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# Nutritive Value of Brined and Fermented Vegetables*

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THE urgency of the food production and preservation program which has faced this nation for the past year cannot be overemphasized. This critical food problem still remains unsolved. To assist in meeting the challenge presented, research men and commercial food processors alike are investigating the possibilities offered by all methods of food preservation.

The salting or brining of food is one of the oldest preservation methods practised by man. Today we recognize that this method still offers tremendous possibilities both for commercial and home preservation of many foods.

An adequate study of the nutritive value of foods preserved by any method should properly include a comparison of the nutritive quality of the processed foods with that of the fresh produce before processing. Generally speaking, a loss in nutrients takes place whenever food is processed whether such treatment be for the purpose of preservation or for cooking for table use. Such loss is dependent upon the products receiving treatment, the processing treatments given, and the care exercised during processing.

The nutrient constituents of a food deserving consideration in a preservation study include carbohydrates, proteins, minerals, and vitamins. There may be a loss of these constituents during food processing either through solution or leaching out of soluble constituents, or through destruction due to chemical changes during processing and storage. Also, since the brining process involves preservation as a result of, or accompanied by, microbiological activity, nutrients may be lost through utilization by microörganisms.

Throughout this discussion the term "brining" will be used whenever reference is made to the preservation of vegetables either through the use of solid salt or through the use of salt brines. Actually, in the preservation of vegetables by this method, the preservation action takes place in brine. The brine may be added as a solution of common salt or it may be formed as the result of the dissolving of solid salt in water withdrawn from the vegetables.

In this connection there seems to be a common belief that brining or salting may be done in such a manner that fermentation either will or will not take place depending upon the exact procedure followed. However, reports by the authors [1, 2] indicate that, throughout the range of brine strength employed in vegetable preservation (upwards of 90 per cent saturation), certain types of salt-tolerant microörgan-

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isms are able to grow and contribute to the general fermentation.

Hence, we consider that a distinction cannot be made between brining procedures strictly on a basis that they will either permit or prevent microbiological activity (fermentation) as the result of such treatments.

The brining of vegetables is an established part of the pickle manufacturing industry. Included among those vegetables so preserved are cucumbers, onions, peppers, tomatoes, and cauliflower. These brined vegetables receive a desalting treatment prior to manufacture into the finished pickle products. Such products have a definite place in our diet but represent a small part of the total food consumed.

The brine preservation of vegetables which can be consumed as non-pickle products, and which can contribute greatly to the food value of our diet offers a distinct possibility for both commercial and domestic-scale production. Vegetables which have been brined for use as non-pickle products include beets, carrots, celery, cauliflower, cabbage, okra, snap beans, green peas, lima beans, greens, and corn. These are important sources of proteins, starch, minerals, and vitamins in the diet.

The salt concentration employed in brining varies from 2½ to 25 per cent by weight, depending upon the vegetable receiving treatment. Sauerkraut from cabbage, or a similar product made from lettuce, turnips, or rutabagas, contains from 2 to 2½ per cent salt. Snapbeans preserved in a low-salt brine contain 5 per cent salt. These products are used in the diet directly without desalting.

Green peas, lima beans, corn, and similar vegetables are generally preserved by the use of either strong brines or large amounts of salt (15 to 25 per cent). In commercial practice snapbeans are mixed with 20 per cent solid salt. With such vegetables it is necessary to reduce the salt concentration materially before they are edible. The reduction in saltiness may be brought about in two ways: Either by the use of a small amount of the salted material in a large volume of soup or a similar preparation; or by soaking in a suitable volume of fresh water before preparing for table use.

The domestic brining of vegetables has been recommended over a period of years by several investigators [3-7] and by the Agricultural Extension Service in many states. Although this method has been repeatedly employed for food preservation, there have been very few reports concerning the nutritive value of such food.

Losses in nutritive constituents may occur, during preservation by brining in the following phases of the process: (1) during preparaton, such as peeling, slicing, or shelling, due to oxidation; (2) during blanching, as the result of leaching; (3) during fermentation as the result of microbiological activity; (4) during the curing and storage period through leaching or through chemical destruction; and (5) during desalting, largely as the result of leaching.

In general, in the brining of vegetables, the soluble carbohydrates or sugars are reduced to a low concentration either during the preservation process, or subsequently during desalting, if the latter process is required.

Brining procedures which are based on the preservation of vegetables at low or moderate salt concentrations (2½ to 10 per cent salt by weight) will be responsible for the complete destruction of the sugars present. This destruction occurs due to the utilization of the sugars by salt-tolerant microörganisms. Brining treatments utilizing high salt concentrations (15 to 25 per cent salt by weight) retard, but do not necessarily prevent, microbiological ac-

TABLE 1

*Effect of Brining Treatments on the Protein Content of Certain Vegetables*

| *Vegetables* | *Pre-brining Treatment* | *Brining Treatment Vegetables Covered with Brine of Strength Listed* | *Desalting Treatment* | *Protein Content Expressed as Percentage of Edible Substance* | | *Protein Retention Per cent* |
|---|---|---|---|---|---|---|
| | | | | *Preserved Material* | *Fresh Material* | |
| Snap beans | Blanched 2 min. in boiling water | 5% salt + vinegar | None | 1.14 | 1.21* | 94 |
| Snap beans | None | " | " | 0.88 | 1.86 | 47 |
| Snap beans | " | 15% salt | 24 hrs.† | 0.67 | 2.4‡ | 28 |
| Lima beans (green) | " | " | " | 4.85 | 7.5‡ | 65 |
| Peas (green) | " | " | " | 5.79 | 6.7‡ | 86 |

* Represents the protein value after blanching; initial fresh value was 1.86 per cent
† 1 lb. brined vegetables in 1 gal. water
‡ Data by Chatfield and Adams [11]

tivity.[8, 9, 1] Vegetables preserved by such brining treatments may lose only a portion of their original sugar content during the preservation process. Fabian and Blum [9] have demonstrated, qualitatively, the presence of appreciable quantities of sugar in corn preserved in brines containing 15 and 20 per cent salt and in peas preserved in brine containing 20 per cent salt after a 6 month storage period. If the brined product is used in the diet in soups or in a similar manner not requiring desalting, the remaining sugar will not be lost. Desalting will effectively reduce the sugar concentration to a very low level irrespective of the amount of sugar which may remain at the end of the fermentation process.

The fate of starch during brine preservation has not, to our knowledge, been reported in the literature. Qualitative tests by the authors demonstrated that starch was present in brined snap beans, lima beans, and peas after a 15 month storage period. This is significant in view of the fact that snap beans, immature corn, peas, and lima beans contain appreciable quantities of starch.[11]

Certain proteins are water- and brine-soluble. These may be lost during hot water blanching, by draining away with the brine, or by desalting if these operations are followed. Also a portion of the protein fraction is utilized by the microörganisms associated with brine fermentations.

Relative to actual losses of protein during brining, there is but limited information reported. The protein content of cabbage and sauerkraut is reported as essentially the same in the tables prepared by Chatfield and Adams.[11] This should be the case provided there has been neither a loss of kraut juice nor a replacement of the juice with a fresh brine.

Table 1 lists the protein content of snap beans, and immature lima beans and peas in studies conducted by the authors. In every case a loss in protein has accompanied the brining operation. The extent of loss appears to vary with the kind of vegetables brined. Also, the short blanch given snap beans materially prevented protein loss with this vegetable.

These data further indicate that, in spite of the possibilities of loss in brining as pointed out above, brine-preserved vegetables when prepared for table use showed a marked retention of protein. The retention varied from a high of 94 and 86 per cent for blanched snap beans and unblanched peas respectively, to a low of 28 per cent for unblanched snap beans from a strong brine. Attention is called to the fact that a 35 per cent loss resulted from the blanching treatment given the fresh snap beans. Subsequent loss of protein during the actual preservation and storage in brine was very small, as has been previously indicated. Due to the fact that the protein values for the fresh vegetables were not determined, the retention figures for the last three vegetables listed in Table 1 were estimated using the protein values for fresh material reported by Chatfield and Adams.[11]

The soluble minerals may be lost during the blanching, brining, or desalting operations. Commercial sodium chloride, however, carries a significant amount of impurities. Due to the quantity of salt employed in the preservation process, there may actually be an increase in the amount of certain mineral constituents other than salt as a result of brining. Peterson, Elvehjem, and Jamison [12] reported an increase of nearly 50 per cent in the iron content of sauerkraut as compared with the cabbage from which it was made.

The calcium content of brined snap beans, lima beans, and peas in studies conducted by the authors is listed in Table 2. A comparison of the brined with the fresh vegetable is not possible in all cases due to the fact that analyses for the mineral content were not made for all of the lots of fresh vegetables. Included in this table for comparison are values for the calcium content of these vegetables as listed in a table by Bridges and Mattice [13] of the mineral content of fresh vegetables. The data presented are interpreted as indicating that the calcium content of brine-preserved foods may be distinctly greater than that of the fresh vegetables which received treatment.

The influence of various food preservation methods on vitamin retention has recently received a great deal of study. Two of the vitamins, namely carotene (pro-vitamin A) and ascorbic acid (vitamin C), have received particular attention relative to their behavior during the treatments involved in food preservation. Carotene is water-insoluble, and although it may be destroyed by oxidation, it is comparatively stable. Ascorbic acid (vitamin C) is water-soluble and is rapidly destroyed by oxidation, especially enzymatically. It is also readily lost by diffusion into water or liquors employed during preservation and processing.

With reference to the behavior of carotene during the preserving of

TABLE 2

*Effect of Brining Treatments on the Calcium Content of Certain Vegetables*

| *Vegetables* | *Pre-brining Treatment* | *Brining Treatment Vegetables Covered with Brine of Strength Listed* | *Desalting Treatment* | *Calcium Content Expressed as Milligrams of Calcium per 100 Grams of Edible Substance* | | *Change Induced by the Treatments Per cent* |
|---|---|---|---|---|---|---|
| | | | | *Preserved Material* | *Fresh Material* | |
| Snap beans | Blanched 2 min. in boiling water | 5% salt + vinegar | None | 24 | 28* | 33 gain |
| Snap beans | None | " | " | 19 | 18 | 6 gain |
| Snap beans | " | 15% salt | 24 hrs.† | 30 | 50‡ | 40 loss |
| Lima beans (green) | " | " | " | 44 | 28‡ | 57 gain |
| Peas (green) | " | " | " | 53 | 28‡ | 89 gain |

* Represents calcium content after blanching; initial fresh value was 18 mg./100 gm.
† 1 lb. of vegetables in 1 gal. water
‡ Data from Bridges and Mattice [13]

TABLE 3

*Influence of Brining Treatment on Carotene Retention in Certain Vegetables (After Etchells, Jones, and Hoffman[2])*

| *Vegetables* | *Brining Treatment. Vegetables Covered with Brine of Strength Given* | *Carotene Retention in Per cent* | *Time of Storage in Months* |
|---|---|---|---|
| Lima beans, unshelled, unblanched | Openheaded kegs out of doors<br>5% brine raised to 15% in 5 weeks<br>10% brine raised to 15% in 5 weeks<br>15% brine held at 15% | Distinctly under 50 | 4 |
| Peas, unshelled, unblanched | As for lima beans | 50 | 4 |
| Snap beans, unblanched | As for lima beans | Distinctly under 50 | 4 |
| Snap beans, blanched and unblanched | Closed kegs<br>4.5% brine plus vinegar. Held at 4.5% | 90–95 | 10 |
| Snap beans, blanched | Closed 1 quart jars<br>2.5, 5, 10 and 15%<br>dry salt, no brine added | 60 | 5 |
| Leafy Vegetables—<br>Kale, turnip greens and mustard greens, unblanched | Closed 1 quart jars<br>6.2% brine plus vinegar. Held at 6.2% | 50 | 4–5 |
| Carrots, blanched and unblanched | Closed 2 quart jars<br>6.2% brine plus vinegar. Held at 6.2% | Little or no loss | 6 |

foods by brining there is but limited information available. Richardson, Mayfield, and Davis[14] reported that the vitamin A content of sweet corn preserved by salting (1 part salt to 7 parts corn by weight) and subsequently desalted and cooked was the same as raw, frozen corn. Furthermore, they found that sweet corn preserved by a brine acidified with vinegar and containing a low salt concentration possessed almost twice the vitamin A content of the raw, frozen corn taken as a basis of comparison.

Etchells and Jones[15] and Etchells, Jones, and Hoffman[2] reported studies on changes in carotene content during the brining of blanched and unblanched snap beans; unshelled lima beans and peas; unblanched leafy vegetables such as kale, mustard greens, and turnip greens; and blanched and unblanched carrots. These data have been summarized in Table 3. The results indicate that carotene losses vary markedly with the vegetable receiving treatment. Under the conditions of the experiments, carrots showed little or no loss of carotene, while lima beans and snap beans, brined and stored in openheaded kegs exhibited a loss of more than 50 per cent. In addition, the results indicated that the brining treatment greatly influenced vitamin retention. Snap beans brined and stored in tightly headed kegs which were filled with an acidified, low salt content brine retained from 90 to 95 per cent of their original carotene content during 7 month storage period in brine.

Blum and Fabian[16] have recently reported changes in carotene content of blanched and unblanched peas, snap beans, corn, and lima beans, preserved mainly with brines of high salt content over a storage period of from 6 to 9 months. The vegetables were brined in 5 and 10 gallon open crocks stored indoors. These investigators summarized their studies in part as follows: "(1) The lower the salt concentration the greater the loss in carotene. . . . (2) Vegetables that were blanched and then salted lost more carotene . . . than did unblanched salted vegetables. (3) Vegetables differed in their ability to retain carotene . . . during fermentation and storage." These investigators also reported a carotene loss ranging from 2 to 17 per cent during the freshening of brined vegetables (peas, string beans, lima beans, and corn) taken from brines of high salt content. Whether this loss was real or apparent cannot be determined since the relative changes in weights of the material upon desalting were not reported.

By way of summarization of the data which has been reported on carotene losses the following observations seem justified. The loss is determined to a great extent by the vegetable under treatment and the brining method employed. Blanching of the vegetable prior to brining does not appear to favor carotene retention. Treatments employing the use of acidified brines appear to favor carotene retention materially in the preservation of snap beans; however, with vegetables such as carrots or leafy greens, such benefits have not been observed.

As mentioned earlier, ascorbic acid is water-soluble and, furthermore, it is readily oxidized, especially in non-acid media. Many vegetable tissues possess enzyme systems responsible for the rapid destruction of this vitamin.

Pederson, Mack, and Athawes,[17] after a detailed study of changes in the vitamin C content of sauerkraut during commercial manufacture arrived at the following conclusions: Raw kraut (solids plus juice) during and immediately after fermentation in large vats contains approximately the same amount of vitamin C as the original cabbage. During storage in vats after the fermentation, the vitamin C content slowly decreases. This loss in vitamin C appears to be associated with the loss of an atmosphere of carbon dioxide. Canned kraut contained only from 25 to 50 per cent as much vitamin C as freshly made kraut. This loss occurs during the processing of the kraut at the time of canning and does not continue during storage after canning.

Studies by Blum and Fabian [15] and Etchells, Jones, and Hoffman [14] on the brining of snap beans, peas, lima beans, and corn indicate that with these vegetables vitamin C is practically entirely lost. This loss occurs during the fermentation and storage period or during the desalting required to make the product edible, providing it has been preserved by the use of a large amount of salt.

As a part of our current investigations, cauliflower was brined according to several treatments as outlined in Table 4. After a storage period of nearly 7 months, the observed changes in the total ascorbic acid content of the brined cauliflower (vegetable plus brine) can be summarized as follows: Cauliflower preserved in acidified

TABLE 4

*Ascorbic Acid Content of Cauliflower Brined According to Several Treatments (After 7 Months' Storage in Brine in Closed Containers)*

| *Material* | *Pre brining Treatment* | *Brining Treatment ** | *Ascorbic Acid Content* |
|---|---|---|---|
| Fresh Cauliflower | None | None | 67 mg./100 gm. |
| Brined " | Not blanched | 5% brine only | 1% retention |
| Brined " | " " | 5% brine + vinegar † | 58% " |
| Brined " | " " | 5% brine + lactic acid † | 62% " |
| Brined " | Blanched | 5% brine only | 24% " |
| Brined " | " | 5% brine + vinegar † | 42% " |
| Brined " | " | 5% brine + lactic acid † | 50% " |

* Vegetable covered with brine containing 5% salt and acid as shown. No additional salt added.
† Initial brine acidity approximately 0.5 per cent when calculated as lactic acid.

brines showed an approximate retention of 60 per cent for the unblanched, and 46 per cent for the blanched lots. On the other hand, cauliflower preserved in non-acidified brines showed a retention of less than 1 per cent for the unblanched, and 24 per cent for blanched lots. This experiment is a striking example of marked ascorbic acid retention obtained by particular brining methods. Substantial ascorbic acid retention was obtained not only on a percentage basis but also on a quantitative basis. The unbrined cauliflower possessed an ascorbic acid content of 67 mg. per 100 gm. and after 210 days' storage in brine, the acidified lots still retained approximately 60 per cent of that amount (based on the total ascorbic acid present in the vegetable and brine).

There is little published information regarding the effect of brine preservation on vegetables in relation to retention of B vitamins. Richardson, Mayfield, and Davis [12] found that corn preserved by salting, after desalting and cooking contained about one-fourth the vitamin $B_1$ content of raw, frozen corn. Preliminary work by the authors under way at this time on the riboflavin content of peas and snap beans, preserved according to a variety of brining and salting treatments, indicates that an appreciable amount of this vitamin is retained by these vegetables.

## CONCLUSION

In conclusion it should be pointed out that the use of vegetables, which have been preserved in strong brines, in a manner not requiring desalting will result in the greatest conservation of nutrient constituents. This can be accomplished through the use of the brined material in the preparation of soups or certain vegetable mixtures.

In the absence of desalting, the total protein retention is high, and mineral losses are small; carotene retention is fair and thiamin and riboflavin may be present in significant amounts. The sugars and ascorbic acid are generally lost during the fermentation period and during brine storage.

When desalting is practised in the preparation of brined foods for table use, somewhat greater losses in protein and minerals may be encountered. The desalting operation will effectively reduce the concentration of the sugars, ascorbic acid, and probably the B vitamins to a very low level. Such losses will be in keeping with degree of dilution required adequately to reduce the salt content.

It has been shown that certain vegetables which are important sources of proteins, starches, and minerals, are well adapted to brine preservation and can be used as non-pickle products. Furthermore, the data presented show that these constituents may be well retained in such brine preserved vegetables. Accordingly, at this time of acute shortages in food supplies, of limitations in labor, transportation facilities, and food processing equipment, it behooves us to give serious consideration to the possibilities of food preservation offered by the brining method.

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