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Vegetable Cookery at High Altitudes

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Vegetable Cookery at High Altitudes

BY EMMA J. THIESSEN

INTRODUCTION

A review of literature reveals that there are no published time tables for cooking vegetables at high altitudes. It was believed the development of such a study would be of value to home economics teachers and to housewives throughout high altitude sections of Wyoming and the Rocky Mountain region. Experimental work was carried out under definitely controlled conditions.

PURPOSE OF STUDY

It has been the purpose of this study to prepare a time table for boiling, steaming and baking winter vegetables at high altitudes, to determine the minimum amount of time necessary for cooking vegetables at high altitudes in order to secure a good cooked product with minimum loss of nutrients, to determine how much more time, if any, is needed for cooking vegetables at high altitudes (Laramie, Wyoming, 7,159 feet) than at low altitudes (University of Chicago, 600 feet).*

It has been of interest in this experiment to note the variables which bring about changes in the color, flavor and texture of the cooked vegetable and to determine the percentage of waste in the ordinary paring of vegetables.

A. STUDY OF TIME REQUIRED FOR COOKING VEGETABLES AT HIGH ALTITUDES

Vegetables Used for Testing. Experimental tests were made chiefly during the winter months, and the tests were limited to the vegetables obtainable at that time.

(a) Boiling tests were made on beets (young and old), cabbage (white), cabbage (green), carrots (young and old), onions (yellow), Irish potatoes, parsnips, rutabagas, squash, sweet potatoes and turnips (young and old).

*Hows and Whys of Cooking.—Halliday and Noble, pp. 23-25.

(b) Steaming tests were made on beets (young and old), carrots (young and old), Irish potatoes, sweet potatoes and squash.

(c) Baking tests were made on squash, Irish potatoes and sweet potatoes.

Preparation of Vegetables for Cooking. To use vegetable time tables successfully, it is essential that housewives adopt uniform methods for the preparation of the vegetable, as outlined in the tables. It is also essential that vegetables be cut into pieces of approximately the size specified in the tables if results comparable with published time tables are to be secured by the housewife. Time tables serve as guides to prevent over-cooking, thereby preserving color, flavor, texture and nutritive value of vegetables.

It will be noted from Table I that the vegetables have been prepared for boiling in the following ways: The cabbage was shredded, cauliflower separated into flowerets, onions peeled and partially quartered at the bud end, carrots and parsnips cut lengthwise in halves or thirds and crosswise once, rutabagas cut lengthwise in half-inch slices, potatoes cut in halves lengthwise, and turnips cut in three-fourth-inch cubes. There is less loss of mineral substances if vegetables are cut lengthwise of the fiber.*

In preparing vegetables for steaming, Table III, the vegetables, with the exception of beets, have been cut into pieces of small size to facilitate quick cooking. The mineral losses by steaming are very slight, therefore the increase in cut surface does not cause a greater nutritive loss.

In preparing vegetables for baking, Table V, the Irish potatoes and sweet potatoes were left whole and the squash was cut into pieces 4x3 inches.

Amounts of Ingredients. (a) The cooking unit for the experimental tests was approximately the amount of vegetables which would yield two cups when cooked. The weights of the vegetables, as purchased at the city markets, also the weight of the edible portion when prepared for cooking, are recorded.

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*Changes in Food Value Due to Cooking Effect of Varying Household Manipulation, Denton, Journal of Home Economics, April, 1919.

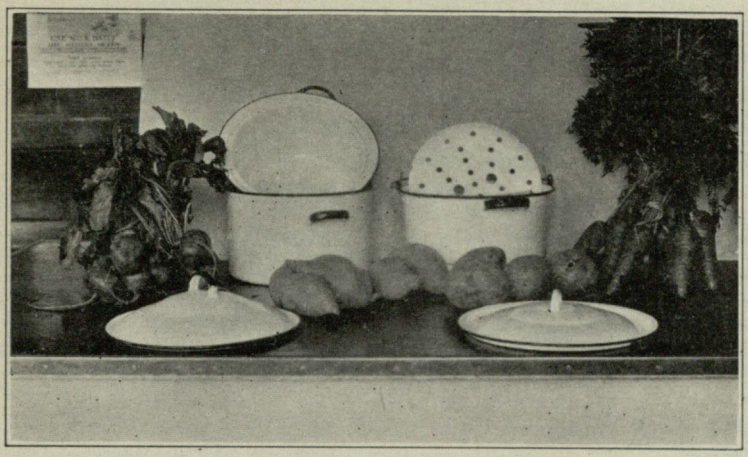

Figure 1. Two types of steamers which may be used for steaming vegetables. The steamer at the right is best to use for starchy vegetables.

(b) The amount of water used for cooking was measured in cubic centimeters and cups. A moderate amount of water, which was sufficient to prevent discoloration or burning, was used for cooking mild flavored vegetables, such as carrots, Irish potatoes, squash and sweet potatoes. A larger amount of water was used for cooking strong flavored vegetables, such as cabbage, rutabagas, turnips and onions. All cooking tests were made with tap water. The time for cooking was calculated from the time of dropping vegetables into the boiling water until removed for testing.

(c) Salt was added to the boiling water in the proportion of 1 to 1½ teaspoons for each quart of water. Salt was added before putting the vegetables in to cook.

Butter, if added, was used in the proportion of 1 to 3 tablespoons for 2 cups of cooked vegetables.

Cream sauce, if desired, was added in the proportion of ½ to ¾ cups for 2 cups of cooked vegetables.

Kinds of Utensils and Type of Heat Used for Cooking. Vegetables were cooked in enameled cooking vessels of uniform size. It was necessary to use larger utensils for boiling the strong flavored vegetables, requiring larger amounts of water. Two types of steamers were used. (See Fig. 1.)

Both gas and electricity were utilized in cooking vegetables. The electric plates were turned on "high" and left at that temperature during the cooking period. The gas was regulated to bring water to the boiling point quickly and keep it at that temperature throughout the cooking period.

Standards for Judging Cooked Products. Several cook books specify minimum and maximum time periods for cooking vegetables, but the majority of recipes simply state "cook until tender." Tender is a qualitative term and has no fixed value. It is, therefore, difficult to measure. The three standards—just cooked, well cooked, and over-cooked—were used for determining the most desirable degree of tenderness for the cooked product. The vegetables were considered "just cooked" when they were barely tender, "well cooked" when very tender and "over-cooked" when mushy in appearance and unpleasant in taste.*

The vegetables were examined at intervals of one minute during the cooking period. They were tested by a fork and by tasting.

The qualities considered in judging the cooked product were the appearance, color, taste and odor, also the texture measured by its tenderness and character.

Boiling Vegetables at High Altitudes. Much difficulty has been experienced by housewives in cooking vegetables at high altitudes, especially by boiling. Their difficulty is easily explained. The boiling point of water is dependent upon the atmospheric pressure. Water boils when its vapor pressure is equal to that of the surrounding atmospheric pressure.† At sea level, where the atmospheric pressure is 29.9 inches of mercury, water will boil at 212° F. or 100° C. At the altitude of Laramie, Wyoming, (7,159 feet) the atmospheric pressure is about 22.8 inches of mercury, and the boiling point of water is approximately 198.5° F. or 92.5° C. In other words, the temperature of the boiling point of water has decreased 7.5° C. or 13.5° F. at the high altitude of 7,159 feet as compared with sea level. As a result of this difference in the boiling point

*Determination of Minimal and Maximal Cooking Time of Vegetables and the Determination of Ensuing Losses, by Susanne Thompson, Journal of Home Economics, December, 1924.

†Cake Baking at High Altitudes by Peterson. Bul. 365, Colorado Agril. Expt. Station, Fort Collins.

of water, the time required for boiling vegetables at high altitudes will need to be increased considerably as compared with low altitudes.

This increase in time makes it of utmost importance that the time for cooking vegetables at high altitudes be shortened as much as possible to preserve flavor and color, also nutritive and vitamin content.

The following precautions have been observed to reduce the time for boiling to a minimum. The water was boiling rapidly when the vegetables were dropped into it and brought quickly back to the boiling point. The water was kept boiling rapidly throughout the cooking period.

Cabbage, turnips, cauliflower and other strong flavored vegetables were cut and divided into pieces of small size to facilitate quick cooking, thereby preventing the development of strong odor and flavor through long cooking.

Time Tables for Boiling Vegetables at High Altitudes. Table I gives the method of preparation for boiling vegetables, the weight of the vegetables, as purchased and edible portion, the approximate amount of water to use for cooking, the size of the cooking utensils and the average time for cooking.

The total range of time required for boiling vegetables is given in Table II. The range of time, as given in Table II, includes the results for all experimental tests made for the years 1929-1931. The quality of the cellulose, the variety of the vegetable, the time left in storage, as well as the size and age of the vegetable, have all been factors in varying the time required for boiling.

The widest range in the time required for cooking winter vegetables was found in the boiling tests for rutabagas, Irish potatoes, parsnips and old carrots. These vegetables likewise showed the greatest variation in quality.

Beets gave a wide range in the time period for cooking due to the fact that they were uneven in size.

The root end of the rutabaga was the toughest part of the vegetable. A small portion of the root end was discarded to facilitate cooking the vegetable more quickly.

TABLE I.

TIME TABLE FOR BOILING VEGETABLES AT HIGH ALTITUDE. PORTIONS WHICH YIELD FOUR SERVINGS OR TWO CUPS WHEN COOKED.

(Based on Experiments at Altitude of 7,159 Feet.)

Vegetable	How Prepared for Cooking	Quantity in Grams		Approximate Measure of Water to Use		Size of Cooking Pan		No. of Trials	Average Time to Cook
		Weight as Purchased	Weight of Edible Portions						
		cc.		cups	cc.	qt.	cm.		minutes
Beets (old).....	Washed, left whole.....	308–433		10	2400	6	20	8	210–240
Beets (new)....	Left whole	200–285		10	2400	6	20	12	135–210
Cabbage (white)	Shredded	4 serv. 8 serv.	240–260 480	5 10	1200 2400	2 6	12.5 20	9 4	13–15 12–15
Cabbage (green)	Shredded	4 serv.	210–307	6	1440	8	20	6	9–10
Cauliflower.....	Separated into flowerets		160–325	4	930	2	12.5	10	20–24
Carrots (old)....	Cut in thirds lengthwise	325–400	285–359	5	1200	2	12.5	13	35–45
Carrots (new)...	Cut in thirds lengthwise Sliced crosswise.....	322–597 230–300	260–480 170–210	4 3	960 720	2 2	12.5 12.5	13 7	35–40 28–32
Onions (yellow).	Partially quartered.....	330–418	215–359	9–10	2160 2400	6	20	13	45–55
Potatoes, Irish...	Peeled thin, cut in halves lengthwise	540–630	230–400	4 5	960 1200	2 2	12.5 12.5	11 21	36–44† 25–30
Parsnips.....	Cut in thirds lengthwise and crosswise in 2 pieces	288–409 505–470	215–356 280–350	6	1200	2	12.5	11 12	30–38 45–50*
Rutabagas.....	Cut lengthwise in slices half-inch thick.....	501–500 376–550	313–350 225–400	6	* 1440	8	20	31	43–50
Squash.....	Pared and cut in pieces 2 x 3 inches.....	357–770	475–627	3	720	2	12.5	13	20–25
Sweet Potatoes..	Cut crosswise once and lengthwise in halves.....	390–426	264–321	3	720	2	12.5	12	23–30
Turnips (old)....	Pared and cut in ¾-inch cubes	377–800	269–470	4–5	960 1200	6	20	16	20–25
Turnips (new)...	Pared and cut in ¾-inch cubes	363–500	230–400	4–5	960 1200	6	20	15	17–23

1 to 1½ tsp. salt per quart of boiling water is used. *Woody. †Varied varieties.

Note: Water must be boiling rapidly when vegetables are put in, otherwise time table will not give above results.

TABLE II.

TOTAL RANGE OF TIME FOR BOILING VEGETABLES.

(University of Wyoming, Altitude 7,159 Feet)

Vegetable	Preparation	Range of Time for Total Number of Tests (1929-1931) Minutes	Average Time	Remarks
Beets (old).....	Left whole	210–240	210–240	Watery, poor flavor.
Beets (new).....	Left whole	115–158	135–210	Beets varied in size, hence wide range of time.
Cabbage (white)	Shredded	10–15	13–15	Bluffton slaw cutter used.
Cabbage (green).	Shredded	8–12	9–10	Bluffton slaw cutter used.
Cauliflower.....	Separated in Flowerets	20–25	20–24	Small variation in time.
Carrots (old)....	Cut in thirds lengthwise, then crosswise in half	42–50 (1929–1930) 32–40 (1930–1931)	35–45	Varies with quality of vegetable.
Carrots (young). Carrots (young).	Cut in thirds lengthwise, then crosswise Sliced	32–41 27–33	35–40 28–32	Time for cooking varies with size and shape of pieces.
Onions (yellow).	Partially quartered	45–60	45–55	Varied for two years tested.
Parsnips.....	Cut in thirds lengthwise, and crosswise once	29–38 (if good quality) 45–50 (if woody center)	30–35 45–50	Shorter time needed if good quality. Poor quality with woody center requires longer cooking.
Potatoes, Irish...	Peeled thin, cut in halves lengthwise, 3 in. x 1½ in.	25–30—Bliss Triumph Irish Cobbler 36–44—Other varieties	25–30 36–40	Variety of potatoes gives variable cooking period.
Rutabagas.....	Cut lengthwise in slices ½ inch thick	33–45—Dec. and Jan. 45–55—Feb.	43–50	Varies with period of time in storage.
Squash.....	Pared and cut in pieces 2x3 in.	19–33	20–25	Hubbard squash tested.
Sweet Potatoes..	Cut crosswise once and lengthwise once	21–30	21–30	Pieces cut small to facilitate quick cooking.
Turnips (old).... Turnips (young).	Pared and cut in ¾ in. cubes	20–25 17–23	20–25 17–23	Cooking period varies with quality of vegetable.

Time Tables for Steaming Vegetables. The time required for steaming vegetables in the steamer and pressure cooker is given in Table III. Steaming was chosen as a method for cooking those vegetables which yielded a product of good color, flavor and texture when steamed. Strong flavored vegetables were not desirable steamed.

Table IV gives the range of time for the total number of experimental tests for steaming vegetables in the pressure cooker and the steamer. Consistent results were secured in the time required for steaming all vegetables which were cooked in the pressure cooker with the exception of young beets. The beets tested were uneven in size, therefore the range was greater 15 to 28 minutes as compared with a range of 2 to 3 minutes for carrots. It was found possible at this altitude to maintain an even pressure of 18 pounds in the pressure cooker if the steam was allowed to escape for 12 minutes before closing the petcock. In experimental tests made at Iowa State College the steam was allowed to escape but seven minutes before closing the petcock.*

The time required for steaming vegetables in the two types of steamers gave a more varied range in time. For all tests a longer time was required for steaming vegetables than for boiling.

In Tables V and VI the time required for baking vegetables at high altitudes is given. Sweet potatoes and Irish potatoes gave a varied range in time, depending upon the diameter or thickness of the vegetable. Squash, which varied in thickness from one to one and one-half inches, gave consistent results in the time required for baking.

Two varieties of squash were tested.

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*Pressure Cooker Operation in Home Canning by Mabel Nelson. Journal of Home Economics, February, 1929.

TABLE III.

TIME TABLE FOR STEAMING VEGETABLES (HIGH ALTITUDE)

(In Portions Which Yield Four Servings or Two Cups When Cooked.)

Vegetable	How Prepared	Weight in Grams		Size	No. of Trials	Average Time to Cook		Remarks
		As Purhased	Edible Portion			Steamer	Pressure Cooker	
Beets (old).....	Whole, washed,	317		7½ cm.	9		30 min. at 18 lbs.	Color, bright red; much sweeter than boiled.
Beets (young)...	Whole, washed 3 med.	247 255		3½ cm. diam.	17		25 min. at 18 lbs.	Good, darker in color than boiled. Sweet flavor.
Carrots (old)....	Scraped, sliced	520	328		9 Pressure Cooker) (12 Steamer)	42–53	8 min. at 15 lbs.	Excellent in flavor.
Carrots (young).	Scraped, sliced	345	220		5 (Pressure Cooker) 7 (Steamer)	37–40	6 min. at 12 lbs.	Lower pressure and slightly longer period for cooking gave better results.
Potatoes, Irish...	Peeled, quartered	630	450	10x6x5½	27	30–45		Mealier than boiled potato.
Sweet Potatoes...	Cut lengthwise in 2 pieces and lengthwise in halves	510	470	4½x6	19	23–35		Sweeter than boiled. Also dryer.
Squash.....	Pared and cut in 2-inch squares		235		7	22–25		Excellent means for cooking squash. Much dryer than boiled.

Note: Water must be kept boiling rapidly in order to give comparable results with above table.

TABLE IV.

RANGE OF TIME FOR STEAMING VEGETABLES.

(University of Wyoming, Altitude 7,159 Feet)

Vegetables	How Prepared	Range in Time for Total Number of Tests (1929-1931)		Average Time to Cook	
		Pressure Cooker	Steamer	Pressure Cooker	Steamer
Beets (old).....	Whole	30 min. at 18 lbs.		30 min. at 18 lbs.	
Beets (new).....	Whole	15–28 min. at 18 lbs.		25 min. at 18 lbs.	
Carrots (old).....	Sliced	6–8 min. at 15 lbs.	40–54 min.	8 min. at 15 lbs.	42–53 min.
Carrots (young).....	Sliced	3–6 min. at 15 lbs.	37–47 min.	6 min. at 12 lbs.	37–40 min.
Irish Potatoes.....	Quartered		28–30 min.* 40–51 min.†		30–45 min.
Sweet Potatoes.....	Cut crosswise in two pieces and lengthwise once		23–36 min.		23–35 min.
Squash.....	Cut in two-inch squares		22–32 min.		22–25 min.

*Bliss Triumph and Irish Cobbler variety.
†Other varieties.

TABLE V.

TIME TABLE FOR BAKING VEGETABLES (HIGH ALTITUDE)

(In Portions Which Yield Four Servings When Cooked)

Vegetables	How Prepared	Weight Grams	No. of Trials	Size	Average Time to Cook Oven	Remarks
Squash.....	In pieces, unpealed	202–295	14	4 in. x 3 in. x 1½ in.	20 min. at 450° F. then 25–30 min. at 400° F.	
Sweet Potatoes....	Washed with vegetable brush. Greased	188–231	6 5 3	4–5 cm. diam. 6–7 cm. diam. 9 cm. diam.	35–40 min. at 450° F. 50–65 min. at 450° F. 70–75 min. at 450° F.	Time for baking varies with size of potato
Irish Potatoes.....	Washed and greased	187–300	15	7½x6½x5 cm. 8½x7x6 cm. 9x7x6½ cm.	55 min. at 450° F. 60 min at 450° F. 65 min. at 450° F.	Time for baking varies with size of potato

TABLE VI.

RANGE OF TIME FOR BAKING VEGETABLES

(University of Wyoming, Altitude 7,159 Feet)

Vegetables	How Prepared	Range of Time for Total Number of Tests, 1929-1931	Average Time	Measurement of Vegetable
Squash.....	In pieces, unpeeled	42–55 min.	Total time 45–50 min. 20 min. at 450° F. 30 min. at 400° F.	4 in. x 3 in. x 1½ in. 3 in. x 2½ in.
Sweet Potatoes.....	Left whole	45–60 min.	35–40 min. at 450° F. 50–65 min. at 450° F. 70–75 min. at 450° F.	2 inches in diameter 2¼–2¾ inches in diameter 3½ inches in diameter
Irish Potatoes.....	Left whole	50–60 min.	55 min. at 450° F. 60 min. at 450° F. 65 min. at 450° F.	3 in. x 2½ in. x 2 in. 3½ in. x 2¾ in. x 2¼ in. 6 in. x 3 in. x 2½ in.

Comparison of Time Required for Cooking Vegetables for Two Different Seasons (1929-1930 vs. 1930-1931.) Experimental tests for cooking vegetables were made for two different years.

The comparative time needed for cooking vegetables for the two years, 1929-1930 as compared with 1930-1931, are shown in Tables VII, VIII and IX.

It was thought that vegetables grown under different soil and moisture conditions for the two different seasons would show a wide range in quality, thereby varying the time required for cooking.

The time required for cooking vegetables for the two different years, with the exception of carrots, parsnips and rutabagas, did not show much variation. The woody, fibrous character of the cellulose was very evident in these vegetables for the year 1929-1930. Vegetables that are woody and fibrous are usually overcooked in an attempt to make the cellulose tender and can rarely be made palatable. This was true especially in boiling tests made for parsnips in 1929-1930. The center was so woody the only way it could be made tender was to cook the vegetables in the pressure cooker. The strong flavor developed in the pressure cooker made this method undesirable from the standpoint of palatability. The quality of most of the parsnips tested was excellent in 1930-1931, lessening the time for boiling this vegetable about one-half, as compared with the previous year.

Quality is usually demanded by the consumer in purchasing vegetables from the groceryman. The vegetables used in these tests were, for the most part, of a very excellent quality.

Comparison of the Time Required for Cooking Vegetables at High Altitudes (Laramie, 7159 feet) vs. Low Altitudes (Chicago, 600 feet). Altitude must be considered as a very definite factor in increasing the time needed for boiling vegetables. In Table X will be found a comparison of the time required for boiling vegetables at high and low altitudes. The low altitude time table has been prepared by Halliday and Noble, University of Chicago, and published in "Hows and Whys of Cooking."* The methods which

*Hows and Whys of Cooking by Halliday and Noble, pp. 23-24.

TABLE VII.

COMPARISON OF TIME FOR BOILING VEGETABLES

(1929-1930 with 1930-1931)

Vegetable	Weight		No. of Trials	Time—1929-1930	Weight‡		No. of Trials	Time—1930-1931
	A. P.	E. P.			A. P.	E. P.		
Beets (old).....	308		3	3½–4 hours	280–433		5	2 hours 40 minutes 3 hours 25 minutes
Beets (new).....	213		4	2½ hours	200–285		9	2¼–2½ hours
Cabbage (white)		240–440	4	10–12 minutes		150–260	5	14–15 minutes
Cauliflower.....		251	7	20–23 minutes		139–210	3	21–24 minutes
Carrots (old)....	400	359	6	48–50 minutes		246–421	7	33–42 minutes
Carrots (new)...						170–309	7	27–33 minutes
Onions (yellow)	470	452	6	45–50 minutes		260–402	8	54–60 minutes
Potatoes, Irish...	473	392	6	38–44 minutes*		280–340	35	36–44 minutes* 25–30 minutes†
Parsnips.....	401	305	5	50–60 min. (quality poor with woody center)		250–340	20	29–38 min. (excellent quality) 41–50 min. (woody center)
Rutabagas.....	539	438	9	Nov.—43–48 minutes Dec. Feb.—50–65 minutes		260–326	22	30–40 minutes—January 40–50 minutes—February
Squash.....	800	498	4	25–30 minutes		194–627	9	21–25 minutes
Sweet Potatoes...	370	339	7	23–28 minutes		207–395	5	22–26 minutes
Turnips (old)....	575	470	3	26–30 minutes		230–560	13	18–27 minutes
Turnips (new)...	549	451	6	18–21 minutes		210–340	8	18–23 minutes

*Netted Gem and other varieties used. (Tested throughout winter months.)
†Irish Cobbler and Bliss Triumph used. (January, February, March.) ‡Weight in grams.

TABLE VIII.
COMPARISON OF TIME FOR STEAMING VEGETABLES
(1929-1930 with 1930-1931)

Vegetable	Weight—Grams		No. of Trials	1929-1930		Weight—Grams		No. of Trials	1930-1931	
	A. P.	E. P.		Steamer Time in Minutes	Pressure Cooker	A. P.	E. P.		Steamer Time in Minutes	Pressure Cooker
Beets (old).....	317		9		30 min. at 18 lbs.					
Beets (new).....	291		3		18 min. at 18 lbs.	130–255		16		20–22 min. at 18 lbs.
Carrots (old)....		250–361	4	45–48	8 min. at 15 lbs.	190–222		5	48–54	7 min. at 15 lbs.
Potatoes, Irish...		286–450	18	45–50			240–500	3 3	40–43 29–33	Two different types of steamers used. Same variety of potatoes
Potatoes, Sweet..		317–344	8	23–25			250–470	10	25–35	
Squash.....		332–334	3	25–30			194–235	4	23–25	

TABLE IX
COMPARISON OF TIME FOR BAKING VEGETABLES
(1929-1930 with 1930-1931)

Vegetable	Weight in Grams	No. Trials	Size	1929-1930	Weight in Grams	No. Trials	Size	1930-1931
Squash.....	165–295	4	4x3x1 in.	Total of 50–55 min. with 20 min. at 450°. 30–35 min. longer at 400° F.		10	4x3x1 inch	Total of 45–50 min. with 20 min. at 450° F. 25–30 min. at 400° F.
Sweet Potatoes..	188–339	12	Diameter 4–5 cm. 5½–6 cm. 7.5–8 cm.	 45 minutes 45 minutes 60–70 minutes	188–231	 6 5 3	Diameter 4x5 cm. 6x7 cm. 9 cm.	 35–40 min. at 450° F. 50–65 min. at 450° F. 70–75 min. at 450° F.
Irish Potatoes....	219–232		6 cm. 7.5 cm.	60–65 minutes 70 minutes	187–300	15	7½x6½x5 cm. 8½x7½x6 cm. 9x7x6½ cm.	55 min. at 450° F. 60 min. at 450° F. 65 min. at 450° F.

they have used in the preparation of the vegetables for cooking, also the amounts of ingredients and size of pieces, were duplicated in the Home Economics Laboratory at the University of Wyoming, in order that an adequate comparison with a standard low altitude time table might be made. It was also of interest to determine the extent to which altitude affected the time for cooking vegetables.

It was found that the time required for boiling vegetables is considerable greater at Laramie than at Chicago as the result of this difference of 6,559 feet in the altitude of the two cities.

1. Beets, cauliflower and onions required 55 to 66 per cent more time, or an increase of approximately 9 to 11 per cent for each 1,000 feet rise in elevation.

2. Young carrots, squash, green cabbage, turnips, Irish potatoes, sweet potatoes, rutabagas and parsnips required approximately 20 to 25 per cent more time, or an increase of about 4 per cent for each 1,000 feet rise in elevation.

(Note: The vegetables used in these tests were of excellent quality.)

3. White cabbage, shredded, required 38 to 40 per cent more time, and old carrots required 11 to 14 per cent more time.

Variables which might affect the cooking period, other than the altitude, were controlled in so far as it was possible to do so. A difference in the acidity or alkalinity of the water in which the vegetables were cooked would affect the time for cooking. Alkaline water speeds the cooking process. The pH value of the Laramie city water was 7.5 as compared with pH value of 8.2 for Chicago city water.*

This small amount of difference in alkalinity of the water in the two cities would affect the time for cooking very slightly. It was assumed that other variables, such as freshness, age and character of the cellulose, were controlled through careful selection of the vegetables for cooking. Halliday and Noble state that they were careful to use a uniform grade of vegetables, the best on the market. This was also true at the University of Wyoming.

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*Hows and Whys of Cooking. Halliday and Noble, page 5.

It was found that variations in the size of the pieces made a great difference in the time needed for cooking. The pieces were measured accurately by rule to correspond with the measurements given in the Chicago time table.

It was found necessary, at the University of Wyoming, to use a larger amount of water than was used at Chicago for cooking some of the vegetables requiring exceedingly long periods for boiling, such as beets, onions, carrots and parsnips. It was noticed, however, that a slight increase or decrease in the amount of boiling water did not affect the time needed for cooking to any appreciable extent, neither did slight variations in the weight of the vegetable affect the time for cooking.

The subjective judgments of the individuals doing the testing would be a variable factor. Both experimenters specify they were careful to cook the vegetables *only until tender*. What constitutes a desirable degree of tenderness in the cooked vegetable would vary to some extent with the individual doing the testing.

In Table XI will be found a comparison of the time required for steaming vegetables at high and low altitudes. Vegetables steamed in the pressure cooker at high altitudes (7,159 feet) may be cooked in the same period of time as at low altitudes (Chicago) if the pressure is increased three pounds. The reading of the pressure gauge is affected by the altitude. Commencing with 2,000 feet, the pressure must be increased one pound for each 2,000 feet elevation in order that the relationship between temperature and pressure indicated in the following table may be maintained.*

Steam Pressure Pounds	Temperature F.	C.
5	228	109
10	240	115
15	250	121
20	259	126
25	267	131

When other types of steamers were used there was an increase in the time for cooking at Laramie as compared with Chi-

*Farmers Bulletin No. 1471, pp. 5 and 6.

cago. The additional time required at Laramie ranged from 27 to 40 per cent for new carrots, and 16 to 22 per cent for Irish potatoes. Squash and sweet potatoes were steamed in the same length of time at Laramie and Chicago.

In Table XII will be found a comparison of the time required for baking vegetables at high and low altitudes. It was found that vegetables could be baked at high altitudes in approximately the same amount of time required at low altitudes if the oven temperature and the size and the weight of the vegetables were similar.

B. EFFECT OF COOKING ON VEGETABLES COLOR AND FLAVOR

The various processes employed in cooking vegetables, as well as the length of time they were cooked, had very definite effects upon the color, flavor and texture of the cooked product.

The *natural color* of the vegetables was retained in so far as possible by observing the following precautions in cooking:

Green vegetables were cooked in a moderate or rather large amount of boiling water with the cooking vessels uncovered. The vegetables were cooked only until tender. Water that was slightly alkaline helped to preserve the green color. The addition of soda intensified the green color. Soda has been found to be destructive to Vitamin C, consequently should not be used for this purpose.* The pigment or chlorophyll of green vegetables turns brown when heated in the presence of acid. The volatile acids present in vegetables escape with the steam if the kettle has been left uncovered, thereby preventing the development of an undesirable brownish color in the vegetable.

White vegetables were dropped into boiling water and cooked the shortest possible time to produce a tender product. Long cooking darkened the vegetable.

Red vegetables retained the color best if cooked in a slightly acid medium. Beets were the only red vegetable tested. They were cooked in a moderate amount of water with the lid left on the kettle in order that the volatile acids might be retained, thereby helping to preserve the color. Beets were cooked whole with the

*A Summary of Our Present Knowledge of Vitamins by D. Breeze Jones. Protein Investigation Laboratory, Washington, D. C., 1931.

TABLE X. COMPARISON OF LARAMIE AND CHICAGO TIME TABLE FOR BOILING VEGETABLES

Vegetables	Laramie Time Table	Chicago* Time Table Minutes	Altitudinal Time Used at Laramie Minutes	Per Cent Increase
Beets (old)	3½ to 4 hours (210 to 240 minutes)			
Beets (young)	2¼ to 2½ hours (135 to 150 minutes)	40–60	90–95	63–66
Cabbage (white)	13 to 15 minutes	8–9	5–6	38–40
Cabbage (green)	9 to 10 minutes	6–8	2–3	22–30
Cauliflower	20–24 minutes	8–10	12–14	58–60
Carrots (old)	35–45 minutes	30–40	5	11–14
Carrots (young)	32–41 minutes (cut in thirds lengthwise and crosswise once)	20–25	12–16	37–39
Onions (yellow)	45–55 minutes	20–25	25–30	55
Potatoes (Irish)	32–44 (varied varieties)	25–35	7–14	21–31
Parsnips	30–38 minutes (if good quality)	25–30	5–8	16–21
Rutabagas	32–38 minutes (January tests)	25–30	7–8	21
Squash	20–25 minutes	20	5	20–25
Sweet Potatoes	23–30 minutes	15–25	5–8	21–26
Turnips (old)	20–30 minutes	20–25	5	16–25
Turnips (new)	17–23 minutes			

*Hows and Whys of Cooking. Halliday and Noble, University of Chicago, page 23.

TABLE XI.

COMPARISON OF LARAMIE AND CHICAGO TIME TABLES FOR STEAMING VEGETABLES

Vegetable	Size	Laramie Time Table		Chicago Time Table*		Additional Time Used at Laramie Minutes	Per Cent Increase
		Steamer	Pressure Cooker	Steamer	Pressure Cooker		
Beets (old).....			30 min. at 18 lbs.	60–90	30 min. at 15 lbs.	3 lbs. more pressure	
Beets (new).....	3½ cm. 8 cm.		20 min. at 18 lbs. 22 min. at 18 lbs.	60–90	15 min. at 15 lbs.	5 minutes at 3 lbs. more pressure.	Varies with size of vegetable
Carrots (old)....		42–53	8 min. at 15 lbs.	40–50		Depends upon quality of vegetable. 2–3 minutes	5–8
Carrots (new)...		37–40	6 min. at 12 lbs.	25–30		10–12 minutes	27–40
Potatoes, Irish...		30–45		30–35		5–10 minutes, depends on variety of potato. Time of year cooked.	16–22
Sweet Potatoes..		23–35		25–35		Approximately none	
Squash.....		22–25		20–25		Same	

TABLE XII.

COMPARISON OF LARAMIE AND CHICAGO TIME TABLES FOR BAKING VEGETABLES

Vegetable	Laramie Time Table	Chicago Time Table*	Additional Time Used at Laramie Minutes	Per Cent Increase
Potato, Irish.....	55 min. for 7½x6½x5½ cm. 60 min. for 8½x7x6 cm. 65 min. for 9x7x6½ cm.	40–60 min. at 450° F. Diameter 1½x2 in.		Approximately none
Potato, Sweet.....	35–40 min. for 4–5 cm. diam. 50–65 min. for 6–7 cm. diam. 70–75 min. for 9 cm. diam.	35–45 min. at 450° F.		Approximately none
Squash, Hubbard.....	Total 45–50 minutes 20 min. at 450° F. then 25–30 min. at 400° F.	20 min. at 450° F. then 30–40 min. at 400° F. Total 50–60 minutes		Negligible

*Hows and Whys of Cooking. Halliday and Noble, page 24.

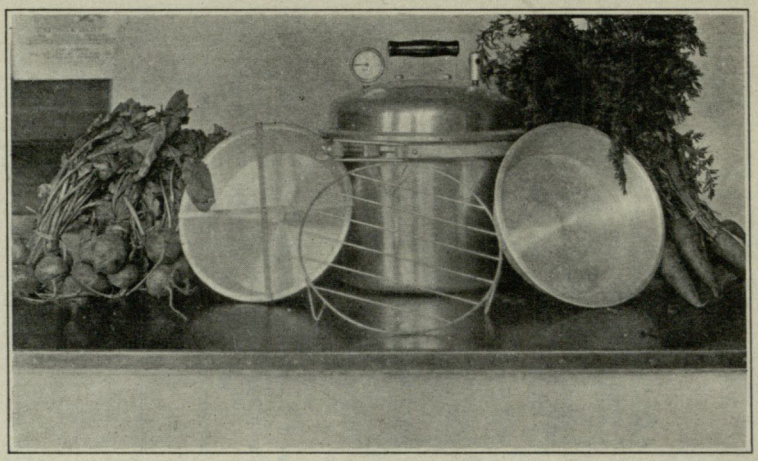


Figure 2. The pressure cooker saves time in cooking vegetables at high altitudes. The natural flavor of the vegetable is retained and the nutrient loss is small.

root and a small portion of the top left on the vegetable. Old beets, which required several hours for boiling at high altitudes, retained their color when a small amount of vinegar was added to the cooking water. One teaspoon of vinegar to a pint of water is a good proportion to use.

The natural flavor of the vegetables was retained best when the vegetables were cooked for the shortest time possible and served as soon as they were cooked.

Mild-flavored vegetables, especially beets, which required long periods for boiling at high altitudes were insipid and tasteless when boiled. When cooked in the pressure cooker the vegetables were of an excellent flavor. The time for cooking was also greatly lessened. In using the pressure cooker it was found that vegetables cooked at a lower pressure for a longer period of time gave better results than if cooked at a high pressure for shorter periods of time.

A comparison of the quality of carrots and beets cooked by the three methods—steamer, pressure cooker, and boiling—was made, and in all tests the pressure cooked vegetables rated highest in flavor. The steamed vegetables rated second, and the boiled vegetables rated third. The natural color was well preserved in

the pressure cooker and steamer. The new type of pressure cooker with inset pans was used; the vegetables were not placed in direct contact with water. (See Figure 2.)

Steaming, as a method of cooking mild flavored vegetables, might well be used to a much greater extent than has been done by the average housewife.

The loss of mineral substances by cooking in water or steam are tabulated in the following table.

AVERAGE LOSS OF MINERALS WITH DIFFERENT COOKERY METHODS†

	Steamer	Pressure Cooker	Average Amount Boiling Water	Large Amounts Boiling Water
Calcium	10%	10%	20%	30%
Magnesium	20%	20%	30%	45%
Iron	20%	20%	40%	50%

It will be noted that vegetables cooked in the steamer and pressure cooker show the least loss in minerals. Steaming has the further advantage of retaining the natural flavor and color of the vegetables to a much larger extent than boiling. The time period for cooking is in all cases slightly longer for steaming, but the improvement in flavor and the saving in mineral content might well justify the housewife in using this method more extensively even though it takes a slightly longer period of time.

Two types of steamers were used. Vegetables which were cooked in the steamer at the right in Figure 1 with perforations in the bottom of the inset pan cooked more quickly than the other type of steamer with perforations at the side of the inset pan but none in the bottom. Starchy foods, such as Irish potatoes and sweet potatoes, seemed more mealy when cooked in the steamer perforated at the bottom.

If vegetables are cooked in various types of waterless cookers, the loss depends upon the amount of water which leaves the vegetables. If this liquid is utilized the loss will be very small.‡

†Losses of minerals and other constituents from vegetables by various methods of cooking. Peterson and Hoppert, Univ. of Wis., Jour. of Home Economics, 17,265. 1925.

‡Chemistry of Cooking. McLeod and Nason, p. 368.

TABLE XIII.

QUALITY OF VEGETABLES COOKED IN STEAMER VS. PRESSURE COOKER VS. BOILING WATER AT HIGH ALTITUDES

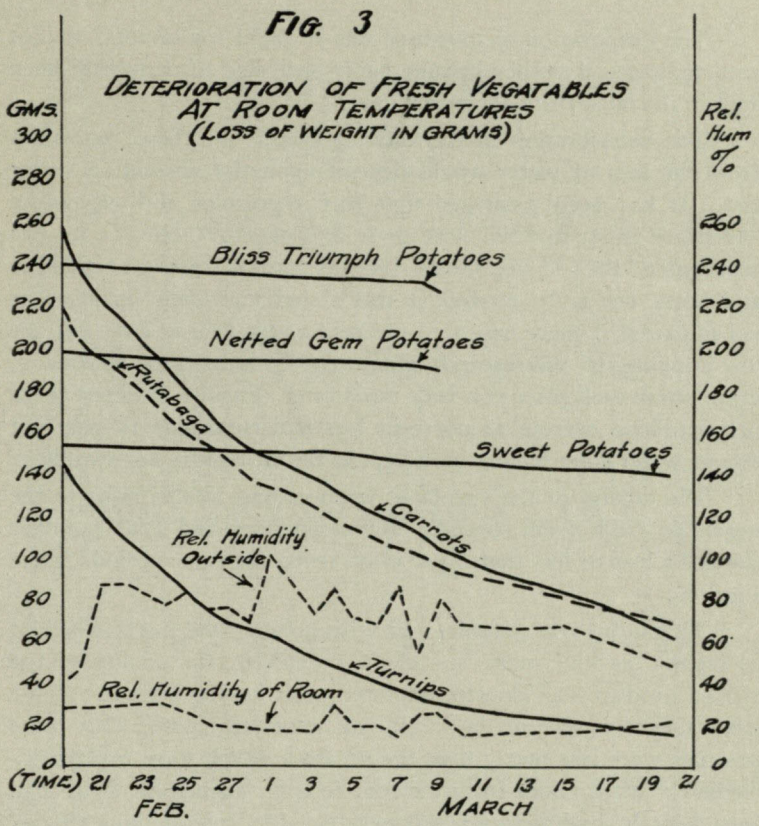
Vegetable	Date	Method of Cooking	Weight		Time	Quality
			Before Cooking E. P.	After Cooking		
Beets(new).....	2/21/31	Steamer	148	137	2 hours 50 minutes	Steaming rated second
Beets(new).....	2/21/31	Pressure Cooker	130	115.5	(Complete time 44 min.)* 22 minutes at 18 lbs.	Pressure Cooker rated first in quality
Beets(new).....	2/21/31	Boiling Water	158.5	160	2 hours 15 minutes	
Carrots (old).....	2/16/31	Steamer	165	161	50 minutes	Rated next to Pressure Cooker in flavor
Carrots (old).....	2/16/31	Pressure Cooker	181	176	(Complete time 23 min.) 7 minutes at 15 lbs.	Most excellent of three methods in flavor
Carrots (old).....	2/16/31	Boiling Water	209	205	35 minutes	Most insipid in flavor of three

Entire process in use of pressure cooker takes following amount of time for beets (University of Wyoming):

Let steam out 12 minutes, then close petcock. Pressure up in 7 minutes. Hold pressure 22 minutes. Open petcock. Let out steam 3 minutes. Total time, 44 minutes.

*Pressure Cooker Operation in Home Canning. Iowa State College. Steam allowed to escape 7 minutes before petcock was closed.

*Pressure Cooker Operation in Home Canning. Mabel Nelson, Jour. of Home Econ., Feb., 1929.



C. EFFECT OF STORAGE UPON THE QUALITY OF VEGETABLES WHEN COOKED

Vegetables kept in a room of low humidity and high temperature deteriorate very rapidly. The daily loss in weight of carrots, turnips, rutabagas, sweet potatoes and Irish potatoes was recorded over a period of several weeks. The relative humidity and the temperature of the steam-heated laboratory were also recorded. The relative humidity of the laboratory averaged 20 per cent, which is very low. The desirable relative humidity of a room should be around 60 per cent with a temperature of 68° F.* The relative humidity out of doors, as recorded in the University of Wyoming weather reports, averaged 71 per cent.

*Personal Hygiene Applied, Williams. 1930.

The evaporation of moisture was so rapid for carrots, turnips and rutabagas that they became badly shriveled after having been kept in the laboratory for a few days.

The deterioration in the cooking quality of these vegetables from the loss of water would depend upon the amount of water lost. It has been estimated that leaf vegetables and vegetables which are eaten raw will lose their crispness if there is a 10 per cent water loss. If vegetables, such as turnips, carrots, rutabagas and beets, are to be cooked, it was found that their quality was not impaired if there was a 10 per cent water loss or less. At the low humidity of the research laboratory, University of Wyoming, evaporation took place at a very rapid rate. Turnips suffered an 18 per cent loss, carrots 14 per cent loss and rutabagas 11 per cent loss of water after having been kept in the laboratory for two days.

The quality of the vegetable when cooked was inferior to the vegetable fresh from storage. Sweet potatoes and Irish potatoes showed a loss of less than 1 per cent during the same period. (See Figure 3.)

Although sweet potatoes and Irish potatoes did not lose weight as rapidly as the more succulent vegetables, the quality of the cooked product was likewise impaired after having been left in the laboratory for several days. It was especially noted that these potatoes were less mealy than the potatoes which were cooked immediately when taken from the root cellar. Vegetables which had been kept in hydrators of refrigerators for several days yielded excellent cooked products. The relative humidity of the hydrator would probably average 90 to 100 per cent saturation† as compared with the relative humidity of 20 per cent in the laboratory. Most kitchens, especially in high altitude areas where there is little precipitation, would average very low in relative humidity and the deterioration of vegetables, if kept in the kitchen, would be rapid. It is essential that vegetables purchased in large quantities for several days' use be placed in hydrators of ice boxes or vegetable cellars and not be left exposed in rooms of low relative humidity and high temperature.

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†Vegetable Storage in Hydrator. Frigidaire Company, page 4.

TABLE XV.

DETERIORATION OF FRESH VEGETABLES AT ROOM TEMPERATURE (LOSS OF WEIGHT IN GRAMS)

Date	Carrots	Turnips	Rutabagas	Sweet Potatoes	Bliss Triumph Irish Potatoes	Netted Gem Irish Potatoes	Rel. Humidity Out of Doors	Rel. Humidity of Room
Feb. 19.....	260	142.1	218.4	153.3	240.1	194.9	42%	27%
" 20.....	237.5	131.4	200	152.5	239.3	194.4	45%	
" 21.....	221.6	117.8	194	152.5	238.6	194	86%	
" 22.....	212.8	110	185.9	151.9	237.8	194	86%	
" 24.....	192.6	92.8	168.3	151.9	237	193.8	78%	29%
" 25.....	181.1	82.8	158	150.8	237	193.6	84%	
" 26.....	172.2	75.4	150.9	150.5	235	193	72%	20%
" 27.....	158.7	68.7	145.7	150	235	192.5	76%	
" 28.....	151	65	137.3	149.9	234.9	192.1	68%	
Mar. 1.....	146.1	61.5	132.5	149.3	134.5	192	100%	17%
" 3.....	137.5	50.8	125.3	149	233.6	192	73%	18%
" 4.....	133	47.2	118.6	148.1	233.1	191.7	84%	30%
" 5.....	125.9	42.7	113.5	148	232.5	191.7	70%	19%
" 6.....	120	39.5	108.5	147.5	231.9	191.2	68%	19%
" 7.....	115.5	36.5	104	146.8	230.5	190.5	84%	15%
" 8.....	111.2	34.7	102.9	146.6	230	190.5	53%	25%
" 9.....	102	29.5	95.2	146	226.7	188.7	79%	24%
" 10.....	98	27.3	91	145.5			68%	15%
" 13.....	88.6	23.1	86	143.9			66%	17%
" 15.....	82	20	81	142.7			67%	16%
" 20.....	62.3	15	69.6	139			49%	22%

D. PERCENTAGE OF WASTE IN ORDINARY PARING OF VEGETABLES

It has been of interest in this experiment to compare the percentage of waste in the paring of different kinds of vegetables. The loss was approximately one-third for old carrots, parsnips, rutabagas and old turnips. The loss was about one-fourth for new carrots, Irish potatoes, squash and new turnips.

The loss was greater for vegetables which had been kept in storage as compared with young or new vegetables. Young carrots showed a 29 per cent loss compared with a 35 per cent loss for old carrots. Young turnips showed a 29 per cent loss compared with a 39 per cent loss for old turnips.

The vegetables showing the least loss from paring were onions and sweet potatoes. This would be expected in case of onions which have a thin outside covering, but was rather surprising in case of sweet potatoes. A comparison of the loss from paring the three varieties of Irish potatoes gave a difference of but 1 to 2 per cent. Irish Cobbler irrigated potatoes showed a slightly greater loss than Bliss Triumph dry-land and irrigated potatoes. Bliss Triumphs have thinner skins than Irish Cobblers. Tests were made on the above varieties of potatoes in January, February and March. The loss would be greater during this period than during the fall months.

Langworthy estimates the average waste from paring potatoes to be 20 per cent.* Our loss was greater due perhaps to the fact that our tests were made late in the winter. Margaret Vosbury,† scientific assistant, Office of Horticultural Investigation, estimates the loss from paring potatoes to be but 12.47 per cent with mechanical peelers.

The loss in paring was less for most vegetables tested in 1929-1930 than for 1930-1931. The paring of the vegetables for the two years was done by two different individuals which probably accounts for this difference.

Percentage loss in paring may also depend upon many other factors, chiefly firmness of the vegetable, freedom from rot or decay, variety, shape, regularity of tuber or root.

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*Potatoes, Sweet Potatoes, and Other Starchy Roots as Food. U. S. Dept. of Agriculture, Bul. 468, 1917.

†Methods of Manufacturing Potato Chips, Margaret Vosbury. Office of Horticulture and Pomological Investigation. 1922, page 16.

TABLE XIV.
LOSS IN PARING

Vegetable	Date	No. Tests	Per Cent Loss in Paring	Date	No. Tests	Per Cent Loss in Paring
Carrots, Old	1930–1931 Feb. 1–16	12	35	1929–1930 Dec.–Jan.	16	16.8
Carrots ,New	Feb.–March	11	29			
Onions	Jan.–Feb.	8	17	Feb.	5	24.2
Parsnips	Feb.	19	31	Nov.–Feb.	10	27.5
Rutabagas	Jan.–Feb.	21	31	Nov.–Feb.	9	20.7
Potatoes—B. T. Irrigated	Feb.–March	10	24	Jan.–March	10	19.7
Potatoes—I. C. Irrigated	Feb.–March	9	26			
Potatoes—B. T. Dry Land	Feb.–March	13	25			
Squash	Nov.	6	29			
Sweet Potatoes	Jan. and Feb.	9	19	Nov.–Feb.	16	15.6
Turnips, Old	Dec., Jan. and Feb.	12	39	Nov.	3	22.6
Turnips, New	Feb –March	11	29	Jan.–Feb.	7	13.9

SUMMARY AND CONCLUSIONS

Time Required for Cooking Vegetables. 1. The most consistent results and the smallest range in the time needed for cooking vegetables were secured in boiling tests for shredded cabbage (white and green), turnips cut in ¾-inch cubes, cauliflower separated into flowerets, and sliced carrots. The variations resulting from a number of tests for two different years for each of these vegetables showed a total range of but five minutes in time. It would, therefore, seem possible that a standard time might be used successfully for boiling these vegetables if the following precautions are observed: Standard method for preparation, standard size of pieces, dropping the vegetable into boiling salted water and bringing the water quickly back to the boiling point.

2. The widest range in the time needed for cooking winter vegetables was found in boiling tests for rutabagas, Irish potatoes, parsnips and (old) carrots. These vegetables likewise showed the greatest variation in quality. An exact time table could not be devised for these vegetables, but a time table giving a wider range for cooking could be used advantageously. The age of the vegetables, time left in storage, the quality of the cellulose and the variety (Irish potatoes) all seemed to affect the time needed for cooking.

Beets gave a wide range in the time required for boiling if they were uneven in size.

3. Baking tests for Irish potatoes and sweet potatoes showed very little variation in the time required for baking at different times of the year if the vegetables were uniform in size. This was also true of squash if cut in pieces of uniform size.

4. The range in time for steaming vegetables in the pressure cooker was small. Young beets gave the widest range. They were uneven in size. The time for steaming vegetables in two types of steamers showed a total range of approximately 10 to 14 minutes for carrots (old and young), sweet potatoes, Irish potatoes and squash.

Comparison of Time Required for Cooking Vegetables at High vs. Low Altitudes. 1. The chief variations found upon comparing high and low altitude time tables for cooking vegetables occurred in boiling vegetables. Green cabbage, Irish potatoes, parsnips (if good quality), rutabagas, squash, sweet potatoes and turnips require about 20 to 25 per cent more time than Chicago quotes. This would mean an increase of approximately 4 per cent in time for each 1,000 feet rise in elevation. Beets, cauliflower and onions require the greatest increase in time, 55 to 66 per cent, or an increase of 9 to 11 per cent more time for each 1,000 feet rise in elevation. Old carrots require 11 to 14 per cent more time.

2. Vegetables steamed in the pressure cooker at high altitudes (7,159 feet) cook in the same period of time as at low altitudes (Chicago table), but they require three pounds more pressure.

3. Irish potatoes and carrots cooked in steamers at high altitudes require longer periods for cooking at Laramie than at Chicago. Sweet potatoes and squash may be steamed in the same period of time at Laramie and Chicago.

4. Vegetables may be baked at high altitudes in the same period of time required at low altitudes.

5. Mild-flavored vegetables which require long periods for cooking, such as carrots and beets, yield a product better in flavor and color if cooked in the pressure cooker.

Percentage Loss from Paring Vegetables. 1. Percentage loss from paring vegetables was greater for vegetables which had been kept in storage for some time than for young vegetables.

2. The loss in paring was approximately one-third for old carrots, parsnips, rutabagas and old turnips. The loss was about one-fourth for young carrots, young turnips and Irish potatoes.

Deterioration of Vegetables in a Room of High Temperature and Low Humidity. Vegetables deteriorate rapidly in a room of high temperature and low humidity. The quality of the vegetables

kept under these conditions is much inferior to vegetables cooked immediately when taken from storage. Vegetables should be placed in the vegetable cellar or hydrator in the icebox when received from the grocery store or when taken out of root cellar if the best flavor and quality would be preserved.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of Miss Ellen Feusner, student assistant in Home Economics, for her work in checking the tests in vegetable cookery.