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FACTORS AFFECTING THE RETENTION OF
"VITAMIN C IN COMMUNITY CANNED TOMATOES

by

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CHAPTER I

INTRODUCTION

The summer of 1943 marked a new interest in community food preservation that was shown during the preceding summer. The people for this extended interest were attracted to the community food preservation program.

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The summer of 1943 marked a new interest in community food preservation that was shown during the preceding summer. The people for this extended interest were attracted to the community food preservation program. They are interested not in a nutritional laboratory to take their food but in a nutritional laboratory to take their food.

CHAPTER I

INTRODUCTION

The summer of 1943 marked a keener interest in community food preservation than was shown during any preceding summer. The reasons for this accelerated interest were war-time food shortages and the need for conserving all the food produced in both large and small gardens. These conditions brought about the opening of community canneries and the increased use of those already in operation. Many of these canneries were located in crude buildings; or lacking buildings, the canneries were nothing more than tables and boilers set up in the open. In most of the canneries, tin containers were used, because tin is easily handled and allows the food to be processed and cooled quickly which prevents overcooking the product.

The placement of equipment in a community cannery lends itself to the ease of preparation and processing of large quantities of food. In this respect the community cannery has the advantage over the ordinary home kitchen where the preparation and processing of large quantities of food is difficult.

The success of a community cannery was formerly measured in the amount of spoilage of processed food occurring during the winter months. But now the managers are asking about the quality of product coming from the community cannery. They are interested now in a nutritional comparison of the community product with that of commercial

companies. This comparison is important in order that the housewife who uses the products of the community cannery can be assured a satisfactory source of vitamins.

It is known that vitamin C is one of the constituents most likely to be left out of diets not abundant in fresh fruits and vegetables. Therefore, it is important that the maximum amount of vitamin C be retained in the canned product. During the preparation and processing of the food, some ascorbic acid can be lost. Additional losses can occur when the canned product is opened for use. The present study deals with the vitamin C content of the canned food after it is opened for use.

Tomatoes are generally considered an acceptable and available source of vitamin C. For this reason, they were selected as the food most suitable for the present study. This study had two related aims - (1) to compare the vitamin C content of community canned tomatoes with that of commercial brands, (2) to discover how the vitamin C content of the canned tomatoes is affected by various common household procedures after the cans are opened in the home kitchen. The effect of several procedures was studied including the use of different methods of preparation, addition of seasoning and other food materials, and varying conditions and times of storage.

The two parts of this study are closely related and of equal importance to the average householder using the tomatoes. To be a satisfactory source of vitamin C for the householder, a canned food must have at least two qualifications. It must retain a large share of its original ascorbic acid

content during processing and must also be stable towards common household manipulations to which the householder might subject it before consumption. If the vitamin C is not stable and will be lost easily when the canned tomatoes are opened all the work of canning has been wasted effort so far as the content of vitamin C for consumption is concerned.

Community canned tomatoes are considered generally a reliable source of vitamin C, but no reported data are available on the vitamin C content of this product. This study contributes information on this point as well as upon the loss of the vitamin in the home kitchen. It is hoped that suggestions for the homemaker may be compiled from this study which will aid her in preventing the loss of vitamin C after the canned tomatoes are opened. The product tested was tomatoes taken from the 1943 crop canned in community canneries in tin containers. Information regarding the tomatoes was ascertained by use of a questionnaire.

The canning procedure employed in the different canneries is outlined in the chapter on procedures. The method of testing for vitamin C was the chemical dye titration method outlined by Bessey and King in 1933.¹ The procedure is one of rupturing the vegetable cells, making a paste, centrifuging the paste, and testing the decanted liquid for

¹ Otto A. Bessey and C. G. King, "The Distribution of Vitamin C in Plant and Animal Tissues and Its Determination," Journal of Biological Chemistry, CIII, (1933), 687-698.

ascorbic acid using 2-6 dichlorophenolindolphenol dye. The results were compiled, tabulated, and compared with the results of other workers as given in the literature, on the vitamin C retention in canned tomatoes. So far as the author has been able to ascertain, no other experimental study has been made with community canned tomatoes although other studies have been made dealing with the factors affecting the retention of vitamin C in commercial canned and home canned tomatoes.

CHAPTER II

REVIEW OF THE LITERATURE

Much research on the ascorbic acid value of various foods has been reported in the literature. A large proportion of this reported research has dealt with tomatoes and tomato products which will be the principal food discussed in the review presented here.

Many factors regulate the amount of ascorbic acid in the tomato before canning. Some of these factors are variety, degree of ripeness, and size of the fruit, weather conditions and the amount of sunshine received during the growth period, period of holding before canning, and the blanching and cutting preparatory to canning. After the canned product is sealed, additional factors may help to reduce the amount of usable ascorbic acid as the headspace in the container, the amount, kind and time of processing and the time and conditions of storage of the finished product. Finally, after the canned tomato is opened for use, the amount of vitamin C may be affected by various common household practices which include permitting the opened can to remain uncovered either at refrigerator or room temperature for a period of time, and the addition of seasonings and other food materials as milk, flour, and fat in the making of cream of tomato soup.

In the reported experimental work there has been some contradictory evidence on the effect of the different variables. Fellers, Clague, and Isham in 1935 found that the Marglobe variety gave a higher scurvy score than the Stone variety indicating a lower vitamin C content.¹ In an abstract of work done by Maclinn, Fellers, and Buck in 1937 it was reported that the vitamin C content varies from 74 to 249 units per ounce in different varieties grown under the same conditions. They reported also the absence of correlation between vitamin C content and the degree of ripeness of tomato fruit.² On the other hand, Gomalyako in Russia found variety differences but reported that green fruit contained less vitamin C than ripe fruit. He observed that small and large fruit of the same variety were equal in ascorbic acid quantity.³ Clow and Marlott in 1930 found that field-ripened and hot house tomatoes had about

¹ Carl R. Fellers, J. A. Clague, Paul Isham, "Value of Canned and Laboratory Prepared Tomato Juice as Antiscorbutics", Journal of Home Economics, XXVII, (1935), 447-451.

² W. A. Maclinn, Carl R. Fellers, R. E. Buck, "Tomato Variety and Strain Differences in Ascorbic Acid (Vitamin C) Content", Chemical Abstracts, XXXI, (1937) 4737.⁶

³ L. G. Gomalyako, "Variability in the Amount of Antiscorbutic Vitamin in Different Tomato Varieties", Chemical Abstracts, XXXIII, (1939), 1366.

equal amounts of vitamin C. They stated that the vitamin C content increases as the tomato matures and ripens.⁴ Currence reported, on the contrary, that hot house products had less ascorbic acid than field-grown ones. He also stated in an abstract in 1941, that there were no differences in varieties grown in the same field.⁵ Brown and Moser in 1941 reported that ripe tomatoes gave a higher titration value, indicative of more vitamin C, than less ripe ones of the same variety. This author suggested that an inverse ratio might exist between the ascorbic acid content and the size of the tomato.⁶ But Wokes and Organ found that small tomatoes contain about as much ascorbic acid as large ones and that there is little increase of ascorbic acid during the ripening process.⁷

Weather conditions and amount of sunshine were considered in the work reported by Currence revealing that the amount of sunlight apparently makes little difference in the amount of

⁴ Bertha Clow, Abby L. Marlatt, "Studies in Vitamin C in Fresh and Canned Tomatoes", Journal of Agricultural Research, XL, (1930), 767-775.

⁵ T. M. Currence, "A Comparison of Tomato Varieties for Vitamin C Content", Experiment Station Record, CLXXXV, (1941), 708.

⁶ Almeda Perry Brown and Faye Moser, "Vitamin C Content of Tomatoes", Food Research, VI, (1941) 45-55.

⁷ F. Wokes and J. G. Organ, "Vitamin C From Green Tomatoes", Nature, CL, (1942), 523.

ascorbic acid in tomatoes from one week to the next during growth periods.⁸ Brown and Moser found the titration values of tomatoes increased during the latter weeks of the season and attributed this increase to many conditions including natural seasonal factors. They supported plants by poles so that they would receive more sunlight and discovered that fruit from these plants gave titration values higher than the non-supported tomatoes.⁹

After the fruit is grown and is ready to be canned other factors may affect the ascorbic acid content. Among these are holding fruit for a period before using, blanching, cutting, heating, sealing, processing and cooling. Storage before canning does not seem to affect to any extent the ascorbic acid content of the tomato. Maclinn, Fellers and Buck in 1937 found that storing two varieties of tomatoes at room temperature for 10 days did not affect the vitamin C content.¹⁰ Rostovskoya in 1941 observed that raw tomatoes stored five days retained their ascorbic acid content well.¹¹ Brown and Moser in 1941 held tomatoes from

⁸ Currence, loc. cit.

⁹ Brown and Moser, loc. cit.

¹⁰ Maclinn, Fellers and Buck, loc. cit.

¹¹ Yu V. Rostovkoya, "Experimental Data on Stability of Vitamin C in Canning Vegetables", Chemical Abstracts, XXXVI, (1942), 2936.⁴

1 to 8 days at room temperature and detected no definite decrease in the ascorbic acid content.¹² Vail in 1942 found in the preparation for freezing of vegetables including blanching and cutting, a procedure similar to the preparation for canning, a loss as high as 30 to 40 per cent of the original ascorbic acid.¹³ Kohman found that blanching may be the cause of some destruction of vitamin C but does not state how much.¹⁴ King and Tressler reported that the process of blanching may affect the retention of vitamin C more than was thought formerly. The process of blanching should destroy oxidative enzymes but should be controlled to cause the minimum loss of vitamin C. These workers used vegetables other than tomatoes but the results could be applied to the preparation of tomatoes.¹⁵ Hamner and Maynard reviewing the literature up to 1942 warned the canner to use care because much of the ascorbic acid

¹² Brown and Moser, loc. cit.

¹³ Gladys E. Vail, "Effect of Processing Upon the Nutritive Value of Food", Journal American Dietetics Association, XVIII, (1942), 572-4.

¹⁴ Edward F. Kohman, "Handbook of Nutrition, Preservation of Nutritive Value of Foods in Processing", Journal American Medical Association, CXX, (1942), 831-38.

¹⁵ C. G. King and Donald M. Tressler, "Effect of Processing on Vitamin C Content of Foods", Chemical Abstracts, XXXV, (1940) 2617⁸⁻⁹.

content can be lost through carelessness in the canning procedures.¹⁶ Abbott in 1939 observed that canned juice processed at ten pounds pressure (240°F.) and then immediately cooled gave higher titration values than juice sterilized in a hot water bath.¹⁷ Rostovskoya found serious losses of ascorbic acid when tomatoes were heated to 70°-80°C. before pulping.¹⁸

Shmidt working in a commercial cannery followed tomatoes through the entire canning process and found that the fruit retained 90 to 100 per cent of the original vitamin C content. The author urged that a complete seal be placed on the product to prevent further oxidation of ascorbic acid. He suggested that blanching may be an important cause of loss of vitamin C.¹⁹ Daniel and Rutherford discovered that both canning and subsequent storage produced a product with less ascorbic acid than the original fruit. In filling the cans before sealing, the amount of headspace left may be a cause of destruction

¹⁶ K. C. Hamner and L. A. Maynard, "Factors Influencing the Nutritive Content of the Tomato", United States Department of Agriculture Miscellaneous Publication 502, (1942).

¹⁷ C. D. Abbott, "Standardization of Home Canned Tomatoes and Tomato Juice", Chemical Abstracts, XXXV, (1940), 1531.

¹⁸ Rostovskoya, loc. cit.

¹⁹ A. A. Schmidt, "Stability of Vitamin C During Commercial Canning of Fruits and Vegetables", Chemical Abstracts, XXXVI, (1941) 2943.

of usable ascorbic acid.²⁰ Hauck suggested that the difference in the amount of headspace left in tin and glass containers might be an explanation of the difference in the vitamin C content as with more space there might be greater oxidation of the vitamin present.²¹ Tressler and Curran canned tomato juice in quart and pint bottles leaving a headspace of 2.5 cubic centimeters for pints and 11.5 cubic centimeters for quarts and completely filling some containers. After cooling, the headspace was remeasured and found to be 20, 30, and 12 cubic centimeters respectively. Results of the tests after storage indicated that there was more loss in the filling, processing, and storing of partially filled bottles than loss from completely filled bottles.²² Lueck and Pilcher, working in a commercial cannery, canned tomato juice in tin and glass containers leaving the average commercial headspace of 20 cubic centimeters for cans and 11 cubic centimeters for bottles. Results showed that the rate of ascorbic acid

²⁰ Esther P. Daniel and Marjorie B. Rutherford, "Effect of Home Canning and Storage on Ascorbic Acid Content of Tomatoes", Food Research, I, (1936), 341-47.

²¹ Hazel M. Hauck, "Ascorbic Acid in Home Canned Tomato Juice - Effect of Type of Container and Method of Extraction", Journal of Home Economics, XXXV, (1943), 295-300.

²² Donald K. Tressler and Katherine M. Curran, "Cause of Loss from Bottled Tomato Juice", Journal of Home Economics, XXX, (1938), 487-488.

disappearance from either container was not the same and that more ascorbic acid was retained in tin than in glass containers.²³ Fellers and Buck canned tomato juice in pint flint glass bottles and quart milk bottles leaving a headspace of 18 and 30 cubic centimeters respectively. After 165 days of storage, tests showed the average loss of ascorbic acid content to be 7.4 per cent for pint and 11.2 per cent for quart containers.²⁴ Fixsen tested tomatoes canned only 24 hours and found values of 14.0 to 21.0 milligrams of vitamin C per 100 grams. After 6 months storage the values found were 7.0 to 18.0 milligrams per 100 grams or about one-third to one-half the amount in the product at the end of 24 hours.²⁵ Tressler and Curran observed a 10 per cent vitamin C loss during preparation and canning. After 40 days there was a further 10 per cent loss but after 190 days additional storage time no further loss occurred.²⁶ Shmidt found tomatoes lost 20 to 70 per cent of their ascorbic acid shortly after canning.²⁷ Rostovskoya reported that if

²³ R. H. Lueck and R. W. Pilcher, "Canning Fruit Juices, Technical Aspects", Industrial and Engineering Chemistry, XXXIII, (1941), 292-300.

²⁴ Carl R. Fellers and R. E. Buck, "Retention of Vitamin C and A in Glass Packed Foods", Food Research, VI, (1941), 135-41.

²⁵ Margaret A. Boas Fixsen, "Vitamin C Content of Human Foods as Affected by Processes of Cooking and Canning", Nutrition Abstracts and Reviews, VIII, (1938), 281-307.

²⁶ Tressler and Curran, loc. cit.

²⁷ Shmidt, loc. cit.

tomato pulp were properly canned it lost only 20 per cent of its vitamin C content but if improperly canned it lost 60 per cent. In tin ~~the~~ pulp lost 10 per cent of its ascorbic acid in one month and 40 per cent in one year. In wood, a 65 per cent loss was sustained in one month and there was none left after one year of storage.²⁸ Lueck and Pilcher stored tomato juice for eight months and reported an average of .158 milligram vitamin C per gram of tomato juice for tin-packed and .068 milligram for glass-packed juice.²⁹ Fellers and Buck found the greatest vitamin C loss occurred during the first 60 days of storage and that little loss occurred thereafter. Food canned in glass and stored in light retained 79.2 per cent of vitamin C after one year of storage, and that canned in tin retained 84.5 per cent. The authors felt that the difference of 5.7 per cent was not significant.³⁰ Hauck reported that tomatoes stored from one day to 8 1/2 months lost 3.6 milligrams of ascorbic acid per 100 grams of tomatoes. The author suggested that tin protects the tomatoes from light

²⁸Rostovskoya, loc. cit.

²⁹ Lueck and Pilcher, loc. cit.

³⁰ Fellers and Buck, loc. cit.

which might have a favorable affect on the preservation of ascorbic acid.³¹

After the cans of tomatoes are opened, additional factors may cause further loss. If the can is uncovered in the refrigerator some loss of vitamin C content may occur. Daniel, Kennedy, and Munsell in 1936 detected a loss of 3 per cent ascorbic acid after allowing the juice to stand uncovered one hour. There was a loss of 60 per cent of the original ascorbic acid after 4 days of standing.³² Hauck in 1938 found that canned juice lost about one-fourth of the total ascorbic acid when held 4 days in a refrigerator.³³ Fenton in 1940 suggested that vitamin C loss may occur in vegetables both at room temperature and in a refrigerator.³⁴ Richardson and Mayfield stated that the vitamin C content of tomato juice was not destroyed when the juice remained in a refrigerator for as long as 48 hours.³⁵ Brown and Moser in 1941

³¹ Hauck, loc. cit.

³² Esther P. Daniel, Mary H. Kennedy, and Hazel E. Munsell, "Relative Vitamin C Content of Orange and Tomato Juice Determined Chemically and Biologically", Journal of Home Economics, XXVIII, (1936), 470-474.

³³ Hazel M. Hauck, "Vitamin C Content of Home Canned Tomato Juice", Journal of Home Economics, XXX, (1938), 183-188.

³⁴ Faith Fenton, "Vitamin C Retention as a Criterion of Quality and Nutritive Value in Vegetables", Journal American Dietetics Association, XVI, (1940), 524-35.

³⁵ J. E. Richardson and H. L. Mayfield, "Vitamin C Content of Winter Fruits and Vegetables", Experiment Station Record, LXXXV, (1941), 705.

found that refrigeration apparently held no advantage in the preservation of vitamin C in tomatoes.³⁶ Vail reported that it took as long as four days for commercially canned juice to lose an appreciable amount of vitamin C and then the proportion of loss was not large. Home-canned juice, however, lost some vitamin C upon standing only 48 hours.³⁷

In preparing a recipe with canned tomatoes, other food materials may be added. Fixsen reviewing the literature up to 1938 referred to work in which the addition of salt and sugar altered the vitamin C content of lemon juice and felt that it might possibly alter the content of other foods as well. Oxidation of ascorbic acid may be affected by pH and ion content of the medium.³⁸ Kanitz and Dammann in 1939 found that addition of neutral salts alone as sodium chloride and sodium sulphate favored the destruction of ascorbic acid but when combined with sodium hydrogen sulphate and calcium sulphate the oxidation of vitamin C was inhibited.³⁹ Wokes and Organ in 1942 reported

³⁶ Brown and Moser, loc. cit.

³⁷ Vail, loc. cit.

³⁸ Fixsen, loc. cit.

³⁹ N. R. Kanitz and E. Dammann, "The Destruction of Vitamin C in Cooking", Chemical Abstracts, XXXIV, (1940), 1357^c.

preliminary results of a study in which sugar concentrated on tomatoes in pickle making made little difference in the stability of the vitamin.⁴⁰

There has been little work reported on the cooking losses of tomatoes resulting either from the type of utensil used or from reheating the canned product. Investigators working with other vegetables such as cabbage, turnips, and string beans have reported a difference in the vitamin C content depending whether glass, aluminum, stainless steel, or iron pans were used in cooking the foods. Cormack in 1941 stated that cabbage cooked in aluminum gave the highest value for the retention of vitamin C and glass the lowest value.⁴¹ McIntosh, Tressler, and Fenton in 1942 used various types of pans in studying quick frozen vegetables. They concluded the type of pan had little effect on the ascorbic acid content. The pans used were aluminum, enamel, pyrex, and stainless steel.⁴² Brinkman, Halliday, Hinman and Hamner cooked vegetables in large enamel pans, "waterless cookers", and a pressure saucepan with ability to reach 15 pounds

⁴⁰ Wokes and Organ, loc. cit.

⁴¹ Eunice Cormack, "The Effect of Different Methods of Cooking Upon Vitamin C Content of Cabbage", Master's Thesis, University of Oklahoma, (1941).

⁴² Jennie A. McIntosh, Donald K. Tressler and Faith Fenton, "Ascorbic Acid Content of Fine Quick-Frozen Vegetables as Affected by Composition of Cooking Utensil and Volume of Cooking Water", Journal of Home Economics, XXXIV, (1942), 314-318.

pressure. The vitamin C content varied both with the vegetable and the pan used. The highest retention figure given was 70 per cent in turnips cooked in a pressure saucepan, the lowest 40 per cent in cabbage cooked in an open kettle and green beans cooked in a pressure saucepan. These figures represent the per cent of original ascorbic acid present.⁴³

Another factor which may affect the further loss of vitamin C is reheating the canned vegetable for use in food preparation. Fixsen reviewing the literature referred to work which indicated that there is still further loss in reheating the canned vegetable when opened for use.⁴⁴ Fenton suggested further loss may occur in the reheating of canned vegetables especially if held at a higher than room temperature for a period of time.⁴⁵

In summarizing the work reported on factors influencing the vitamin C content of tomatoes, it is seen that there are three stages during which the vitamin C content may be affected. In the first period before the fruit is canned, the vitamin C content may vary dependent on the variety, degree of ripeness, and size of the fruit, on weather conditions and the amount of sunshine received during the

⁴³ E. V. S. Brinkman et al, "Effect of Various Cooking Methods Upon Subjective Qualities and Nutritive Value of Vegetables", Food Research, VII, (1942), 300-5.

⁴⁴ Fixsen, loc. cit.

⁴⁵ Fenton, loc. cit.

growth period, on the period of holding before canning, and on blanching and cutting preparatory to canning. In this study the influence of these factors could not be determined experimentally but information concerning these variables was gathered by questionnaire.

In the second period, after the fruit has been sealed in the cans additional factors may influence the amount of usable ascorbic acid present. Among these are the amount of headspace in the containers, the amount, kind and time of processing, and the conditions and length of storage of the finished product. Information concerning these variables again was ascertained by questionnaire but no experimental work could be conducted to determine their influence.

The final group of factors which may affect the vitamin C content of tomatoes operate in the third period when the can is opened for use. The ascorbic acid may be affected by common household practices which include leaving the uncovered open can either in the refrigerator or in the work room, the addition of other food materials, and the use of various types of cooking utensils. The influence of these factors has been experimentally determined in the present study as described in detail in succeeding chapters.

CHAPTER III

PROCEDURE

The tomatoes used in this study were obtained from the Community Canneries in Colleton County, South Carolina. The products were canned in tin during the 1943 season. The director of each of the canneries filled in a questionnaire for each can of tomatoes. This information was obtained to see what factors might have affected the vitamin C content of the tomatoes before canning. This information is summarized in Table III in the following chapter. A copy of the questionnaire is in the appendix.

The tomatoes were canned according to the following procedure. The tomatoes were washed as soon as they arrived at the cannery, sorted, dipped in boiling water three minutes for blanching, then cooled and peeled. The skins were slipped off by hand, and the fruit either cut into quarters or left whole, then packed into clean tin cans. Seasonings were added next. Salt and sugar are the usual ones in the proportion of one teaspoon per quart, or number three size can. Juice from cutting the tomatoes was poured over the product and any air expelled by gently sliding a knife around the inside of the can. The packed cans were put into the hot steam table to heat throughout. When hot, the cans were topped and sealed by using either a hand turned or electric sealing machine. The sealed

product was processed in a large retort at 10 pounds for 10 to 12 minutes, or in a hot water bath for 20 minutes. After processing the cans were removed from the retort or hot water bath, plunged immediately into cold water, and cooled until the bulging ends snapped back into place. The cans were removed from the cold water and allowed to cool completely in the air and then stored.

Before each can was opened for experimental procedures it was thoroughly cleaned and rinsed with distilled water to prevent any foreign material from entering the can. The top was cut with a hand-turned mechanical can opener. Immediately upon opening the can, two samples each, 108.2 grams of the tomato pulp and juice, were put into 150 milliliter beakers and the storage time started. One beaker was left uncovered at room temperature, the other put into an electric refrigerator uncovered. An immediate test was run on the freshly opened tomatoes to determine the ascorbic acid content. The procedure as outlined below was used in all the tests made on the tomatoes. Acetic acid in an 8 per cent solution was used as the extracting fluid. It was measured accurately into small beakers in the amounts of 25 cubic centimeters, 10 cubic centimeters, and 5 cubic centimeters. The acid was heated on a hot plate until it boiled. Five grams of tomato pulp and juice combined was weighed on a trip balance, then two grams of acid - washed sand was added, and the hot 25 cubic centimeters of acetic acid poured over the mixture. It was ground with a pestle

in a mortar until a thin paste was formed. The liquid and any solids were poured into a centrifuge tube and centrifuged for 10 minutes. The clear liquid was decanted into a 50 cubic centimeter volumetric flask. The mortar and pestle were rinsed with the already heated 10 cubic centimeters of acetic acid, and again with the 5 cubic centimeters of hot acid. This acid was added to the solids already in the centrifuge tube. The new liquid was stirred into the solids and recentrifuged for another 10 minutes. The second extract was decanted into the same flask with the first extract and made up to a volume of 50 cubic centimeters, with distilled water. Ten cubic centimeters of this liquid were pipetted into another 50 cubic centimeter volumetric flask and made up to volume with distilled water. Four cubic centimeter aliquots of this final tomato extract were pipetted into small beakers or test tubes and titrated against a solution of 2-6 dichlorophenolindolphenol dye. The amount of dye used to turn the clear almost colorless liquid a faint pink color was recorded. The amount of ascorbic acid present in the tomato extract was calculated using the standardization factor previously determined for the dye against pure ascorbic acid solution.

At the end of 12, 24, 36, 48, 60, and 72 hours, tests were run on samples of tomatoes stored at room temperature and those stored at refrigerator temperature. Results were compiled and are presented later in the discussion.

Then a sample of tomatoes (usually 108.2 grams) was

boiled five minutes in different types of saucepans which might be found in the average kitchen. In each case a test for vitamin C was made on the tomatoes at the end of the boiling time. The amount of tomato pulp used for the test was determined mathematically according to weight before and after boiling.

The saucepans used were as follows: black-speckled enamel, aluminum, pyrex glass, stainless steel and pressure saucepan. A larger volume of tomatoes was used for testing with both the stainless steel saucepan and the pressure saucepan due to the increased size of the utensil. For the stainless steel saucepan 216.4 grams of tomatoes were used and for the pressure saucepan 324.6 grams of tomatoes were used. The results are given later in the discussion.

One gram of ordinary household table salt was boiled with 108.2 grams of tomatoes in an aluminum saucepan and the resulting product tested. A similar test was made using one gram of sugar (sucrose), an amount which might be used to sweeten or flavor the tomatoes. The results are presented later.

The last test made on the tomatoes was to determine whether any ascorbic acid is destroyed in preparing a recipe using these tomatoes. Cream of tomato soup was chosen because this recipe is popular in most households. The soup was prepared by melting 12.2 grams of fat in an aluminum saucepan, adding 6.5 grams of all purpose flour, and mixing these together to form a smooth paste. The flour - fat

mixture was allowed to cook together one minute and then 70 milliliters of evaporated milk and 70 milliliters of distilled water were added. The mixture was stirred and allowed to cook until thickened. The 62.5 grams of tomatoes used were strained through a small tea-size metal sieve and the pulp pushed through. The resulting product was heated separately in a pyrex pan and added slowly to the flour - fat - milk mixture. One-half gram of salt was added at the last. The combined mixture was heated thoroughly and then tested for vitamin C. The amount of soup to be tested was worked out mathematically by weight in order to be comparable to the original quantity of tomatoes used in the soup.

The commercial brands of tomatoes tested were obtained from the local market and the procedure previously outlined was used to determine their ascorbic acid content. The results of the various tests are discussed in the following chapter.

CHAPTER IV

PRESENTATION AND DISCUSSION OF RESULTS

Many directors of community canneries are interested in a comparison of their products with the commercially canned tomatoes as found on local markets. The vitamin C content of commercially canned products has been tested by several investigators whose results are published in the literature. These findings are summarized in Table I. The variation in the values presented ranged from .113 to .290 milligram of ascorbic acid per gram of tomato fruit. The commercially canned tomatoes tested in this experiment had an ascorbic acid content well within the range shown in Table I. The results of these tests are given in Table II. The largest amount found was .266 milligram of vitamin C per gram of tomatoes in two brands and the smallest amount was .177 milligram found in only one brand. The smallest amount of ascorbic acid in the tested tomatoes is slightly larger than the average of results for canned tomatoes found in the literature. But the highest value found in testing is less than the highest value of the products listed in Table I.

TABLE I

Ascorbic Acid Values of Commercially Tin Canned Tomatoes
as Found in the Literature

Investigators	Year	Milligram Vitamin C Per Gram of Tomato
Daniel, Kennedy, Munsell	1936	.120 - .210
Hanning	1936	.129 - .137
Rogers and Matthews	1938	Lot I .148 II .113 III .143 IV .169
American Medical Association, Council on Foods	1938	.290 - .130
McElroy, Munsell and Steenbarger	1939	No. 1 .20 2 .20 3 .21 4 .21
Newman and Fellers	1940	.126
Kirk	1940	.174 - .281
Holmes, Pigott, Tripp	1941	.140
Range of Value		.113 - .290
Average Value		.174

TABLE II

Ascorbic Acid Content of Commercially Canned Tomatoes
Put Up in Tin

Name of Brand	Price	Ascorbic Acid Content Milligram of Acid Per Gram of Tomato
Premier	\$.20	.267
Yacht Club	.20	.178
Iona (A & P)	.10	.267
Board Mountain	.10	.207
Warsaw	Gift	.207

The values are closely comparable and well within normal variations found in different samples of tomatoes.

The range found with the community canned tomatoes tested was not so wide, .118 milligram of vitamin C being the lowest value and .178 milligram the highest value. These values are below the average value of the commercial tomatoes but not as low as the extreme value. The product with the least amount of ascorbic acid was canned at Smooks cannery. The ones with the largest amount of ascorbic acid were canned in Walterboro. The others came within the range given above.

From the foregoing results, the amount of community canned tomatoes needed to secure the daily requirement of ascorbic acid would be approximately two and one-half cups per person.

Each cannery director supplied two number three size cans of tomatoes for this experiment with the exception of Smooks cannery which sent number two size cans. There were four canneries surveyed in all.

There were too few community canneries surveyed and too small a number of tomato products tested from each cannery to make a conclusive study. But indications can be given of what can be expected of other similar cannery set-ups. Had a greater number of cans of tomatoes been examined different values for vitamin C might have been found even for the same cannery. There were differences in ascorbic acid content of each product tested from the same cannery.

The value for each can is given in Table III. Cottageville cannery seemed to present the greatest difference, the lowest value being .059 milligram, the highest value .177 milligram per gram of tomato fruit. The products of the other three canneries were somewhat alike in vitamin C values.

A summary of pertinent information on the canned tomatoes is given in Table IV to which reference was made in an earlier chapter. This information includes data on what processes had been used during canning, processing time, and length of storage after canning before the present experiment was started. The variety, year, type of soil and weather will not be discussed as any effect they had on the fruit need not be considered here. The effect of these factors was discussed in the review of the literature. The responsibility of the cannery begins in consideration of the size of fruit to be canned, the blanching of the food, the amount and kind of liquid poured over the product, the type of can and seal, the length of exhausting time, the length of processing and the amount of headspace. The director of the cannery could suggest and help the clients to select the best fruit they have brought to be canned. The director could encourage the production of a better quality of tomatoes and thereby improve the product to be canned for future use. Blanching should be a rapid process, long enough to destroy oxidative enzymes but short enough to retain maximum ascorbic acid. The length of time could be

TABLE III

Ascorbic Acid Value of Each Freshly Opened Can of
Community Canned Tomatoes as Milligram
per Gram of Tomatoes

	Can No. 1	Can No. 2
Cottageville	.059	.177
Smooks	.118	.148
Springtown	.148	.177
Walterboro	.178	.207

determined by the cannery policy and directions. The liquid to be poured over the product in the cans might be suggested in the directions given by the supervisor or director of the plant.

Ample steam should be provided for the exhaustion period so that all the tomatoes for one customer can be exhausted about the same time. The containers should be provided by the cannery and proper machinery in good working order should be on hand for sealing. The proper processing time could be planned for and obtained by the person operating the retort under direct supervision. The manager could supervise and see that these procedures are carried out properly.

The headspace left in the cans should not exceed $\frac{4}{8}$ of one inch. Commercial canneries allow $\frac{3}{8}$ to $\frac{5}{8}$ of one inch headspace. The community cannery products varied in the headspace from $\frac{3}{8}$ to $\frac{7}{8}$ of one inch.

Table IV shows that there are variations from one community cannery to the next in all the above-mentioned processes with the exception of the blanching process which was the same in all canneries. To overcome most of these variations desirable standardized procedures could be established and directions given to each of the canneries.

TABLE IV

Summary of Information Regarding Possible Factors Affecting
Tomatoes Before Canning

1. Variety	Marglobe Wilt Resistant (2) Marglobe (5) Rutgers (1)
2. Year	Summer of 1943 (8)
3. Type of Soil	Sandy Loam (8)
4. Weather	Rather Dry (6) Wet (2)
5. Size of Fruit When Canned	Medium (6) Small (2)
6. Length of Processing Time	
Pressure Cooker	12 Minutes (2)
(Retort)	10 Minutes (2)
Hot Water Bath	30 Minutes (4)
7. How the Skins Were Re- moved	Blanching in Boiling Water
8. Liquid Put over the Tomatoes	Juice from Cut Tomatoes (6) Water (2)
9. Length of Time for Exhausting	5 Minutes (2) 10 Minutes (2) 15 Minutes (2) 30 Minutes (2)
10. Type of Can and Seal	Tin Can (8) Seal Rubber (6) Cardboard (2)
11. Where Stored	Home Smoke House (3) Cook Place (1) Kitchen Pantry (2) Dark Store Room (2)

Effect of Storage at Refrigerator Temperature Upon Vitamin C Retention in Opened Tomatoes

The effect of storing the opened community canned tomatoes at refrigerator temperature is shown in Table V. The conclusion to be drawn from this part of the experiment is that some ascorbic acid is lost upon storage of several hours uncovered. The tomatoes from various canneries appeared to lose vitamin C at a slightly different rate but none lost any ascorbic acid until 12 hours had passed. Cottageville cannery tomatoes lost 16 per cent after only 12 hours, then no loss occurred again until 48 hours had passed. This was 33 per cent of the original amount. The final ascorbic acid content remained the same through 72 hours. The Smooks cannery product lost ascorbic acid after 36 hours of storage and again after 60 hours. The loss was 24 per cent of the original vitamin C the first time and 59 per cent the last time. The Springtown's product's loss occurred after 48 hours and showed no further loss up to 72 hours. The first loss was 20 per cent and the final loss was 50 per cent of the original ascorbic acid value.

The Walterboro cannery tomatoes held their original ascorbic acid content until 60 hours had passed, then a loss of 16 per cent was observed. There was no further loss up to the 72 hours of the experiment. The loss in each case was less than in tomatoes left at room temperature but there was still a loss when the opened product was held for a period of time at the refrigerator temperature. In the literature, several investigators found losses of ascorbic

TABLE V

Effect on Ascorbic Acid Content of Opened Tomatoes of
Storage at Refrigerator Temperature

Name of Cannery	Milligram per gram of tomatoes						
	Freshly Opened	12 Hours	24 Hours	36 Hours	48 Hours	60 Hours	72 Hours
Cottageville	.178	.149	.149	.149	.119	.119	.119
Smooks	.118	*.090	.118	*.090	.090	.090	.060
Springtown	.149	.149	.149	.149	.119	.090	.090
Walterboro	.179	.179	.179	.179	.179	.149	.149

* Not able to redetermine because of lack of
test material.

acid at refrigerator temperature. These findings are summarized in Table VI. These losses occurred steadily from one day to the next. The daily loss varied from 0.6 per cent to 14.3 per cent. The loss in the experiment presented here did not occur steadily but seemed to be a little spasmodic. There was a loss after only a few hours storage, and then no further loss for quite a number of hours, then a sudden loss.

Refrigerator temperature is undoubtedly a factor in both rate and amount of loss. In the home, variation in loss of vitamin C from opened canned tomatoes would be dependent not only on the temperature at which the refrigerator was set, but also on the number of times that the refrigerator door was opened during storage. The colder the refrigerator temperature was consistently held, the less the loss of ascorbic acid.

In the present experiment, home conditions were duplicated in that the refrigerator was used for other purposes in addition to storage of the tomatoes. There was therefore occasion for opening the refrigerator door, which caused fluctuations in refrigerator temperature. It is apparent that loss of vitamin C from tomatoes under home conditions of refrigeration would be more spasmodic than under rigid laboratory control adhered to in other studies. The loss of ascorbic acid would doubtless be more extensive than previous laboratory experimentations would indicate. Practical considerations in the home would therefore encourage the use of opened canned tomatoes as soon after

TABLE VI

Ascorbic Acid Values of Tomatoes Stored in Refrigerator
Temperature Milligram of Ascorbic
Acid per Gram of Tomatoes

Investigator	Year	1 Day	2 Days	3 Days	4 Days
Hauck	1938	.171	.169	.168	.165
McElroy	1939	.180	.160	.40	.100
Munsell and Steinbarger		to .190	to .170		to .120

12 hours as possible even though they were kept in the refrigerator. But if for some reason the canned tomatoes can not be used so soon, they are still valuable as a source of some ascorbic acid. The largest amount of ascorbic acid lost was 59 per cent of the original amount after 72 hours.

Investigators reported in the literature that using a tightly fitting container on the opened canned tomatoes would exclude more air. This, in turn, would prevent a greater destruction of ascorbic acid.

Effect of Storage at Room Temperature Upon Vitamin C Retention in Opened Canned Tomatoes

The results of this part of the experiment are shown in Table VII. The first loss of vitamin C occurred after 12 hours as it did during refrigerator storage. The loss in each case here was greater than at refrigerator temperature. Cottageville Cannery tomatoes showed the first loss at 24 hours and then the level remained constant until 72 hours had been reached. The first loss was 49 per cent and the second loss was 61 per cent. Smooks cannery tomatoes lost ascorbic acid after 12 hours, again after 24 hours and then remained constant until after 60 hours when another loss was observed. The losses were 24 per cent for the first, 50 per cent for the second, and 76 per cent for the final loss. The Springtown's cannery tomatoes lost ascorbic acid after 24 hours, again at 36 hours and still further loss at 60 hours. These losses were 20 per cent for the first, 33 per cent for the second, and 60 per cent for the third. The

TABLE VII

Effect on Ascorbic Acid Content of Opened Tomatoes of
Storage at Room Temperature

Name of Cannery	Milligram per gram of Tomatoes						
	Freshly Opened	12 Hours	24 Hours	36 Hours	48 Hours	60 Hours	72 Hours
Cottageville	.178	*	.089	.089	.089	.089	.060
Smocks	.090	.090	.060	.060	.060	.060	.030
Springtown	.149	.149	.119	.090	.090	.060	.060
Walterboro	.179	.179	.179	.179	.119	.090	.030

* Test not made.

Walterboro cannery product held its ascorbic acid content up to 48 hours before a loss was observed. There was another loss at 60 hours and a final loss at 72 hours. These losses were 33 per cent for the first, 49 per cent for the second, and 84 per cent for the final loss of ascorbic acid. The figures are all percentages of the original ascorbic acid. A conclusion to be drawn from this study is that ascorbic acid is lost more rapidly at room temperature and to a greater extent.

Effect Upon Vitamin C Retention of Boiling Tomatoes for Five Minutes in Various Types of Ordinary Kitchen Utensils

The complete figures for each cannery product tested are given in Table I in the appendix but only the values of the tomatoes from the Walterboro cannery will be discussed here. These values are summarized in Table VIII. These results give a representative sample of the whole group of values obtained. The tomatoes would seem to have gained ascorbic acid on boiling on the original weight basis. This rise in the titration values of the tomatoes was further investigated and found to be due to the loss of water by evaporation during the boiling process. The test sample was then more concentrated in pulp content than in juice content and gave the higher titration value. It has been found that the pulp contains a slightly larger portion of ascorbic acid than the juice of the tomato fruit. The rise in ascorbic acid content was from .030 milligram to .059 milligram. The conclusion to be drawn here is that the

TABLE VIII

Effect on Ascorbic Acid Content of Tomatoes or Boiling Five
Minutes in Various Type Pans Walterboro Only

Milligram Ascorbic Acid per Gram
of Tomatoes

Pan Type	Before Boiling	After Boiling
Aluminum	.178	.208
Stainless Steel	.178	.208
Pyrex Glass	.207	.266
Pressure Saucepan	.179	.179
Black-speckled Enamel	.207	.266

ascorbic acid in canned tomatoes is not destroyed by boiling for a few minutes; and that because of water loss the vitamin C content per gram of tomatoes is actually increased.

The type of open pan used apparently makes no difference. Copper or copper alloy utensils, while not in use extensively, would make a difference in loss of ascorbic acid. Copper catalyzes the destruction of ascorbic acid, and tomatoes cooked in such a utensil would lose much of their vitamin C content. This might be a definite factor in rural homes where copper utensils are still in use. The pressure saucepan does not permit evaporation of water to any great extent and hence does not give a product more concentrated in Vitamin C.

Salt (sodium chloride) of the ordinary table variety was used in boiling the tomatoes. The amount added was comparable to the amount used in ordinary seasoning. In all cases, the salt made no difference in the ascorbic acid values. There was a rise in the titration values obtained but this again, was due to evaporation. Seasoning the tomatoes with salt will not effect the usable ascorbic acid. The results of the tests are given in Table IX for the products of all canneries.

Another seasoning used was sugar (sucrose) in the proportion used usually for seasoning. This addition, too, made no difference and the tomatoes lost none of their ascorbic acid. There were higher titration values but these were due to the evaporation of water by boiling. The results

are included in Table IX.

Cream of tomato soup was the last product tested. The addition of flour, fat, milk, and salt did not alter the ascorbic acid content of the tomato itself. The vitamin C content of the sieved tomatoes was .149 before being made into soup; after preparing the recipe the value was the same. These values are summarized in Table X. The results indicate that the addition of other food materials did not alter the vitamin C content of the tomatoes used.

In summarizing the discussion there appears to be only one factor which effects the loss of ascorbic acid to any great extent. This factor is storage of the tomatoes uncovered at either room temperature or at refrigerator temperature for **any** long length of time. The other processes commonly used in the household would not effect the vitamin C content to any marked extent. These findings would not indicate that the ascorbic acid could not be destroyed by careless procedures such as prolonged boiling. With some consideration a maximum amount of vitamin C will be retained in the tomatoes.

CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

The tomato fruit has been proven to be an excellent source of vitamin C. It has been canned extensively both in the home and commercially for household use. Community cannery tomatoes are just beginning to be used in many rural and small urban homes and the use of these products probably will increase to a considerable extent in the future. The purpose of this study was to test some products of representative small canneries and compare them with commercial products in regard to ascorbic acid content; then to subject these tomatoes to processes used commonly in the household to discover if the ascorbic acid content would be altered. By these means, it was hoped that a partial evaluation could be made of the importance of community canned tomatoes as a source of ascorbic acid for the home.

The review of the literature offered many contradictory findings of other investigators in regard to the retention of vitamin C in commercial and home canned tomatoes. The findings in this experiment were in accord in the main with the results as reported for canned tomatoes in general. The factor which caused the most loss of ascorbic acid was storage at room temperature; next in order was storage at refrigerator temperature. The other processes employed had little effect on the ascorbic acid value.

In summarizing, the following conclusions may be drawn from this study:

1. Community canned tomatoes tend to be lower in ascorbic acid values than the average commercially canned ones of standard manufacturers commonly used.

2. The community canned products, however, are a good source of vitamin C and can be relied on by the householder.

3. The tomatoes are not only a good source of vitamin C when opened but the vitamin C would appear to be retained well when subjected to common household manipulations.

4. The only procedures affecting the opened tomatoes to any great extent are storing uncovered at either room or refrigerator temperature for as long as 72 hours. The other procedures employed in this study seemed to have little or no affect on the ascorbic acid content.

From the study the following recommendations can be made to the cannery director and to the householder in order to assure a product supplying a maximum quantity of vitamin C when consumed:

1. A standardized procedure could be worked out and followed for selection of fruit to be canned, for the blanching, for the exhausting, and for processing after sealing.

2. The householder can use these tomatoes with confidence knowing they are a reliable and stable source of vitamin C.

3. To retain maximum vitamin C value the householder should store the opened canned product in a tightly covered container in the refrigerator and use item in some way before

72 hours have passed.

4. In preparing canned tomatoes for table use, the householder may cook the tomatoes in either an enamel, pyrex, glass, aluminum, stainless steel or pressure saucepan without fear of destroying the ascorbic acid present.

5. Open-kettle boiling for a short period need not be feared as it serves merely to concentrate the vitamin C present.

6. In preparing a recipe using tomatoes with added food materials the householder may be confident that the ascorbic acid of the tomatoes will not be altered by moderate lengths of cooking time.

7. Since the canning procedure is simple and quickly done in a community cannery or in the home and the product is satisfactory more tomatoes should be canned for winter use during the production season.

8. It may be more economical to consume alternate sources of vitamin C in the fresh state during the summer months in order to save additional tomatoes for canning. Tomatoes are more suitable for community or home canning, and provide a more stable supply of vitamin C for winter months than most garden products.

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Information Report

Name

Address

City

State

Zip

Telephone

Occupation

Education

References

APPENDIX

1. Name

2. Address

3. City

4. State

5. Zip

6. Telephone

7. Occupation

8. Education

9. References

10. Name

11. Address

12. City

13. State

14. Zip

15. Telephone

16. Occupation

17. Education

18. References

CAN NUMBER _____ Information Regarding Tomatoes Canned
in Tin

1. Variety (Name) _____.
2. Year of Crop and Time of Year _____.
3. Where Grown (give type of soil and general climatic conditions) _____.
4. Degree of ripeness (picked green, vine ripened.) _____
_____.
5. Size of Fruit when canned (small, medium, large.) _____
_____.
6. How long were they processed in pressure cooker or hot water bath? _____.
7. How were the skins removed (blanching, peeled by hand, etc.) _____
_____.
8. Liquid put over the tomatoes. Was it plain juice from the cut tomatoes, or juice extracted and boiled down, or just plain water? _____.
9. Length of time from blanching to sealing before processing (the length of time in the steam table for exhausting.) _____
_____.
10. Type of can and seal (was it rubber lined or cardborad?) _____
_____.
11. Where are they stored in the home? _____.
12. Name of cannery where they were put up. _____.
13. Any remarks.

Table I

Effect on Ascorbic Acid Content of Tomatoes of
Boiling Five Minutes in Various Type Pans.

Milligram Ascorbic Acid per gram of Tomato

Pan Type	Smoaks		Cottageville		Springtown		Walterboro	
	Before	After	Before	After	Before	After	Before	After
Aluminum	.089	.148	.089	.118	.148	.178	.178	.208
Stainless Steel	.059	.089	.059	.089	.119	.148	.178	.208
Pyrex Glass	.089	.119	.089	.118	.148	.178	.207	.266
Pressure Saucepan	.148	.148	.059	.089	.177	.118	.179	.179
Black Speckled Enamel	.059	.119	.059	.118	.148	.178	.207	.266