C, although some vegetables seem to retain their vitamin C after they have been dried, better than others. According to several reports, savoy and red cabbage lost 14 to 24 percent; carrots, tomatoes and onions, 40 to 60 percent; and celery, green beans, potatoes, parsley, spinach, and cabbage, 70 to 95 percent of their vitamin C when dried. It is evident from these reports that most dried vegetables would be poor sources of vitamin C.

SUMMARY

Losses of Minerals. Minerals are lost because they dissolve out of the vegetables into the cooking water. They are not destroyed. The loss of iron, calcium, and phosphorus in the cooking of vegetables depends upon the method of cooking, the type and condition of the vegetable, and the kind of water that is used.

The greatest losses of these minerals occurred when the vegetables were cooked the longest time in an excess of water, and the smallest losses when they were steamed or cooked in the pressure cooker. Leafy vegetables lost more of their minerals than seeds, roots, bulbs, or tubers.

Cutting the vegetables into small pieces increases the losses of minerals in cooking.

Calcium losses of vegetables are small when vegetables contain an insoluble form of calcium.

Calcium may be absorbed by vegetables when cooked in hard water containing calcium.

The losses of minerals in canning may be greater than those in ordinary cooking, because of the losses in blanching, and those due to greater breaking down of vegetable tissue in processing.

Mineral losses in the cooking of frozen vegetables are also increased by blanching and the breaking down of the vegetable tissue, but this increased loss is probably offset by the shorter cooking time used for frozen vegetables.

Losses of vitamins. Vitamins A, B, and C are the vitamins present in vegetables which are most affected by the processes used in their preparation and preservation.

Vitamin A exists in plants in the form of a yellow substance called carotene, which is transformed by the body into vitamin A. Green leafy vegetables are very rich in carotene, and yellow vegetables are good sources of it.

Carotene and vitamin A are not soluble in water, but are soluble in fats and oils. They are stable towards heat but may be destroyed by oxidation.

Ordinary cooking and canning processes cause little loss or destruction of vitamin A. Long cooking in water containing fat may cause destruction of vitamin A and loss in the cooking water.

Quick-freezing of vegetables does not
result in loss of their vitamin A value. Loss of this vitamin was not observed after several months storage.

Drying is destructive of vitamin A because of the opportunity for oxidation. Leafy vegetables may lose half or more of their vitamin A as a result of drying and still be good sources of it.

Vitamin B₁.—Most vegetables do not have a high vitamin B₁ content. Legumes are an exception as they are rich in this vitamin.

Vitamin B₁ is soluble in water and easily extracted by it when vegetables are cooked in water. It is destroyed by heat in the presence of alkali, as soda, but not in the presence of acids, except at high temperatures.

Cooking and canning processes do not destroy vitamin B₁ to any extent, except in the presence of alkali. Losses are brought about chiefly by the solution of vitamin B₁ in the cooking water. Blanching may cause considerable loss of vitamin B₁.

In the quick-freezing of vegetables vitamin B₁ is lost in the blanching process, but is not affected by freezing.

Vitamin C—All fresh vegetables contain vitamin C. Particularly good sources of it are peppers, vegetables belonging to the cabbage family, and all leafy vegetables and tomatoes.

Vitamin C is more easily destroyed than any of the other vitamins. It is oxidized when foods containing it are exposed to the air. Thus, vegetables begin losing vitamin C as soon as they are harvested. Plants contain an oxidase or oxidizing enzyme which plays an important part in the destruction of vitamin C. This destruction goes on more rapidly as the temperature increases, but the oxidizing enzyme is destroyed by the boiling temperature. When vegetables are put into boiling water, which is kept boiling, the oxidase is quickly destroyed, and the vegetables retain their vitamin C much better than when they are cooked slowly. Slow, long cooking is very destructive of vitamin C. High temperatures above the boiling point are also destructive of this vitamin.

Vitamin C is very soluble in water. In boiling, more vitamin C goes into the cooking water than is destroyed.

Chopping or shredding vegetables greatly increases the loss of vitamin C through oxidation and, if they are cooked, through loss of vitamin C in the cooking water.

Cooked vegetables allowed to stand lose vitamin C. The rate of destruction is highest when they are kept warm, but there is considerable loss in the refrigerator.

Vegetables usually retain more vitamin C when they are canned than when they are cooked, but much of the vitamin may go into the canning liquor.

Acid vegetables lose less vitamin C when cooked or canned than non-acid vegetables.

Canned vegetables lose vitamin C during storage. The loss is related to the head space in the jar and the amount of oxygen remaining in the vegetables. Reheating canned vegetables causes further loss of vitamin C.

Quick-freezing is not destructive of vitamin C. Cooked frozen vegetables and freshly cooked vegetables have about the same vitamin C content when cooked by similar methods.

Drying is very destructive of vitamin C in vegetables. The loss depends upon the method of drying and the kind of vegetable.