ASCORBIC ACID CONTENT AND PALATABILITY OF MONTMORENCY CHERRIES CANNED BY THE COLD AND HOT-PACK METHODS

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ASCORBIC ACID CONTENT AND PALATABILITY OF MONTMORENCY CHERRIES CANNED BY THE COLD AND HOT-PACK METHODS

by

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INTRODUCTION AND PURPOSE OF THE STUDY

There still is a question as to how small fruits should be canned in order to obtain the best product and still retain as much of the vitamins as possible. It is generally believed that precooking foods for a short time, packing while hot and then processing helps to preserve the vitamin values and ensures better keeping qualities. Another advantage of the hot-pack method is that precooking shortens the processing time of acid foods and thus there should be less injury to flavor and texture. It is thought that this precooking inactivates the enzymes responsible for the oxidation of ascorbic acid and thus hot-packed foods should retain more ascorbic acid than those canned by the cold-pack method.

As there is little experimental evidence for the above assumptions it is felt that investigations in the field are needed. The purpose of this study was to compare the relative merits of the hot- and cold-pack methods of home-canning. The factors evaluated in comparing Montmorency cherries canned by each method were palatability and ascorbic acid retention and the effect of three months storage on these factors. It is difficult to retain the natural color of deeply pigmented fruits. For this reason the measurement of color retention is important and so objective as well as subjective color measurements were made on the fruit.

REVIEW OF THE LITERATURE

The successful use of a canning method depends on the destruction of microorganisms during the processing period. There are several factors which effect this destruction, the most important one being hydrogen-ion activity in the presence of heat. The organisms causing spoilage in products have a relatively low heat resistance at a pH of 4.5 or less and are commonly destroyed by a few minutes heating at 212°F. (Pederson, 1929). Cruess (1938) states that fruits with a high degree of hydrogen-ion activity such as plums (pH 2.9) and apricots (pH 3.2) require heating for only 10 minutes at 167°F. for preservation.

Because heat takes longer to penetrate to the center of the jar contents than to the product near the side of the container, the internal temperature and the length of time it is to be applied greatly influence "effective sterilization." In commercial canning, processing is accomplished in two steps -- exhausting and then processing. "Exhausting" is the process by which the filled cans of food are heated to a certain temperature for a certain length of time before sealing. This process shrinks the product and drives out entrapped air. Prescott and Proctor (1937) have found that in commercial canning a moderate temperature of 160 to 170°F. in exhausting produces fruit of

better appearance and texture than if exhausted at a higher temperature and that there is apparently a slowly continuing development in flavor." In the commercial canning of red sour cherries the average temperature at the center of the can is 145°F. after exhausting and 205°F. when the cans emerge from the boiling water bath (Reynolds and Reynolds, 1929). Prescott and Proctor feel "that the success of much of the home-canning of fruits depends upon the fact that they are made safe at low temperatures (185-195°F.) for in following many of the recipes the contents at the center of the jars do not reach the degree which is assumed, i.e. 210°F. or above." According to Bigelow and Cameron (1932), the sterilization of acid products may be accomplished by a relatively short processing in boiling water sufficient to give a minimum temperature of 180°F. in the coolest part of the contents.

Additional factors influencing the value of sterilization of a process are the initial temperature of the food and the concentration of the syrup. If two foods having different initial temperatures were processed the same length of time, the food with the higher initial temperature would be subjected to high heat longer than the food with the lower initial temperature. Although a 50 per cent syrup has definitely slower heat penetration than water, Cruess (1938) states that the retarding effect of sugar on convection currents is not serious at the concentrations used in canning. Cruess cites work done along

this line by Bigelow. Bigelow found that with 50 per cent syrup it took 24 minutes for the center of the can to reach the temperature of the retort, whereas it took only 6 minutes with water.

On compering the hot and cold-pack methods for retention of ascorbic acid, McElroy, Munsell and Stienberger (1939) found that the ascorbic acid content of tomatoes was 17 mg. per 100 ml., in the raw tomatoes, 16 mg. per 100 ml. in hot-packed and 16.8 mg. per 100 ml. in the cold-packed tomatoes by either method of canning. Losses in ascorbic acid with the hot and cold-pack methods were considered insignificant. The initial loss of ascorbic acid in the hot pack tomatoes was about 6 per cent and after storage for six months at 70 to 80°F. there was a 30 to 50 per cent loss. Daniel and Rutherford (1936) report an ascorbic acid loss of 31 per cent in cold pack tomatoes after six months storage; 21 per cent occurred with canning and the remaining 10 per cent was lost during storage. In agreement with McElroy et al., Adams (1944) concludes that the ascorbic acid content of fruits is not effected by either canning method.

Kirk and Tressler (1941) conclude that loss of ascorbic acid is due to the oxidation of ascorbic acid during the preparation of fruit for canning and not due to the heat treatment itself. Ascorbic acid was found to be inversely proportional to the amount of sugar added in canning and loss was attributed to increased oxidation from the stirring in of sugar. They

felt that the destruction of ascorbic acid oxidase takes place when foods are heated to 140 to 170°F. On the other hand, Adams (1944) found that a closing temperature of 130 to 170°F. had little effect on the ascorbic acid retention of canned fruit. This would indicate that the ascorbic acid oxidase had not been destroyed at those temperatures.

Beattie, Wheeler and Pederson (1943) have carried out interesting work on changes in ascorbic acid and the red color of some highly pigmented fruit juices. They feel that, since ascorbic acid is oxidizable and pigments are reducible, there is a possibility that there may be a relationship between the loss of red color and the increase in intensity of yellow with the loss of ascorbic acid during storage. In reference to the change in color of cherries with canning, Culpepper and Caldwell (1927) believed the original color was preserved but, due to heating, the intensity was lessened by the partial conversion of the anthocyanins into a colorless form.

The home-canning procedure as given by Stanley, Stienberger and Shank (1942) recommends the hot-pack method for these reasons: (a) products canned in their juice have more of the natural fruit flavor and food value (b) precooking shrinks fruit so that more may be packed into a container (c) precooking cuts down the time that fruits need to be processed. They also state that fruits packed in this way may not look as attractive as cold-packed fruit. In the 1944

bulletin issued by the Bureau of Human Nutrition and Home Economics on "Home Canning of Fruits and Vegetables", the hot-pack method again is recommended. The directions in the older method of simmering the pitted fruit 5 minutes, adding sugar and then processing 5 minutes were slightly modified by adding the sugar to the pitted fruit, bringing to a boil and then processing 15 minutes.

EXPERIMENTAL METHODS

The choice of berry fruits for study was somewhat limited by the month of maturity and the season's crop. Raspberries rather than cherries would have been a more suitable experimental fruit because of their higher ascorbic acid content, but due to the small crop of raspberries the latter were chosen. Montmorency cherries were obtained in sixty pound lots from the college orchard. Those processed the first day were picked in the morning, whereas the second day's lot was picked late the previous day and stored until noon at 40°F. Cherries used for the third and fourth series were picked at the same time and remained in storage at 40°F. for two and four days respectively.

In order to insure adequate sampling the day's lot of cherries was first mixed thoroughly and then smaller amounts were washed in three waters. Before pitting, the cherries were picked over to remove any that were badly bruised or underripe. Those not used immediately were stored in a refrigerator.

A. Ascorbic acid analysis.

The method for determining total ascorbic acid, using dinitrophenylhydrazine, was that described by Roe and Osterling (1944). Six hundred grams of cherries were taken for the analysis of the raw fruit. The cherries were pitted by hand to avoid any metal contamination and three, 100-gram samples were analyzed. The cherries were macerated in a waring blender

with 100 ml. of extractant* and three aliquots of approximately 25 grams each were filtered through norite. Two aliquots of the resulting filtrate were used, thus giving a total of 18 readings daily on the raw cherries.

On the days following canning, three jars of cherries processed by each method were analysed. The contents of each jar were blended separately with 100 ml. of extractant and the same analytical procedure was followed as for each raw sample, making 18 readings for each canning method. In order to calculate the ascorbic acid concentrations on the basis of 100 grams of the fresh cherries, fruit and syrup for the cold-pack method were weighed into the jar before processing, while fruit and sugar for the hot-pack method were weighed into beakers. The total weight of the canned fruit was obtained when the contents were put in the Waring blender, and thus the ascorbic acid values could be calculated back to the raw weight.

B. Canning procedure.

The cherries were canned by the hot and cold-pack methods described by Stanley, Stienberger and Shank of the Bureau of Home Economics (1942). Cherries to be used for the color and palatability studies were pitted with a mechanical pitter while those to be used for ascorbic acid analysis were pitted by hand. Pint Mason jars with glass lids, top-seal rubber rings and metal screw bands were used. Jars and lids were heated in

*Reagents used are given in the Appendix, page 38.

a steamer and the rubber rings were dipped in boiling water before placing on the glass lids. A 45 per cent syrup for the cold-pack method was made from beet sugar and distilled water. A headspace of one-half inch was left in all jars. To 400.6 grams of pitted cherries were added 90 grams of boiling syrup. The amount of cherries packed was based on the recommendation for commercially canned cherries. An 'extra standard fill is defined by Campbell (1937) as one in which a #2 can (equal to 18 fl. oz.) contains 16 oz. of pitted cherries. A 45 per cent syrup was added because, according to Griswold (1944), judges scored cherries canned with this concentration of syrup highest in flavor of fruit. The fruit was processed 25 minutes in a boiling water bath.

From preliminary work it was found that for the hot-pack method 450 grams of pitted cherries, when simmered and sugar added gave an adequate fill, allowing for a one-half inch headspace. In order to maintain the same ratio of sugar to cherries as was used in the cold-pack method, 45.3 grams of sugar were added to each jar of fruit prepared by the hot-pack method. The fruit was simmered 5 minutes in beakers, the sugar was added and the fruit packed into jars and processed 5 minutes in a boiling water bath.

Every other day for four days, 15 pints of cherries were processed by each method. On the day after canning three jars of fruit canned by each method were opened for ascorbic acid analysis and three for color and palatability studies. These ex-

periments were repeated after the jars had been stored for three months in the dark at room temperature.

C. Heat penetration studies.

To insure heat treatment adequate for the prevention of spoilage, preliminary studies were undertaken to determine the internal temperatures reached in jars processed according to both methods. In order to obtain these internal temperatures, copper-constantan thermocouples were inserted in the jars. The tip of the wires was placed in the center of the jar contents and the wires bent at a right angle at the top of the jar so that they would remain in position. Because the wires were very fine it was possible to place the glass top and screw the metal cap over the wires with no difficulty. Unfortunately the time was not recorded between the moment of putting the jars in the water bath and the time it took to reach 210°F. and 212°F. for the experimental bottles in which thermocouples were used. This time was estimated by trying to approximate the original conditions with cold, canned cherries. That is, boiling syrup was added to the cold fruit for the cold-pack method, and the fruit and juice were simmered 5 minutes for the hot-pack method. Readings on Leeds Northrup potentiometer were taken just before the fruit was placed in the water bath, when the water bath reached 210°F. and, during processing, each minute with the hot-pack and every five minutes with the cold-pack method.

Internal temperatures were determined for 17 jars processed by the hot-pack method and for 14 jars processed by the cold-pack method.

D. pH and concentration of syrup.

Because acidity and sugar concentration play a definite role in inhibiting the growth of microorganisms the hydrogen ion activity and apparent syrup concentration were recorded. The pH of the juice of the raw and processed cherries was determined by means of a Beckman pH meter. Specific gravity was measured with a Baum hydrometer. The apparent sugar concentration was calculated form a table of specific gravity figures given in the "Handbook of Chemistry and Physics. 1943-1944."

E. Color measurement.

Color was measured objectively by the use of Munsell color discs according to the method given by Nickerson (1929). For matching the color of the fruit, four discs were overlapped by means of radial slits. These discs were spun by a motor, effecting a blending of the colors into one. The color produced was matched through a color comparator eyepiece with that of the fruit packed in a glass cup. The sample and discs were illuminated by a Macbeth daylight lamp. The percentage of each color used was measured by means of a scale which circumscribed the discs.

In the Munsell system there are three components of color: hue, brilliance and chroma. Hue is the quality as-

pect of color associated with different portions of the spectrum. The hue circle is composed of five principal hues with five intermediates placed between them. The ten hues are designated either by letters or numbers. Each of the hues is divided into ten hue steps, the fifth step being the pure hue. In terms of numbers the hue circuit is 100 and each hue is assigned a number, ei. red is 5, red-yellow-red is 10 and purple-blue is 75. Brilliance or value is the lightness or darkness of a color and the gradations in scale are from zero (black) to ten (white). Chroma is the saturation or purity of a color. Neutral gray, which contains an equal amount of all colors, is zero. Chroma increases with the purity of a color and in numerical terms, extends to ten or even fourteen, depending upon the maximum saturation possible with each color at the different brilliance levels.

The color of a disc is given in the following order: hue, brilliance, chroma. Nickerson advises the use of the same set of discs throughout a piece of work. However, it was not possible to match the color of the raw cherries with the set of discs used with the canned samples. Discs used for determining the color of the raw cherries were neutrals 1/ and 5/, glossy red 2.6/11 and purple-blue 4/6; discs used for the canned cherries were neutrals 1/ and 5/, red 4/14 and yellow-red 6/12. On each canning day, six samples of the raw cherries were matched for color. On the following day, from cherries canned by each method, the color of two samples from each of three

jors as matched. Hue and chroma for each canned sample were determined from conversion tables published by Nickerson (1935). Brilliance for both raw and processed samples was calculated from a formula given by Nickerson (1942)*. With the raw cherries it was necessary to use a formula for chroma developed by Nickerson (1935) which corrects for discs that are more than one-tenth of the hue circuit apart. The hue formula which corrects for a large difference in discs was incorrectly given in Nickerson's 1935 publication. The corrected formula used in this study was as follows:

$$\text{Hue} = \phi + \phi_2 \qquad \tan \phi_2 = \frac{A_1B_1C_1 \sin \phi}{A_1B_1C_1 \cos \phi + A_2B_2C_2}$$

A_1 = % area of first hue
B_1 = brilliance " " "
C_1 = chroma " " "

A_2 = % area of second hue
B_2 = brilliance " " "
C_2 = chroma " " "

ϕ = angle between the two hues

F. Palatability studies.

Triplicate samples of fruit processed by each method were scored by five judges on the day following canning and again three months later. The score sheet used was one compiled by Griswold (1944) as appears in Figure 1.

G. Statistical analysis.

The data were analyzed statistically by determining "t" values according to the method of Fisher (1936) and an analy-

*Formula appears in Appendix, page 41

Sample No. _____ Date _____

Factor	7	6	5	4	3	2	1
Color	Very desirable	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable	Very undesirable
Appearance	Very desirable	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable	Very undesirable
Texture of flesh	Very desirable	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable	Very undesirable
Texture of skin	Very desirable	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable	Very undesirable
Flavor of fruit	Very desirable	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable	Very undesirable
Flavor of juice	Very desirable	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable	Very undesirable
General conclusion	Excellent	Very good	Good	Medium	Fair	Poor	Very poor

Color: (Check one) 1. Bright red 2. Red 3. Faded red 4. Yellowish
5. Purplish red 6.

Signature _____

FIG. 1 GRADING CHART FOR FRUIT

sis of variance was done on the ascorbic acid and palatibility data in the manner recommended by Snedecor (1940).

RESULTS AND DISCUSSION

A. Ascorbic acid analysis.

Mean values of the total ascorbic acid content of triplicate samples of raw cherries, and cherries packed by each method, freshly canned and after a three months storage period, for each of the four series, are given in Table I. Although six readings were made on each of the triplicate samples, not all could be included because of charring of the sugars when the concentrated sulphuric acid was added. These aliquots gave a lower reading and consequently higher ascorbic acid content upon calculating and thus were omitted. As an example of experimental error, the ascorbic acid values for one day in the series appears in Table VI in the appendix.

From Table I it may be seen that the ascorbic acid content of the fresh fruit appeared to increase each day. Similar results have been found with other fruits and the investigators attribute the increase to greater maturity. This was probably the reason here for cherries on the first day were a little firmer and more orange in color than on the succeeding days. By the fourth canning day, the cherries (which had been in storage at 40°F. for 3 1/2 days) were a deep red color and the flesh was rather soft. The average ascorbic acid content of the raw cherries was similar to that obtained

by Kirk and Tressler (1941). Using the indophenol method, they obtained an average of 9 mg. per 100 grams on two test runs of Montmorency cherries. The average value of 7.7 mg. per 100 grams obtained in this study would be comparable and indicates that no dehydroascorbic acid was present, for Peveck and Elvehjem (1944) illustrate the close agreement in results obtained by the phenylhydrazine and indophenol procedures on fruits and vegetables containing only reduced ascorbic acid.

Although the ascorbic acid content of the raw fruit increased each day there was no corresponding increase in the canned fruit and losses due to canning varied from 44 to 83 per cent. Table I shows that immediately after canning the average loss in ascorbic acid was the same for cherries packed by each method. This 67 per cent loss appears to be somewhat higher than losses reported on tomatoes. McElroy et al. (1939) found a 6 per cent loss in ascorbic acid in hot-packed tomatoes during canning and Daniel and Rutherford (1936) reported a 21 per cent loss in cold-packed tomatoes during processing. Possibly the high initial loss found in the ascorbic acid content of cherries occurred during the slow process of pitting.

As will be discussed in the next section, the average closing temperature for the cold-pack cherries was 101°F. with a range of 93-109°F., and the average closing temperature for the hot-pack cherries was 136°F. with a range of 99-174°F. The data on ascorbic acid content of the cherries do not indicate that heating to 140 to 170°F. destroys ascorbic acid

TABLE I

ASCORBIC ACID CONTENT OF CHERRIES CANNED BY THE HOT- AND COLD-PACK METHODS, BEFORE AND AFTER 3 MONTHS STORAGE

Series	Ascorbic acid content*					Per cent loss of ascorbic acid**			
	Raw	Freshly canned		Stored 3 months		During canning		After 3 months storage	
		Cold pack	Hot pack	Cold pack	Hot pack	Cold pack	Hot pack	Cold pack	Hot pack
		mg.	mg.	mg.	mg.	%	%	%	%
1	4.1	2.6	2.2	0.8	1.2				
	5.6	2.8	2.6	1.0	1.2				
	4.6	2.6	1.6	0.8	1.4				
Average	4.8	2.6	2.0	0.9	1.3	44.	56	81	72
2	7.2	1.8	1.1	1.6	1.8				
	7.6	2.6	1.8	1.6	1.4				
	8.0	2.7	1.0	1.3	2.0				
Average	7.6	2.4	1.3	1.5	1.8	68	82	80	77
3	9.0	2.4	3.3	1.4	2.6				
	7.4	3.7	3.4	3.8	3.2				
	7.5	4.0	3.7	2.6	2.9				
Average	8.0	3.3	3.7	2.6	2.9	58	54	67	64
4	8.2	1.2	3.2	2.2	0.6				
	11.4	2.2	2.8	1.2	1.4				
	11.6	2.2	3.1	1.0	1.0				
Average	10.4	2.0	3.0	1.5	1.0	80	70	86	90
Average of 4	7.7	2.6	2.6	1.5	1.0	66	66	78	74

* Based on 100 grams raw cherries. ** Based on raw sample.

oxidase as suggested by Kirk and Tressler (1943), since the cherries canned by the hot-pack method did not have a higher ascorbic acid content; unless as Kirk and Tressler found, losses by oxidation occured during the stirring in of the sugar after heating.

e. Heat penetration studies.

Preliminary experiments were carried out on the internal temperature reached in jars of cherries during processing. In order to determine if cherries processed by each method were subjected to heat treatment adequate for satisfactory preservation, the internal temperature of the jar contents was observed during processing. Figure 2 shows the average rise of internal temperature during processing by each method. Figures 3 and 4 illustrate the individual temperature rise in jars of cherries canned by each method. It was necessary to omit a few of the results, for final temperatures such as 240° and 150°F. were recorded. Possibly such errors occurred in the readings from the potentiometer.

Figure 2 shows that the average temperature reached at the end of the processing period was 208°F. in the cold-pack fruit and 205°F. in the hot-pack fruit. The internal temperatures were in agreement with the 205°F. internal temperature used by Reynolds and Reynolds (1929) for commercially canned red sour cherries and well above the minimum temperature of 180°F. recommended by Bigelow and Cameron (193-) for effec-

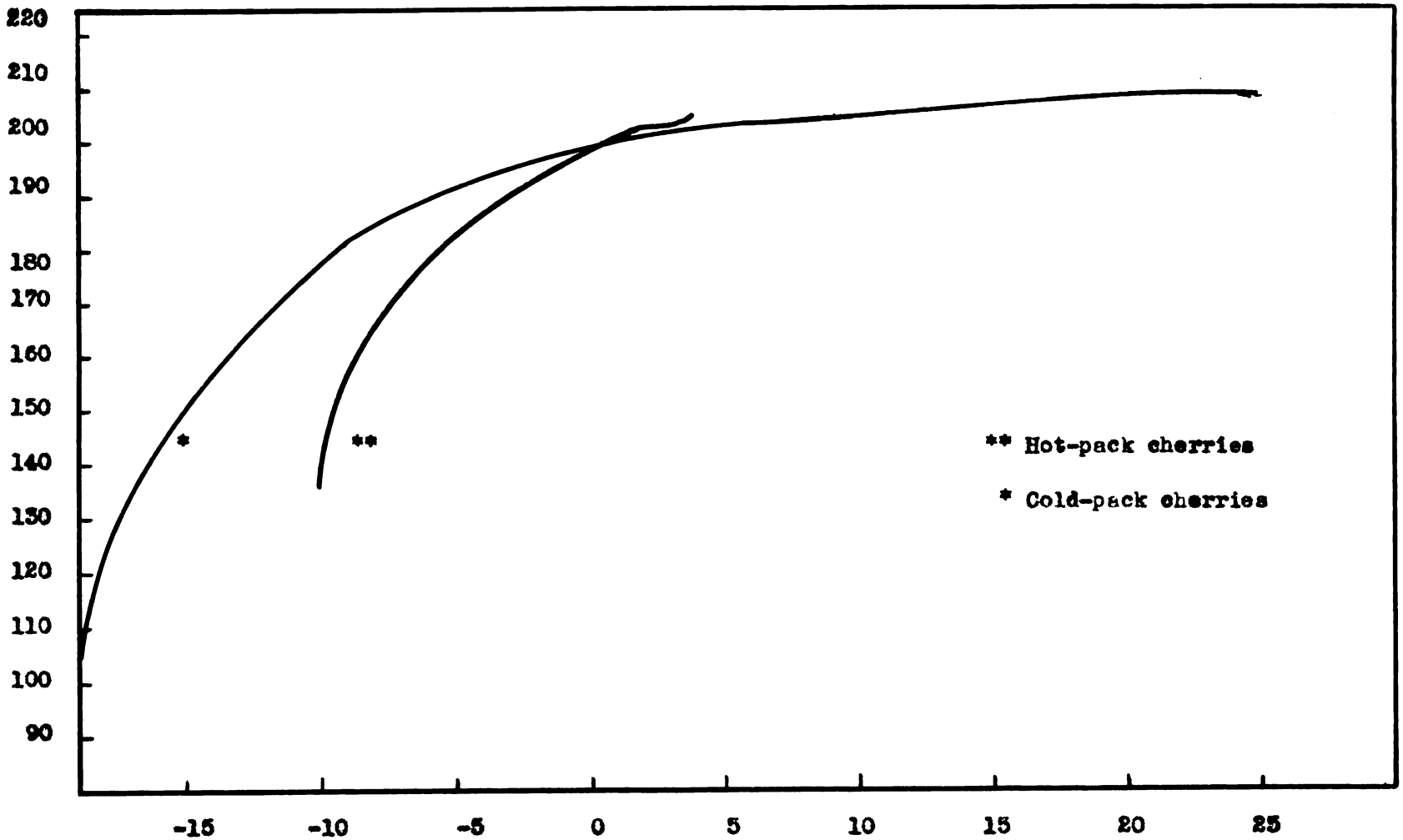

FIG. 2 RATE OF HEAT PENETRATION IN CHERRIES CANNED BY THE HOT- AND COLD-PACK METHODS

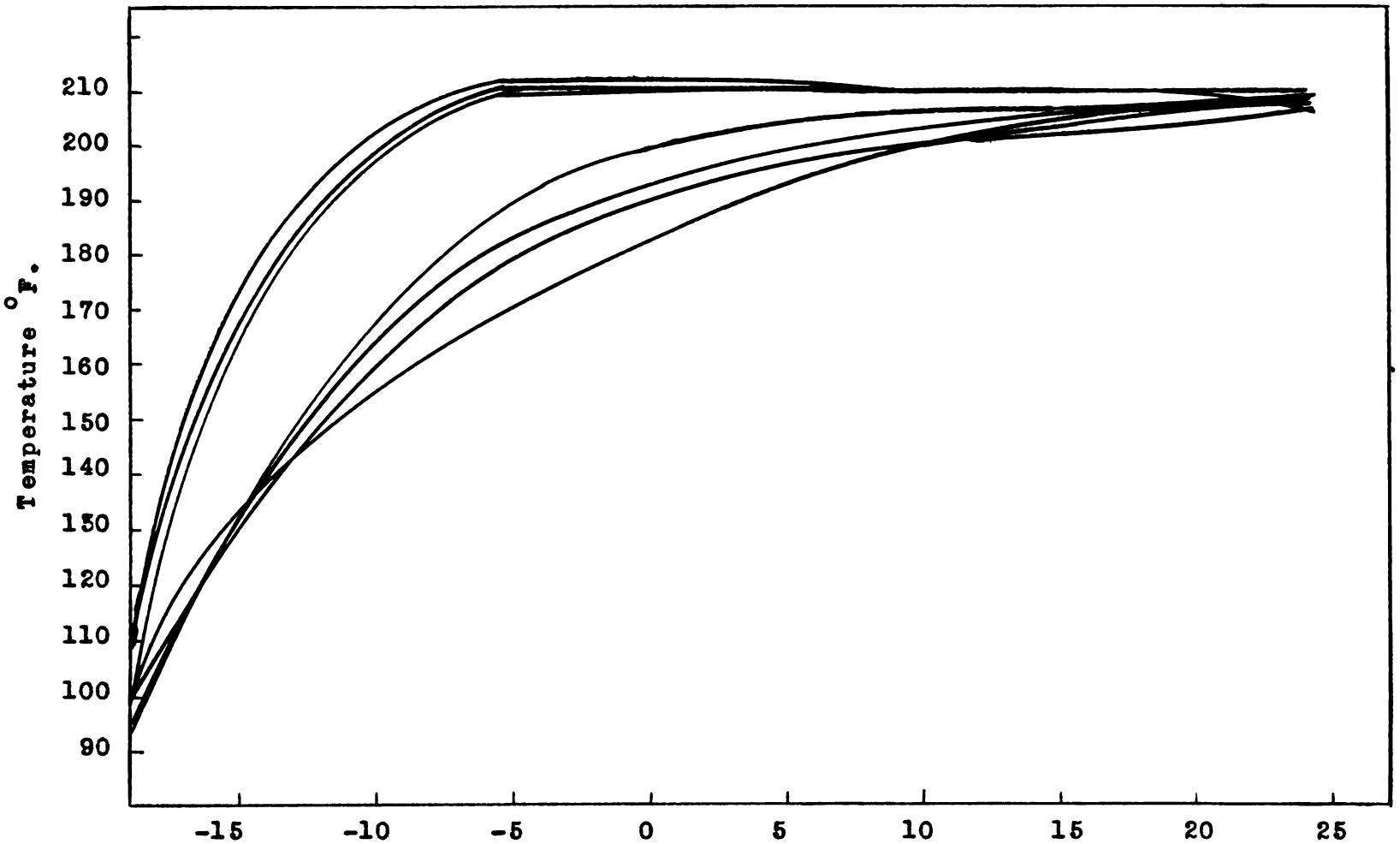

FIG. 5 RATE OF HEAT PENETRATION DURING THE PROCESSING OF COLD-PACK CHERRIES

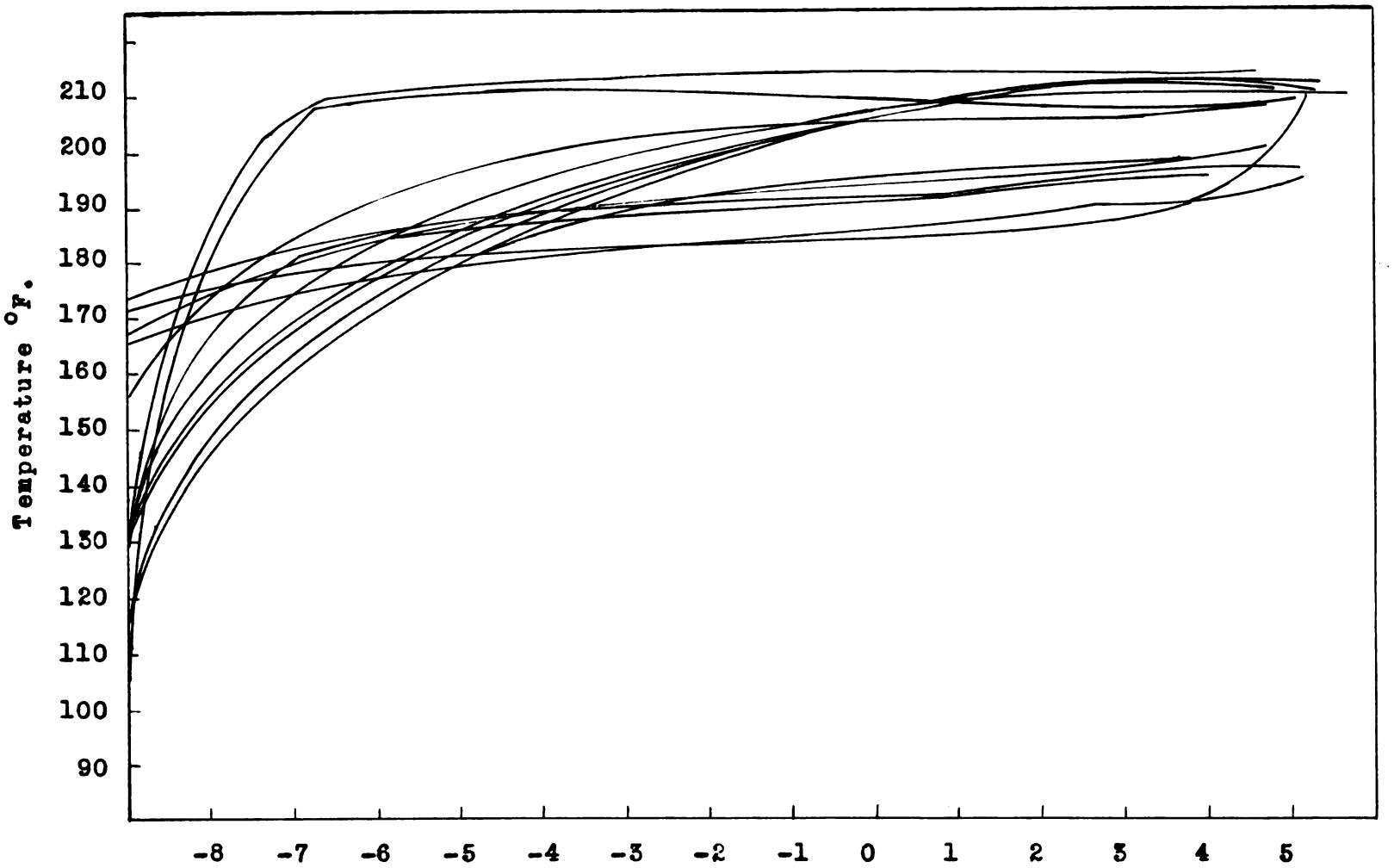

FIG. 4 RATE OF HEAT PENETRATION DURING THE PROCESSING OF HOT-PACK CHERRIES

tive sterilization." Upon examining Figure 2, it is interesting to note that the average internal temperature reached in the cold-pack cherries after 10 minutes processing was the same as that reached in the hot-pack cherries at the end of the processing period of 5 minutes; showing that the processing time of 25 minutes recommended by Stanley et al. (1942) for cold-pack cherries allows a side margin of safety.

C. pH and concentration of syrup.

The determinations of hydrogen-ion activity of the raw and processed cherries (Table II) indicate that the fruit should keep well because of the acidity as well as the temperature reached during processing. The average pH of the raw cherries (3.3) was found to be about the same as the pH of 3.1-3.2 given for sour cherries in 'Food Manufacture 1940.' The average pH of the canned cherries was 3.4.

The apparent sugar concentration was calculated from specific gravity figures to see whether there was a large variation between the fruits packed by each method. From Table II it will be noted that the fruit canned by the hot-pack method had a slightly higher apparent sugar concentration than that canned by the cold-pack method. However, this would be expected; for although the ratio of sugar to cherries was the same for each method, in the cold-pack method water was added by the syrup while in the hot-pack method thejuice was from the cherries. According to Cruess (1938), Bigelow found a difference of 10 per cent in the apparent sugar concentration

TABLE II

pH AND CONCENTRATION OF SYRUP OF RAW AND PROCESSED CHERRIES

Treatment of cherries	pH	Apparent sugar concentration
Raw	3.2 3.2 3.2 3.4	
Average	3.3	
Cold pack Freshly canned	3.3 3.3 3.2 3.4	21.4 27.2 23.2 26.2
Average	3.4	24.5
Stored 3 months	3.3 3.4 3.4 3.4	22.0 27.5 27.5 23.8
Average	3.4	25.2
Hot-pack method Freshly canned	3.3 3.4 3.3 3.4	25.2 28.2 28.4 27.9
Average	3.3	27.5
Stored 3 months	3.3 3.4 3.4 3.4	27.0 29.4 31.3 25.6
Average	3.4	28.2

would lengthen, by one minute, the time taken to reach the boiling point. However, the average difference found was only about 3 per cent and would not have an appreciable effect on the rate of heat penetration. After three months storage there was a slight increase in apparent sugar concentration of fruits canned by each method. The apparent sugar concentration was used as a check for the validity of palatability scores on flavor of fruit and juice. If a large variation had occurred in the scores on these factors, differences in the degree of sweetness might account for the variation in flavor.

D. Color measurement.

The color data for the raw and processed cherries are shown in Table III. It will be seen that the hue of the cherries changed from 95.5 red-purple to 5.2 and 5.4 red with processing. The difference in the hue of cherries packed by the two methods was slight, however. The red color of the canned fruit was slightly lighter than that of the raw fruit, as indicated by increased brilliance. Cherries canned by the hot-pack method were a little lighter than those canned by the cold-pack method. Chroma or the intensity of color decreased greatly with processing and there was a greater loss of color in the cold-packed fruit than in the hot-packed fruit. Griswold (1944), using the same methods but a 50 per cent syrup for the cold-pack method and in the hot-pack method the same ratio of sugar to fruit as in the cold-pack method, found that the red color of the hot-

TABLE III

OBJECTIVE COLOR DATA ON RAW AND PROCESSED CHERRIES

Color attribute	Raw cherries	Canned cherries			
		Freshly canned		Stored 3 month	
		Cold pack	Hot pack	Cold pack	Hot pack
Hue*	98.6 94.2 94.4 94.5	5.2 5.2 5.0 5.2	5.6 5.0 5.0 5.8	6.6 5.9 5.7 6.2	6.6 6.1 6.3 5.5
Average	95.5	5.2	5.4	6.1	6.2
Brilliance**	2.5 2.4 2.4 1.8	2.8 2.4 2.6 2.8	3.2 2.8 3.3 2.8	2.8 2.4 2.4 2.0	2.6 2.4 2.4 2.2
Average	2.3	2.7	3.0	2.4	2.4
Chroma***	9.6 10.0 9.1 10.3	5.0 4.0 4.5 4.6	6.0 4.8 5.4 5.2	3.5 3.4 3.0 2.4	3.0 2.1 3.3 2.6
Average	9.8	4.6	5.4	3.0	3.0

* Hue of red-purple is 95, that of red is 5, and yellow-red is 15.
** Brilliance runs from one (black) to ten (white).
*** Chroma is the strength of a color, and increases from neutral gray which is zero.

packed cherries was significantly more yellow and less intense (lower chroma) than that of the cold-packed cherries. The opposing chroma results in the two studies cannot be accounted for.

After three months storage, cherries packed by the two methods appeared to be about the same in color. There was a slight but general change in color from red towards yellow-red, as shown by an increase in hue; and a decrease in brilliance and chroma, indicating darkening and fading. The color scores from the palatability studies show a significant difference between cherries judged after canning and after storage. The cherries judged immediately after canning were scored higher than those judged after three months but there was no significant difference in the color produced by each method of canning.

2. Palatability studies.

The mean palatability results from scores by the five judges appear in Table IV. For each palatability factor, the probability of significance of difference between the means of scores on both canning methods was determined by analysis of variance; then the means of each method were tested for significance by determining "t" values. Separate analyses were made for fruit examined immediately and three months after canning. Also, the data from both judging periods were pooled for analysis of variance. It was possible to pool the data because the fruit judges each time was comparable, the

TABLE IV

PALATABILITY SCORES FOR COLD- AND HOT-PACK CHERRIES*

Factor	Freshly canned		After 3 months storage	
	Cold pack	Hot pack	Cold pack	Hot pack
Color	6.5	6.7	6.2	6.4
	6.2	6.1	6.0	5.9
	6.7	6.4	5.8	5.6
	6.6	6.2	6.0	6.0
Average	6.5	6.4	6.0	6.0
Appearance	6.3	6.2	6.2	4.8
	6.4	5.2	5.8	5.4
	6.4	5.5	5.6	4.7
	6.6	5.6	5.6	4.7
Average	6.5	5.6	5.8	4.9
Texture of flesh	5.5	5.8	5.2	5.0
	6.2	5.4	6.0	5.5
	6.2	5.8	5.5	4.7
	6.2	6.1	5.8	4.8
Average	6.0	5.8	5.6	5.0
Texture of skin	5.8	5.8	5.4	5.2
	6.1	5.1	5.8	5.4
	6.1	5.7	5.6	4.4
	6.0	6.0	5.4	4.6
Average	6.0	5.6	5.6	4.9
Flavor of fruit	5.7	6.2	5.5	5.0
	5.7	5.6	5.4	5.2
	5.9	5.8	5.6	5.0
	6.2	6.0	5.5	4.7
Average	5.9	5.9	5.5	5.0
Flavor of juice	5.9	6.0	5.2	5.0
	6.1	6.1	5.5	5.3
	5.7	5.5	5.4	4.9
	6.3	6.1	5.9	4.9
Average	6.0	6.0	5.5	5.0
General acceptability	5.4	5.8	4.8	4.8
	6.0	5.0	5.6	5.2
	5.7	5.0	5.4	4.1
	6.0	5.5	5.3	4.6
Average	5.8	5.4	5.2	4.6

*Palatability scores ranged from 1 to 7, seven being very desirable and one being very undesirable.

only difference being the storage factor. A sample analysis of variance made on the pooled "general acceptability' data is given in Table V.

TABLE V

SAMPLE ANALYSIS OF VARIANCE FOR POOLED DATA ON GENERAL ACCEPTABILITY OF COLD- AND HOT-PACKED CHERRIES

Source of variance	Degrees of freedom	Sum of squares	Mean sum of squares	Variance
Total	15	4.00		
Judging periods	1	1.40	1.40	11.32**
Methods	1	1.07	1.07	8.63*
Judging periods methods	1	0.03	.03	
Within judging periods and methods	12	1.48	.12	

*Significant.
**Highly significant.

Table VI is a summary of the results of analysis of variance on all palatability factors. It is evident that differences between the two methods were not significant until the canned cherries had been kept several months. However, upon examination of Table IV it may be seen that there was a slight difference in favor of the cold-packed cherries in most palatability factors on the freshly canned fruit. These results are similar to ones obtained by Griswold (1944). In her study, however, immediately after canning, differences in all pala-

tability factors in fruit canned by the two methods appeared significant or highly significant in favor of the cold-pack method.

TABLE VI

RESULTS OF ANALYSIS OF VARIANCE OF PALATABILITY SCORES OF COLD- AND HOT-PACKED CHERRIES

Factor	Significant difference between methods			
	Freshly canned	After 3 months storage	Pooled data from both judging periods	Judging periods
Color	no	no	no	**
Appearance	no	*	**	**
Texture of flesh	no	*	**	**
Texture of skin	no	no	**	**
Flavor of fruit	no	*	*	**
Flavor of juice	no	no	no	**
General conclusion	no	*	*	**

* Significant.
** Highly significant.

After the canned cherries were stored three months, differences in the method of packing were reflected in the changes that occurred in the fruit. Judges scored the cold-packed cherries significantly higher in appearance, texture of flesh, flavor of fruit and general acceptability.

When data from the two judging periods were pooled there

was a highly significant difference between the two methods in all factors except flavor and color. The flavor of the fruit processed by the cold-pack method was judged significantly better than that of the hot-pack method, but there was no significant difference in judges' scores on flavor of juice. Judges scored the appearance of the hot-packed cherries lower than the cold-packed fruit because of the crushed, broken and somewhat mushy appearance. The flesh was judged a little too soft and the skin slightly shrunken and tough. Remarks on flavor were about the same for cherries canned by both methods. After the storage period some jars of fruit processed by each method had taken on the flavor of the rubber rings, and juice of each pack was scored lower. Judges felt that, in general, the cold-pack method yielded a more acceptable product than that of the hot-pack method.

SUMMARY

Ascorbic acid concentration and palatability of Montmorency cherries canned by the cold- and hot-pack methods were studied. The canned fruit was examined after three months to determine any change with storage in these factors. Ascorbic acid content was determined by the phenylhydrazine method, and color was measured objectively by the Munsell system as well as subjectively by palatability scores. The pH and apparent sugar concentration were measured, and the internal temperature of the fruit during processing was determined.

The average ascorbic acid content of the raw cherries was 7.7 mg. per 100 grams. In the canned fruit there was a 67 per cent loss in the ascorbic acid of cherries processed by both methods. After three months there was a total loss of 79 per cent in the cold-packed cherries and 74 per cent in the hot-packed fruit. These losses were not significantly different.

The average initial temperatures of the cold- and hot-pack cherries were 101°F. and 191°F. respectively. The average temperature of the cold-pack cherries at the end of the 25 minute processing period was 208°F. and at the end of the 5 minute processing period with the hot-pack method it was 205°F. By the end of 10 minutes processing the cold-pack cherries had reached the final internal temperature of the hot-pack fruit.

The acidity of the raw and processed cherries was about the same. The average pH of the raw and hot-packed cherries was 3.3, while that of the cold-packed cherries was 3.4. After three months the canned cherries, packed by both methods, had an average pH of 3.4. From the data on final internal temperatures and hydrogen-ion activity for cherries canned by both methods, one might conclude that either canning method would preserve the products satisfactorily.

The apparent sugar concentration of the canned fruit syrup was 24.5 per cent in the cold-packed cherries and 27.5 per cent in the hot-packed cherries. The sugar concentration of fruit canned by both methods appeared to rise about three per cent during storage.

The color changed from a 95.5 red-purple in the raw cherries to a 5.2 and 5.4 red in cold and hot-packed cherries respectively. There was a large decrease in intensity of color with processing, the cold-pack cherries losing a little more color (lower chroma) than the hot-pack cherries. During canning, the cherries became lighter (higher brilliance number) with the hot-pack cherries being the lighter of the two. Three months later there appeared to be no difference in the color of cherries processed by the two methods. With storage the red color in all the fruit became slightly yellow (increased hue), darker (decreased brilliance), and less intense in color (decreased chroma).

The significant difference between the two methods appeared in the results of the palatability scores. Although differences in method had little effect on the palatability of the freshly canned cherries, the cold-pack fruit scored slightly higher than the hot-pack fruit in almost all factors. After storage of the canned fruit, differences between methods showed up significantly. The cold-pack method produced cherries which scored higher in appearance, texture of flesh and skin and flavor of fruit. The general conclusion was that cherries canned by the cold-pack method were more acceptable than those canned by the hot-pack method.

BIBLIOGRAPHY

Adam, N.B., 1914. Factors effecting the vitamin C content of canned fruit and vegetables. Univ. Bristol, Fruit and Veg. Preserv. Res. Sta., Campden, Ann. Rpts., 1941, pp. 14-20; 1942, pp. 12-17.

Beattie, H.G., Wheeler, K.A. and Pederson, C.S., 1943. Changes occuring in fruit juices during storage. Food Res. 8, 395-404.

Bigelow, W.D., and Cameron, E.J., 1932. Microbiology of canning. Ind. Eng. Chem. 24, 655-658.

Campbell, C.H., 1937. Campbell's book; canning, preserving and pickling. Revised edition. New York. Vance Publishing Corp. p. 28.

Cruess, W.V., 1938. Commercial fruit and vegetable products. Second edition. New York and London: McGraw-Hill Book Co., Inc. pp. 111-112,114.

Culpepper, C.W. and Caldwell, J.S., 1927. Behavior of anthocyan pigments in canning. J. Agri. Res. 35, 107-132.

Daniel, E.P. and Rutherford, M., 1936. Effect of home canning on ascorbic acid content of tomatoes. Food Res. 1, 341-347.

Fisher, R.A., 1936. Statistical methods for research workers. Sixth edition. Edinburgh and London: Oliver and Boyd.

Food Industries Manual, 1940. London: Leonard Hill Ltd. p. 126.

Griswold, R.M., 1944. Factors influencing the quality of home-canned Montmorency cherries. Mich. Sta. Agr. Exp. Sta. Tech. Bul. 1914, 38 pp.

Handbook of chemistry and physics. Twenty-seventh edition, 1943-1944. Cleveland: Chem. Rubber Pub. Co., p. 1556.

Home canning of fruits and vegetables. 1944. Published by the Bureau of Human Nutrition and Home Economics. U.S.D.A. Bul. AAI-93, 16 pp.

Kirk, L.L. and Tressler, D.K., 1941. Ascorbic acid content of pigmented fruits and vegetables and their juices. Food Res. 6, 395-411.

McElroy, O.E., Munsell, H.E. and Steinberger, H.C., 1939. Ascorbic acid content of tomatoes as effected by home-canning and subsequent storage, and of tomato juice and fresh orange juice as affected by refrigeration. Home Econ. 31, 325-330.

Nickerson, D., 1939. A method of determining the color of agricultural products. U.S.D.A. Tech. Bul. 134, 32 pp.

_____. 1935. Color tables for converting greys of selected discs to terms of hue, brilliance and chroma. Mimeo., Bur. Agri. Econ., U.S.D.A., 115 pp.

Peveck, F.L., and Elvehjem, C.A., 1944. Work of the committee on food composition. J. Am. Diet. Assoc. 20, 218-219.

Pederson, C.S., 1929. The types of organisms found in spoiled tomato products. N.Y. Agri. Exp. Sta. Tech. Bul. 150.

Prescott, S.C. and Proctor, B.E., 1937. Food technology. First edition. New York and London: McGraw-Hill Book Co., Inc., pp. 417, 421, 423.

Reynolds, M.S. and Reynolds, D.W., 1928. Modern methods of producing handling and canning red sour cherries. Canner 66, 19-23.

Roe, J.H. and Oesterling, M.J. 1944. The determination of dehydroascorbic acid, and ascorbic acid in plant tissues by the 2, 4-dinitrophenylhydrazine method. J. Biol. Chem. 52, 511-517.

Snedecor, G.W., 1940. Statistical methods. Ames: Iowa State College Press.

Stanley, L., Stienberger, H. and Shank, D., 1942. Home canning of fruits, vegetables, and meats. U.S.D.A. Farmers' Bul. No. 1762, 46 pp.

APPENDIX

Reagents used in ascorbic acid analysis:

(1) Extractant-1:1 mixture of 5 per cent metaphosphoric acid and 10 per cent acetic acid.

(2) Acid washed norite.

(3) 2,4-dinitrophenylhydiozine reagent. Two grams of 2,4 dintrophenylhydiozine in 100 ml. of approximately 9N sulphuric acid (3 parts water to 1 part H_2SO_4).

(4) Thiourea solution-10 grams thiourea in 100 ml. of 50 per cent (by volume) aqueous ethyl alcohol.

(5) Sulphuric acid - 95.5 per cent.

TABLE VII

DATA ON ASCORBIC ACID ANALYSIS OF CHERRIES CANNED THE THIRD DAY

Sample	Ascorbic acid content *				
	Raw	Freshly canned		Stored 3 months	
		Cold pack	Hot pack	Cold pack	Hot pack
		mg.	mg.	mg.	mg.
1	9.38	2.20	4.53	1.05	3.00
	9.52	2.91	2.92	1.30	2.40
	8.11	2.23	2.57	2.04	2.40**
2	8.55	3.87	3.92	2.96	3.42
	6.99	3.52	3.11	3.57	3.23**
	6.85	----	3.08	3.54	3.20
3	8.30	4.56	4.94	3.20	3.27
	7.01	3.72	3.77	2.84	2.83
	7.32	3.56	3.72	3.06	2.54

*Based on 100 grams of the raw cherries.
**Calculation from one reading as second reading omitted because of charring; all other figures are the mean of two readings.

TABLE VIII

INTERNAL TEMPERATURE OF COLD-PACK CHERRIES AT VARIOUS TIMES DURING CANNING

Sample no.	Internal temperature of sample						
	Initial	When water bath 210°F.	After processing at 212°F.				
			5 min.	10 min.	15 min.	20 min.	25 min.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	93	187	204	206	206	207	207
2	94	181	199	203	205	208	209
3	99	176	196	200	202	204	206
4	99	188	193	200	204	206	207
5	99	188	193	199	203	206	207
6	99	209	210	209	209	209	209
7	107	210	210	210	209	210	210
8	107	211	211	210	209	209	206
9	109	209	210	209	209	209	209
Average	101	190	203	205	206	208	208

TABLE IX

INTERNAL TEMPERATURE OF HOT-PACK CHERRIES AT VARIOUS TIMES DURING CANNING

Sample no.	Internal temperature of sample					
	Initial	When water bath 210°F.	After processing at 212°F.			
			1 min.	2 min.	3 min.	4 min.
	°F.	°F.	°F.	°F.	°F.	°F.
1	97	206	208	207	208	208
2	105		210	210	210	210
3	112		211	212	212	211
4	122	208	209	209	209	209
5	125	181	193	195	196	197
6	125		196	198	199	200
7	126		210	211	212	211
8	127		209	210	210	210
9	128		211	212	212	212
10	156		206	205	208	209
11	165		188	191	190	195
12	167		185	187	189	210
13	174	182	192	193	195	195
14	171		190	193	195	196
Average	136	191	201	203	205	205

Formula used in calculating brilliance in color of cherries:

$$B = \sqrt{\frac{A_1 B_1^2 + A_2 B_2^2}{100}}$$

A_1 = area of the first disc.

B_1 = brilliance of first disc.

A_2 = area of the second disc.

B_2 = brilliance of second disc.