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The Effect of the Use of Salt in Cooking Vegetables

Faith R. Lanman and Elsie Steiger Minton

OHIO
AGRICULTURAL EXPERIMENT STATION
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THE EFFECT OF THE USE OF SALT IN COOKING VEGETABLES*

FAITH R. LANMAN AND ELSIE STEIGER MINTON

INTRODUCTION

The nutritive value of vegetables in the diet has been clearly demonstrated by a large number of authorities in nutrition. Dr. Sherman (1) says,

> Vegetables and fruits taken as a group may be ranked next after grain products and milk in importance as constituents of an economical and well balanced diet. They tend to correct both the mineral and the vitamin deficiencies of the grain products and in a sense they supplement the milk also in that many of the vegetables and fruits are rich in iron or vitamin C, or both.

Dr. McCollum (2) expresses his views on this subject by saying,

> In western countries the consumption of green vegetables has never reached the extent which is desirable. Here milk and its products have served as the principal 'protein food'. A marked increase in the consumption of leafy vegetables in Europe and America is to be recommended.

If vegetables are so valuable in the diet it seems wise to study carefully the methods of preparation, not only to find out how to retain their different valuable nutrients, but also how to preserve their color, and preserve or improve the flavor and texture. Miss Evelyn Halliday (3) makes the following statement in regard to this matter:

> It should be our aim, of course, to save food value as well as appearance and flavor, and by intelligent selection of a method of cooking it is usually possible to do so. If, however, we have to sacrifice anything let it be some of the food value, for if the vegetable looks well and tastes well it will be eaten, otherwise it will not.
>
> No amount of talk about the value of vegetables in the diet is going to persuade us to eat them unless we like them, while if we do like them nothing can stop us; even if we had to buy them surreptitiously we should get them and we should eat them.

*The authors wish to express their appreciation to Mrs. Pauline Snyder, a graduate student, for her assistance in the project.

The subject of vegetable cookery presents numerous questions. Among the studies reported is an investigation by Helen Masters (4) on methods of cooking beans.

> The addition of salt to cooking water in amounts of 0.25, 0.50, and 1.00 parts of salt per 100 parts of water caused losses of total solids 9.2 percent, 8.7 percent and 8.3 percent respectively showing a decrease in loss of total solids with increasing amounts of salt.

After working on a vegetable problem, Susanne Thompson (5) drew the following conclusions:

> 1. Such vegetables as onions, cauliflower, cabbage, asparagus, string beans, carrots, and peas are much more choice in flavor, color and palatability when cooked as short a time as possible to make tender.
> 2. Such vegetables are ruined in appearance, color, odor, and taste by long cooking.
> 3. The longer cooking period causes a greater loss in solids, ash, and iron than the shorter period of cooking.
> 4. Vegetables may be cooked, cooled and reheated for serving with less loss of color and flavor than if kept warm for an hour.
> 5. The loss in spinach cooked in the water which clings to the leaves is approximately the same as in spinach cooked a short time in boiling water.

Esther Cooley (6) while working on the problem of "Methods of Cooking Vegetables Containing Pigments and Sulfur Yielding Glucosides", summarized her conclusions in the following way:

> 1. Carrots, beets, parsnips, and rutabaga turnips were better cooked in the steamer than in the open kettle.
> 2. Carrots cooked in the pressure cooker were similar to those cooked in the steamer, and the pressure cooked beets were much superior to steamed beets.
> 3. Spinach, sweet potatoes, and string beans were better in flavor when steamed, altho there was some loss of color.
> 4. White turnips and white onions may be steamed altho there was some loss of color.
> 5. Cabbage, yellow onions, and cauliflower were ruined by steaming.
> 6. Cabbage, spinach, and carrots were ruined by continuously heating for one and one-half hours, whereas if they were cooled to room temperature and then quickly heated for eight minutes, the product was almost equal to the originally cooked vegetable. The losses incurred for the vegetable which was cooled to room temperature and then reheated were less than for the one which was continuously heated, these losses being 1.345 percent and 1.492 percent, respectively.

Another phase of the work has been studied by Steinbarger (7). This consisted of a study of the effect of salt upon the loss of iron in cooking vegetables. The results showed an increase in the loss of iron when salt was added.

Peterson and Hoppert (8) in an experiment on "The Loss of Mineral and Other Constituents from Vegetables by Various Methods of Cooking", studied sixteen vegetables to determine the loss to dry matter, crude protein, calcium, magnesium, phosphorus, and iron by four methods of cooking, namely: steaming, pressure cooking, boiling in a moderate quantity of water and boiling in double this volume of water. There was an increase in losses for different methods in the order named.

> Certain vegetables show notably large losses. Cabbage is conspicuous in this respect, while the closely related cauliflower retains its food constituents to a much greater degree. Celery, beet greens, and onions are other vegetables which suffer great loss, particularly of the mineral elements. Spinach shows a complete and unlooked for retention of calcium when subjected to the operations of cooking. Apparently the calcium in spinach is in an insoluble form, quite different from that found in most vegetables.

Such experimental work will add a great deal to our knowledge of vegetable preparation and will help to overcome the innumerable notions concerning food preparation that are so generally accepted.

The question as to the best time to add salt in the cooking of vegetables is frequently asked. In reviewing recipe books it has been found that directions for the time of adding salt are not given in many cases. In some instances a general precaution is made against adding salt in the beginning because of its hardening effect. Lord (9) makes the following statements:

> Salt has a slight hardening effect on the cellulose of vegetables, and also helps extract the juices. For this reason many recipes direct that salt be added when the vegetable is half cooked, nearly cooked or wholly cooked. In any of these cases, however, the salt does not penetrate and season the vegetables as well as if it is in the liquid or on the vegetable from the first, and the hardening or extractive effect is so slight as to seem more than compensated by the better flavoring. In this book, therefore, the directions are for salting at the beginning. The individual housekeeper can try for herself the effect of different times of salting.

STATEMENT OF THE PROBLEM

The object of the present study was to find out what is the difference, if any, in the palatability, appearance, and texture of vegetables cooked in water to which salt is added previous to, during, or at the end of the cooking process, and to determine at which time it is desirable to add the salt.

It is believed that the color of cooked vegetables should approximate that of the uncooked vegetable as nearly as possible, that is,

cooked spinach should have a natural green color, not the bright green developed by adding soda to the cooking water, or the reddish brown color developed by over cooking.

The texture of a cooked vegetable should be such that, while the product retains as nearly as possible its original shape, it must be tender.

Every vegetable has its characteristic flavor. The problem in preparation is to retain or improve it. To most tastes the addition of a small amount of salt helps to bring out the flavor. While certain vegetables are unpalatable in the raw state, overcooking or keeping the vegetable too closely covered during cooking develops, in most cases, an undesirable flavor.

In general, it is believed that the simpler methods make the most appetizing products and that the cooking period should be as brief as possible to produce the desired texture.

PROCEDURE

Effect of Salt on the Color, Texture, and Flavor

Material and equipment.—For the present study the method of cooking vegetables in boiling water was used since steaming, baking, or cooking under steam pressure would not demonstrate the effect of the use of salt.

Five types of vegetables were used:

1. Green leafy vegetables, represented by spinach and cabbage.
2. Root vegetables, represented by carrots, turnips, and beets.
3. Legumes, represented by dried navy beans and fresh peas.
4. Tubers, represented by white potatoes.
5. Seed pods, represented by green string beans.

The length of time the different vegetables were cooked varied. The vegetables used in this problem were cooked until tender but the original shape was retained. The navy beans were cooked until the skins burst when blown on.

It seemed advisable to use the chemically pure salt for the present study. It is hoped that at some time experiments which will compare the effect of the use of pure salt and so-called table salt may be made. In each series of the present study parallel experiments were made with tap water and distilled water.

The cooking vessels used were white enamel similar in shape, size, and capacity. The gas burners were adjusted so that they would all heat at about the same rate. This was accomplished by

placing cooking vessels of the same size, shape, and material on burners and heating equal amounts of water in them. This operation was repeated until all the valves were adjusted so that the boiling point of the water was reached simultaneously in all the vessels. The burners were checked frequently during the experiment. Care was taken not to have drafts in the room during the cooking process.

Preliminary tests.—In order to standardize the method of cooking each vegetable to be studied, preliminary tests were made. The following points were considered:

1. Method of preparation of the vegetable.
2. Amount of vegetable by weight to use in each series.
3. The proportion by weight of salt to vegetable.
4. The proportion by measure of water to vegetable.
5. The use of covered or of uncovered vessels.
6. Length of the cooking period for each vegetable studied.

TABLE 1.—Results of Preliminary Tests

Vegetable	Weight of vegetable	Amount of salt		Amount of water		Average time of cooking
		Wt.	Meas.			
	Grams	*Grams*	*Tsp.*	*CC.*	*Qt.*	*Minutes*
Spinach	227	1.015	¼	250	¼	11
Cabbage	227	3.045	¾	750	¾	26
Turnips	170	2.03	½	750	¾	25
Beets	170	1.015	¼	750	¾	30
Carrots	170	2.03	½	1000	1	32
Dried navy beans	113	4.06	1	1000	1	40
Green peas	100	1.105	¼	750	¾	30
White potatoes	283	4.06	1	750	¾	23
Green string beans	117	2.03	½	1000	1	40

The figures in Table 1 show the proportions and time of cooking each vegetable, judged most satisfactory in the preliminary tests by staff members, graduate and undergraduate students of the Home Economics Department, Ohio State University.

In all cases the products seemed more desirable when they were cooked uncovered, the difference in flavor being obvious. The green vegetables, and especially the peas, retained a more desirable color when cooked with the vessel uncovered.

The proportion by weight of salt to vegetables varied considerably for the different vegetables. The smaller amounts of salt were better for the sweet juiced vegetables, such as beets and carrots. The addition of 1 teaspoonful of salt to 12 ounces of vegetable was satisfactory for navy beans and potatoes but seemed to develop a bitter flavor in carrots.

Method of the experiment.—The vegetables used in each series of the experiment were from the same crop. The quantity used for each sample was approximately that which would serve two persons. In preparing the vegetables an attempt was made to have the samples of uniform character. For example, the carrots, beets, potatoes, turnips, green beans, and cabbage were each cut into sections and distributed among the four or eight samples. Each sample of beans was soaked over night in the same kind of water in which it was to be cooked.

In each series of the experiment the variant was the time the salt was added. In samples Number 1 and 5 there was no salt. In Numbers 2 and 6 salt was added in the beginning, that is, before adding the vegetables. In Numbers 3 and 7 salt was added after the first half of the cooking period and in Numbers 4 and 8 it was added at the end of the cooking process. As previously stated parallel experiments were made with tap water and distilled water. Tap water was used in Numbers 1, 2, 3, and 4 and distilled water in Numbers 5, 6, 7, and 8.

In order to be sure that the tap water used was uniform, a sufficient quantity was drawn into a large granite container to supply all the tap water used for a series. For each series the desired amount of water was placed in each cooking vessel and brought to the boiling point. The vegetables were then added.

The products were marked in code and judged by the same persons who judged the vegetables during the preliminary tests. The score sheet used is shown in Table 2. Each product was graded as to color, texture, and flavor. When a product was considered excellent in any one of these particulars it was given four points in the appropriate column; if considered good three points; if fair two points, and if poor one point.

Each series of tests was repeated enough times to eliminate possible errors in conclusions. The average scores are given in Tables 3, 4, and 5.

Table 3 shows only a slight variation in color due to the difference in the time of adding the salt.

In observing the various descriptive words checked under color on the score sheets, it appears that the navy beans of Number 1 were of lighter color. Some judges observed that in the samples cooked with distilled water the beans were slightly lighter in color than those cooked in tap water. Numbers 1 and 4 seemed to yield a lighter color in peas, those cooked in distilled water being of a

slightly lighter color than those cooked in tap water. After standing for a short time this difference was not noticed. The color of young beets was not as stable as that of the older beets.

TABLE 2.—Score Card

Vegetable..... Series..... Date.....

Indicate the grade by the following marks:

XXXX	Excellent
XXX	Good
XX	Fair
X	Poor

Check (v) the word in the appropriate square that indicates the reason for your decision.

	Number	1	2	3	4	5	6	7	8
Color	Grade								
	Too light Too dark Dull Natural								
	Number	1	2	3	4	5	6	7	8
Texture	Grade								
	Too soft Very tender Tender Slightly tough Tough Very tough Mealy								
	Number	1	2	3	4	5	6	7	8
Flavor	Grade								
	Lacking Mild Strong Too salty Pungent								

Judged by.....

TABLE 3.—Average Points Given for Color

	Number of tests	No salt	Salt added		
			Before cooking	After first half of cooking period	At end of cooking period
Vegetables cooked in tap water					
Spinach	11	23	24	25	25
Cabbage	9	16	15	16	15
Turnips	9	17	17	17	17
Beets	9	14	13	12	14
Carrots	10	24	23	25	24
Dried navy beans	9	18	18	17	17
Green peas	8	15	20	20	16
White potatoes	8	19	20	20	19
Green string beans	8	13	14	14	14
Vegetables cooked in distilled water					
Spinach	11	21	25	25	22
Cabbage	4	16	16	15	17
Turnips	1	19	18	18	9
Beets	0				
Carrots	6	16	16	16	16
Dried navy beans	4	15	19	20	20
Green peas	0				
White potatoes	0				
Green string beans	0				

Table 3 shows only a slight variation in color due to the difference in the time of adding the salt.

TABLE 4.—Average Points Given for Texture

	Number of tests	No salt	Salt added		
			Before cooking	After first half of cooking period	At end of cooking period
Vegetables cooked in tap water					
Spinach	11	22	23	22	23
Cabbage	8	12	16	14	14
Turnips	9	13	17	16	14
Beets	9	16	20	19	20
Carrots	10	16	20	19	18
Dried navy beans	9	12	15	14	14
Green peas	8	17	21	19	17
White potatoes	8	14	20	20	18
Green string beans	8	11	13	14	13
Vegetables cooked in distilled water					
Spinach	11	22	24	23	22
Cabbage	4	11	14	12	13
Turnips	1	12	19	17	17
Beets	0				
Carrots	6	18	20	21	20
Dried navy beans	4	14	18	15	18
Green peas	1	17	20	19	18
White potatoes	0				
Green string beans	0				

When comparing average points for texture it will be seen that vegetables to which salt was added before cooking scored highest; those to which salt was added after the first half of the cooking period scored second. Most of the vegetables seemed to be less tender when no salt was added to the cooking water. Potatoes cooked without salt had a tendency to be soggy. The addition of salt previous to cooking seemed to make them more mealy.

TABLE 5.—Average Points Given for Flavor

	Number of tests	No salt	Salt added		
			Before cooking	After first half of cooking period	At end of cooking period
Vegetables cooked in tap water					
Spinach	11	15	24	23	20
Cabbage	8	10	18	16	13
Turnips	9	9	18	16	14
Beets	10	15	15	16	15
Carrots	10	15	19	19	17
Dried navy beans	9	8	18	16	15
Green peas	8	11	22	19	14
White potatoes	8	10	19	18	14
Green string beans	8	8	13	14	10
Cooked in distilled water					
Spinach	11	14	24	22	20
Cabbage	4	8	14	15	13
Turnips	1	9	17	14	12
Beets	0	.....	.....	.....	.....
Carrots	6	16	19	20	22
Dried navy beans	4	12	18	17	13
Green peas	1	12	19	18	13
White potatoes	0	.....	.....	.....	.....
Green string beans	0	.....	.....	.....	.....

It has often been said that adding salt to navy beans in the beginning of the cooking process causes them to become tough. Judging from the results of this experiment, the addition before cooking of chemically pure sodium chloride in a proportion to give desirable flavor tends to soften navy beans. It was noted also that those cooked with distilled water were more tender and more desirable in texture than those cooked in tap water.

In judging for flavor most of the vegetables were scored highest when the salt was added before the cooking period, as shown in Table 5. Some of the judges thought that the beets and carrots seemed to become less sweet when the salt was cooked with the vegetable from the beginning. Adding the salt after cooking seemed to give an uneven flavor. When no salt was added they were said to lack flavor.

CHEMICAL ANALYSIS

In connection with the experimental work, the total ash of some of the vegetables and the total ash and chlorine content of the water in which the vegetables were cooked were determined in order to find out whether different amounts of minerals were extracted from the vegetable when the salt was added at various times of the cooking process.

Fresh 5-gram portions of the original samples of spinach, turnips, peas, and navy beans were weighed, dried, charred, and heated in a muffle to cherry redness until a white ash was obtained. The average results in percentage are as follows:

ASH CONTENT OF VEGETABLES

Vegetable	Ash percent
Peas E. P.	0.9
Beans (navy)	3.25
Spinach E. P.	2.46
Turnips E. P.	1.27

To obtain cooking water for analysis the cooked vegetables were drained in sieves of the same size and mesh for approximately the same length of time. For quantities of materials used see Table 1. The cooking water was made to 250 cc. volume.

In determining the total ash of the cooking water, 25 cc. portions were used, care being taken to mix the sample before the 25 cc. was drawn from it. Flat-bottomed platinum and vitreosil dishes were used in determining the total ash.

The method (11) used in analyzing the chlorine content of the cooking water was as follows: after thoroly mixing the 250 cc. sample of cooking water, 25 cc. of liquid was pipetted and placed in a 100 cc. graduated flask. To this were added 25 cc. of distilled water and 5 cc. of concentrated nitric acid. After shaking the contents well, the flask was placed on a water bath and heated to destroy any organic matter. After cooling, 5 cc. ferric alum indicator and 25 cc. of $\frac{N}{10}$ silver nitrate solution were added. After thoroly mixing, the solution was made to 100 cc. with distilled water and allowed to stand 24 hours, when it was filtered into dry receiving flasks. Of this, 50 cc. was placed in a dry flask and titrated with $\frac{N}{10}$ potassium thio-cyanite. The following equivalents were used in the calculations:

1 cc. $\frac{N}{10}$ KScN equivalent to 0.03546 gram chlorine

1 cc. $\frac{N}{10}$ KScN equivalent to 0.05846 gram sodium chloride

The total sodium chloride in the cooking water was calculated by multiplying the result obtained for the above procedure by 10. The chlorine in the cooking water to which no salt was added was determined. This was regarded as a blank in calculating the amount of chlorine extracted from the vegetables. The approximate amount of sodium chloride in the cooking water was calculated and subtracted from the total ash. The result was considered as the total amount of ash extracted from the vegetable.

The ash and sodium chloride content of the cooking water of spinach, peas, turnips, and navy beans may be found in Tables 6, 7, 8, and 9, respectively.

TABLE 6.—Ash and Sodium Chloride Content of Water in Which Spinach Has Been Cooked and Percentage of Ash Lost

	Total ash in 250 cc. Gm.	Sodium chloride in 250 cc. Gm.	Total ash minus sodium chloride Gm.	Loss of ash Percent
Tap water				
No salt	1.20	0.009*	1.20	21.48
Salt added before cooking	1.58	0.29	1.29	23.09
Salt added after first half cooking	1.59	0.30	1.29	23.09
Salt added at end	1.52	0.29	1.23	22.07
Distilled water				
No salt	1.13	0.01*	1.13	20.26
Salt added before cooking	1.51	0.30	1.51	24.27
Salt added after first half cooking	1.58	0.26	1.32	23.78
Salt added at end	1.53	0.31	1.22	21.90

*The chlorine found in this case was extracted from vegetables or was present in the water used.

As may be seen in Table 6 the percentage loss of ash from spinach was lowest when no salt was used. Adding the salt before cooking and after the first half of the cooking period gave a slightly higher loss of ash than adding the salt at the end.

In Table 7 the percentage loss of ash from peas is shown to be least when salt was added before cooking and greatest when added at the end of the cooking period.

TABLE 7.—Ash and Sodium Chloride Content of Water in Which Peas Have Been Cooked and Percentage of Ash Lost

	Total ash in 250 cc Gm.	Sodium chloride in 250 cc. Gm.	Total ash minus sodium chloride Gm.	Loss of ash Percent
Tap water				
1 No salt	0.24	0.01*	0.24	27.00
2 Salt added before cooking	0.68	0.28	0.40	44.49
3 Salt added after half of cooking	0.86	0.25	0.60	66.80
4 Salt added at end	1.13	0.42	0.71	78.69
Distilled water				
5 No salt	0.14	0.005*	0.14	16.00
6 Salt added before cooking	0.61	0.29	0.32	35.18
7 Salt added after half of cooking	0.86	0.34	0.52	57.55
8 Salt added at end	1.08	0.44	0.64	71.51

*The chlorine found in this case was extracted from the vegetable or was present in tap water used.

The percentage loss of ash from turnips did not show any definite tendency as may be observed in Table 8.

TABLE 8.—Ash and Sodium Chloride Content of Water in Which Turnips Have Been Cooked and Percentage of Ash Lost

	Total ash in 250 cc. Gm.	Sodium chloride in 250 cc. Gm.	Total ash minus sodium chloride Gm.	Loss of ash Percent
Tap water				
1 No salt	0.47	0.03*	0.47	43.97
2 Salt added before cooking	1.82	0.64	1.17	54.70
3 Salt added after first half of cooking	1.38	0.66	0.72	33.40
4 Salt added at end	1.87	0.68	1.19	54.98
Distilled water				
5 No salt	.....	0.03*	.....	.....
6 Salt added before cooking	1.75	0.66	1.09	50.50
7 Salt added after first half of cooking	1.19	0.68	0.51	23.80
8 Salt added at end	1.72	0.68	1.05	48.53

*The chlorine found in this case was extracted from the vegetable or was present in tap water used.

As shown in Table 9 there is no evident correlation in the time of adding salt and the loss of ash in the cooking of navy beans. Determinations were difficult to make of the cooking water. It seemed possible that some unknown factor may have influenced the results of the determinations.

TABLE 9.—Ash and Sodium Chloride Content of Water in Which Navy Beans Have Been Cooked and Percentage of Ash Lost

	Total ash in 250 cc. Gm.	Sodium chloride in 250 cc. Gm.	Total ash minus sodium chloride Gm.	Loss of ash Gm.
Tap water				
1 No salt	0.90	0.003*	0.90	24.70
2 Salt added before cooking	2.14	0.72	1.42	38.58
3 Salt added after first half of cooking	0.72	0.33	0.39	10.70
4 Salt added at end	2.07	0.72	1.35	36.75
Distilled water				
5 No salt	0.82	0.001*	0.82	22.31
6 Salt added before cooking	2.14	0.73	1.41	38.50
7 Salt added after first half of cooking	2.72	0.73	2.01	54.54
8 Salt added at end	2.49	0.73	1.76	49.99

*The chlorine found in this case was extracted from the vegetable or was present in tap water used.

SUMMARY

1. Color.—The variation of time of adding chemically pure sodium chloride in the cooking of vegetables affected the color only to a slight extent. The addition of the salt appeared to aid in the retention of the red coloring matter of beets and to slightly lighten the color of potatoes. All the vegetables except carrots turned somewhat darker on standing. In most cases there appeared to be no difference in the color of vegetables cooked in tap water and those cooked in distilled water.

2. Texture.—The addition of chemically pure sodium chloride to the cooking water had a softening effect on the texture of the vegetables tested. The best texture was developed when the salt was added in the beginning. Navy beans cooked in distilled water seemed to have a slightly better texture than those cooked in tap water. No difference due to the use of tap or distilled water was noticed in the texture of other vegetables studied.

3. Flavor.—The vegetables that were cooked in water to which chemically pure sodium chloride was added before cooking were considered to have the best flavor. Addition of the salt after the first half of the cooking period gave relatively a better flavor than when salt was added at the end. The flavor of the vegetables cooked in tap water was preferred to the flavor of those cooked in distilled water.

4. Loss of ash.—It does not seem possible to make a general statement concerning the percentage loss of ash due to the relative

time of adding sodium chloride in the cooking of vegetables. Spinach lost the least ash when salt was added at the end of the cooking period. Peas lost most ash when salt was added after cooking; somewhat less when salt was added after the first half of the cooking period; still less when it was added at the beginning of the period; and least when no salt was used at all. The figures for turnips and navy beans seemed somewhat irregular and no general tendency was indicated as to the effect of the salt when added at different times during the cooking process. It would be of interest to continue the study of this problem.

CONCLUSIONS

1. The color of vegetables does not seem to be noticeably changed when chemically pure sodium chloride is added at various times of the cooking process.

2. The texture and flavor of vegetables is improved by adding chemically pure sodium chloride to the cooking water before the vegetables are added or after the first half of the cooking period.

3. There seems to be little correlation in the percentage loss of ash from various vegetables when chemically pure sodium chloride is added at relatively the same time and at different times in the cooking process.

4. In spite of the fact that in some cases there is more loss due to the presence of salt in the cooking of vegetables, there appears to be enough advantage in texture and flavor to warrant the use of the addition of salt at the beginning of the cooking period.

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