DEVELOPMENT OF A COMMERCIALLY FEASIBLE METHOD OF PRODUCING DEHYDRATED BERRIES AND CHERRIES

PROJECT NO. R 43 - 44

by

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July 1, 1945

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in cooperation with
War Department, Office of Quartermaster General

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INTRODUCTION

The end of the European phase of the war lessens somewhat the demands os the military for food in one theater of operations. The successful prosecution of the Pacific phase of the war and the needs of the liberated peoples of the world, plus the civilian requirements of the allied nations, make imperative increased rather than reduced food production. The problems of adequate shipping space and tremendous transport distances accentuate more than ever the need for dehydrated foods. Thus the dehydration of cherries and berries, especially in the Pacific Northwest, remains important as an industry.

The figures on the production of sweet and red sour cherries, aswell as berries of various types, show that the west rn states, and e specially Oregon and Washington, can grow the raw products for a greatly expanded dehydration industry. Comparative production data for 1943 are as follows:

Table I

* Figures on Fruit Production
1943

Item	Oregon Washington pounds	Western pounds	United States pounds
Frozen:			
Red Cherries	3,158,433	3,158,433	27,529,931
Sweet Cherries		626,564	626,564
Total Berries	50,878,275	54,471,462	73,814,204
Strawberries	15,743,965	16,471,726	26,634,255
Total Berries and Cherries	69,780,673	74,728,185	128,604,954
Canned:			
Red Cherries		16,306,640	44,942,240
Sweet Cherries		42,890,496	44,712,240
Strawberries		155,700	155,700
All Berries		19,508,034	42,000,000
Total canned cherries and berries		78,860,870	131,810,180
Grand total frozen and canned cherries and berries		148,641,543	260,415,134

Total Western States production is over 57% of national total.

FROM WESTERN CANNER AND PACKER YEARBOOK

Thus it is evident that cherries and berries are available in quantities to warrant commercial dehydration of these fruits. Expansion of the production of these, particularly of berries, is possible. This is indicated by the fact that acreages of the small fruits are now less than they were a few years ago. That equipment and manpower shortages, and not the returns on the fruits, are responsible for this decline, seems evident from the following data:

Table II

Certain Small Fruits, Acreage, Production Price and
Value Estimates by Kinds, Oregon 1936 and 1943

Kind and year Harvested	Acres Harvested	Pounds Harvested	Average Price per lb.	Value of farm Marketings
Strawberries				
1936	10,900	32,976,000	5.4¢	$1,786,000
1943	8,000	15,264,000	13.9	2,020,000
Red Raspberries				
1936	3,300	7,000,000	5.7	382,000
1943	2,400	6,800,000	15.7	1,020,000
Loganberries				
1936	2,150	6,200,000	4.0	242,000
1943	1,350	3,500,000	12.4	417,000
Boysenberries and Youngberries				
1936	1,000	1,800,000	5.8	95,000
1943	2,600	9,000,000	12.4	1,079,000
Tame Blackberries				
1936	750	3,000,000	4.1	120,000
1943	700	4,200,000	12.2	506,000

Above figures from Oregon Agricultural Extension Bulletin #656,1945

While the acreages of cherries do not fluctuate as readily as those of the small fruits, in some sections due to unfavorable economic conditions of prewar days, the plantings of sweet and sour cherries have declined. There is, however, much land which is suitable to cherry production and can be planted if economic factors continue to make profitable the growing of cherries.

That we might better work out certain techniques in the handling of these fruits upon a commercial basis, this year our efforts were confined to the dehydration of only Lambert, Royal Anne and Montmorency cherries and Marshall strawberries. No work was done on any other varieties of cherries or with other small fruits. However, tonnages were dehydrated which provide a basis for commercial application of our methods.

The fresh and dried weights for the fruits that were dehydrated are as follows:

	Fresh	Dehydrated
Lambert Cherries	10,455	2,018
Royal Anne Cherries	1,520	253
Montmorency Cherries	11,931	1,842
Marshall Strawberries	9,742	798

PREPARATION AND DEHYDRATION PROCEDURES

Examination of the cherries and berries prepared last year suggested the elimination not only of many of the pretreatments that were used but also the confining of efforts to three varieties of cherries and to one instead of several kinds and varieties of berries. To provide a clear understanding of the treatments accorded the different fruits each will be discussed separately.

Marshall Strawberries:

To obtain sufficient strawberries of suitable quality without seriously interfering with the normal canning operations of the cooperating plant, it was necessary to obtain the fruits from two different areas. Part of these were grown near Salem, Oregon, where they were dehydrated, but the remainder was transported from Gresham, Oregon. Considerable variation in the berries from the two areas was observed. As pointed out in previous reports, this may have been due mostly to a difference in moisture conditions during harvesting.

Preparation of the strawberries for sulfuring and dehydration was accomplished at the Producers Cooperative Cannery, Salem, Oregon, where the washing and sorting were done by running the berries over the regular line used for other strawberries processed in the plant. The washed and sorted fruits were taken from the picking belt and spread upon wood slat trays. The trays were then stacked on cars and run into a sulfur chamber where they were exposed to sulfur dioxide for one hour. Blanching of the fruits prior to sulfuring was not practised. The sulfur chamber was constructed of plywood sheets, and was large enough to accommodate approximately one ton of berries or five cars of trays at one time. The sulfur dioxide gas was obtained from a cylinder. By weighing the amounts used and by measuring the sulfur dioxide concentration of the atmosphere within the chamber, it was possible to obtain fairly uniform sulfuring. An electric fan inside the chamber was employed to obtain more even distribution of the gas. A portion of the strawberries as controls was dehydrated without sulfuring.

Dehydration was effected in Paulus Brothers tunnel dehydrator at Salem, with the strawberries spread by hand on wood trays that were stacked on cars. A dry bulb temperature of 145-150° F. and a wet bulb temperature of 90-92° F. were maintained. Drying required from 26 to 28 hours with an air velocity of 800 linear feet per minute. Because the dehydrated strawberries adhered tightly to the trays they were very difficult to remove. Much scraping with metal scrapers was necessary to remove them. The berries also badly stained the wood trays. Because these stains were almost impossible to remove, some other tray material than wood seems to be indicated. At least, if wood trays must be used, they should be coated with a neutral mineral oil to prevent undue sticking of the fruits.

Determinations, made later, on the dehydrated strawberries showed they contained approximately 6.5% moisture and the average drying ratio was approximately twelve to one. The finished product was stored in five gallon friction-top tin cans and transported to the Food Industries laboratories at Corvallis, Oregon.

Each lot of dehydrated cherries was then emptied from the cans and all the berries of a particular lot were thoroughly mixed before they were placed again into sealed cans. Each lot was divided into two portions; one part was kept in storage at room temperature and the other was held at 95° F. Sulfur dioxide determinations were made on these at about monthly intervals.

Three to four pounds of strawberries, representing about 800 pounds of fresh fruits, were taken from the picking belt for moisture, soluble solids, and ascorbic acid determinations. The soluble solids averaged 6.4% and 9.5% for strawberries from the two different localities. The moistures of the same fresh lots averaged 93.3% and 90.4%. The sulfur dioxide remaining after dehydrating was 631 and 896 ppm. respectively. The results of ascorbic acid determinations are included elsewhere in this report, as are those of other experiments with the dehydrated strawberries.

The strawberries were dehydrated during the period from June 21 to 23, 1944.

Cherries:

Cherries for dehydration were obtained at Salem, Oregon, from Kelley-Farquhar Company and the Willamette Cherry Growers' Association. Paulus Brothers' tunnel dehydrator was again used, with the operations being carried on from June 14, to 21, 1944.

Washed and pitted cherries were brought to the dehydration plant in buckets. After draining off most of the free juice, the fruits were spread on the metal belt of a continuous blancher which carried them through steam at 180°--205° F., exposing the fruits for about seven minutes. The hand-trayed fruits were stacked 22 trays per car, and the cars of fruit were run into the dehydrator or first exposed for one hour to sulfur dioxide if the particular lot required sulfuring. Since Montmorency cherries collapsed badly and lost too much soluble materials if blanched, these were given no pretreatment except sulfuring.

Wet and dry bulb temperatures were maintained at about 90-92° F. and 145-150° F. respectively. The drying time varied somewhat with the tray load, the number of cars per tunnel, and the variety of cherries but ranged from 18 to 27 hours. Unblanched and unsulfured cherries required somewhat longer time for dehydration.

Blanched cherries, particularly if the trays were not washed after having been used for cherries, were rather difficult to remove. The unblanched fruits, we found upon analysis, did not absorb as much sulfur dioxide nor did they retain it as well as the blanched fruits. Blanching also imparted a translucency to the cherries which was not present in either the control or the unblanched but sulfured lots.

Samples of fresh pitted cherries, one for each ton of pitted Lambert and Royal Anne and one for each two tons of Montmorency cherries were taken for determining moisture and soluble solid contents. These gave averages as follows:

Variety	% Soluble Solids	* % Moisture
Lambert	18.9	78.0
Royal Anne	16.0	80.8
Montmorency	14.8	83.2

*The figures on total moisture, however, must be regarded as only approximate due to the separation of the juice from the pitted cherries which made difficult the obtaining of a representative sample.

As in the case of the strawberries, all the dehydrated cherries were removed from the trays and stored in five gallon friction top tin cans. These were then transported to the Food Industries laboratories where the cans of each lot were mixed and repacked after division into two portions. One of these was kept stored at room temperatures while the remainder was stored at 95° F.

Later most of both portions were washed and steamed to remove dirt, small pieces of tray material, and to make the cherries more pliable by removing dried syrup and adding moisture. A large shipment of cherries so treated was sent to the Quartermaster Subsistence Laboratory, Chicago, Illinois.

EXPERIMENTAL PROCEDURES

Sulfur Dioxide Losses:

Frequent determinations throughout last year were again made of the sulfur dioxide content of cherries and strawberries stored at room temperatures and those held at 95° F. All samples were kept either in screw cap glass jars or friction top metal cans. The first determinations were made soon after dehydration and then at approximately monthly intervals for a period of 10 months. Table III shows the parts per million of sulfur dioxide remaining at each determination and gives the final per cent of loss based on the concentration obtained for the first determination. All concentrations are calculated on the moisture-free basis.

Table III

Parts Per Million of Sulfur Dioxide in Dehydrated Cherries and Strawberries and Per Cent Losses During Ten Month Period

Variety and Pretreatment	Storage Temperature	After Dehydration	Months 1	2	3	4	5	6	7	8	9	10	Final % Loss SO_2
Royal Anne													
	Room	1333		1071		983		974					26.93
Sulfured	95°F	1333	673	400	275	139		77		39			97.07
Blanched and	Room	2390		2170		2080		2120					11.30
Sulfured	95°F	2390	1698	1295	840	581		262		150			93.72
Lambert													
	Room	1158		1175		1096		753					34.97
Sulfured	95°F	1158	498	391	142	130		62		39			96.63
Blanched and	Room	1952		2100		2150		1945					0.36
Sulfured	95°F	1952	1580	1275	708	597		443		184			90.57
Montmorency													
	Room	278		208		240		179					35.61
Sulfured	95°F	278	96	72	31	37		0		22			92.09
Marshall													
Sulfured													
Lot 2													
	Room	631	599	568	446	465		429		340		383	39.30
	95°F		482	375	277	207		186		100		117	81.46
Lot 3													
	Room	896	906	828	726	555		350		655		570	36.38
	95°F		602	462		297		188		155		75	91.63

A study of Table III and analysis of our results show:

1. Fruits which are blanched before sulfuring not only absorb almost twice as much sulfur dioxide but retain more of it in storage than in the sulfured but unblanched material.
2. Elevating temperatures greatly accelerates the losses of sulfur dioxide.
3. A large per cent of the losses of sulfur dioxide occurs during the first three to four months of storage at 95°F. At room temperatures the losses steadily increase in storage but even at the end of eight and ten months significant amounts remain.
4. Fruits stored under tropical conditions after eight to ten months retained too little sulfur dioxide for their adequate protection and preservation.
5. High temperatures within a few months greatly impair the color of dehydrated cherries and in ten months time make them unattractive although not necessarily useless as food. While the bright red of strawberries is changed to a less attractive color, the transformation is much slower than in cherries.

In connection with the color developed in cherries which have been stored at 95°F. it can be said of those carried over from last year that continued high temperatures produce fruits not only black in color but the flavor is greatly impaired. A burned or caramelized flavor develops, and the cherries are rendered unpalatable.

We did not attempt to determine what occurs when sulfur dioxide is lost. Since we had no really effective method (other than storage at low temperatures) of retaining this preservative material (SO_2) some means of replacing what was lost seemed a logical alternative.

Resulfuring Experiments:

If a rapid and practical means of reimpregnating cherries with sulfur dioxide could be developed, we reasoned, then perhaps the fruits might be processed so that they would arrive at the army kitchen with a satisfactory sulfur dioxide concentration. Resulfuring by exposing the dehydrated cherries, containing six to eight per cent moisture, to the fumes of burning sulfur, we had tried without greatly increasing the amount of absorbed sulfur dioxide. During this year we experimented with what we call a vacuum replacement method. This effectively raises the concentrations of sulfur dioxide to levels which are regarded as adequate. The method utilizes both heat and moisture for increasing the absorption of the gas.

Montmorency cherries, because they originally absorbed much less sulfur dioxide than either Royal Annes or Lamberts, were used for this test. A number of variations in the experimental methods were tried. Three hundred fifty grams of the differently treated cherries were placed into desiccators which were evacuated to give a vacuum of 27 inches. The vacuum was replaced with sulfur dioxide from a cylinder until the monometer registered zero. The gas was then retained for different intervals of time. Comparisons were made between cherries which were pressure-cooked and those which were steam-blanched. Finally tests were made with no cooking and vacuum replacement and cooking with no vacuum replacement.

Examination of Tables IV and V seemsto show that absorption of sulfur dioxide increases as the per cent of moisture in the fruit increases.

Prolonging the exposure to the gas appears to promote absorption but seems not to exert an effect that is proportional to the exposure time.

Table IV

Results of Resulfuring Experiments

Treatment	% Moisture	Minutes Exposure to SO_2	ppm. SO_2
Pressure cook 5 minutes 27 inches vacuum	18.3	0.25	711
"	18.4	0.50	866
"	18.7	1.00	1153
"	18.7	1.50	1448
"	19.3	2.00	1428
"	23.3	3.00	3475
"	18.9	3.00	1774
"	17.5	5.00	2281
"	18.8	10.00	3800
Control	12.1	—	—
Pressure cook 5 minutes No vacuum	19.1	0.25	350
"	19.2	0.50	335
"	19.2	1.00	774
"	18.5	1.50	1020
"	19.2	2.00	1005
"	18.2	3.00	1274
"	18.7	5.00	2444
"	18.9	10.00	3132
"	23.4	3.00	2820

Table IV (continued)

Treatment	% Moisture	Minutes Exposure to SO_2	ppm. SO_2
No cook but 27 inches vacuum	12.1	3.00	411
"	13.6	3.00	683
"	12.1	5.00	815
"	12.1	7.00	844
"	12.1	9.00	912
None	13.9	—	—
Pressure cook 5 minutes vacuum 27 inches	21.2	3.00	3815
Pressure cook 10 minutes vacuum 27 inches	22.1	3.00	3460
Pressure cook 15 minutes vacuum 27 inches	22.9	3.00	5450
Pressure cook 5 minutes no vacuum	23.4	3.00	2820
No cook but 27 inches vacuum	13.6	3.00	683

Table V

Montmorency Cherries Resulfured by Vacuum Replacement Method

Steam Blanch in Seconds	% Moisture	Minutes Exposure to SO_2	ppm. SO_2
15	14.5	3	1562
30	15.9	3	2560
45	17.4	3	2660
60	19.1	3	3275
15	15.4	5	2140
30	16.7	5	2705
45	18.4	5	3490
60	19.3	5	4250
0	13.5		

A vacuum of 27 inches was used.

Adequate amounts of sulfur dioxide can be added without vacuum replacement if either the length of the pressure cook or the time of exposure to the gas is increased. Prolonging the cooking time injures the color of the fruit and increasing the exposure time will greatly slow down operations. Our results indicate that blanching the cherries 30 to 60 seconds and gassing under a vacuum of 27 inches will give effective concentrations of from 2000 to 3000 ppm. of sulfur dioxide. While good results may be obtained by pressure cooking and vacuum replacement, it accomplishes, with the exception of some tenderizing of the fruits, no better results that the steam blanch and would require more complicated and expensive equipment. Because of the rather high moisture content necessary for adequate resulfuring without benefit of vacuum, omission of the vacuum seems practicable only if one increases the exposure time to a point where it may prove unprofitable. On the other hand, vacuum equipment is costly and may be difficult to obtain. Certainly, application of the vacuum replacement method would need to be made at processing plants far removed from the army field kitchens. If fruits were heavily resulfured in this manner before shipment to the tropics, they should arrive with more sulfur dioxide than if given the usual handling. Vacuum replacement offers an effective and rapid means of increasing the sulfur dioxide content of dehydrated cherries.

Storage Experiments:

Throughout the year both the three lots of Marshall strawberries and the three varieties of cherries were stored, a part of them at room temperatures and the remainder at 95°F. The influence of temperature has already been mentioned in connection with the losses of sulfur dioxide. At 95°F. all the cherries darkened to a marked degree until after eleven or twelve months' storage--the red of the Montmorency cherries had turned almost black. At room temperatures the color change was very slow, the natural colors of the dehydrated materials remaining quite well as long as any appreciable sulfur dioxide was present. The control samples, even at room temperatures, darkened considerably. The eating quality of all the excessively darkened fruits was greatly impaired. The worst appearing cherries possessed a charred or caramelized taste which made them more or less bitter. High temperatures do not produce as intense color changes in strawberries as rapidly as is true of cherries, but considerable darkening was noted in the samples stored at 95°F. Except for Lot One, which was not sulfured, there was very little darkening at room temperatures. The eating quality of sulfured strawberries kept at room temperatures remained quite good, but the higher temperature resulted in a marked deterioration in the eating qualities.

Vitamin C Retention:

Our results of analysis of total vitamin C on strawberries were disappointing in that with the filters we have for our electrophotometer we were unable to determine the vitamin due to interfering pigments. Analysis for ascorbic acid by the 2-6 dichlorophenol-indophenol method failed to give any significant quantity of the vitamin. It is, however, quite possible that there may be present in cherries appreciable amounts of the biologically active dehydro-ascorbic acid, which we were unable to determine.

Our assays agree with those of other workers which show that fresh strawberries are a good source of vitamin C. We found that considerable amounts of ascorbic acid are retained in dehydrated strawberries, provided they are pretreated with sulfur dioxide. Naturally, compared with fresh berries, the retention in the dehydrated product is often only 50 or 60 per cent of the original. The amount remaining in the dehydrated material also may be further reduced by careless handling. Regardless of the method of pretreatment, the quantity of this vitamin, which is retained even at room temperature storage, drops steadily. When the fruits are subjected to tropical temperatures, the amount of Vitamin C that remains is greatly reduced.

Table VI

Milligrams of Ascorbic Acid Per 100 Grams in Fresh, Dehydrated and Stored Dehydrated Marshall Strawberries

Pretreatment	Storage Temperatures	Fresh Fruit	Freshly Dehydrated	After Month's Storage 1	2	3	4	5	6	7	8	10	12	Per Cent Retained Based on Dehydrated Product	Per Cent Retained Based on Fresh Fruit
None	Room	752	92	85	61	67	61	59	67	—	51	37	47	51.09	6.25
	95°F	752	92	85	49	46	41	36	49	—	43	34	43	46.73	5.72
Sulfured 1 hr.	Room	752	308	284	224	210	207	190	184	—	150	132	140	45.45	18.62
Lot 1	95°F	752	308	284	127	70	49	39	50	—	32	48	46	14.93	6.12
Sulfured 1 hr.	Room	601	325	306	295	237	229	224	229	—	216	174	161	49.54	26.79
Lot 2	95°	601	325	306	159	96	43	47	49	—	34	31	25	7.69	4.16

Study of the above table shows that:

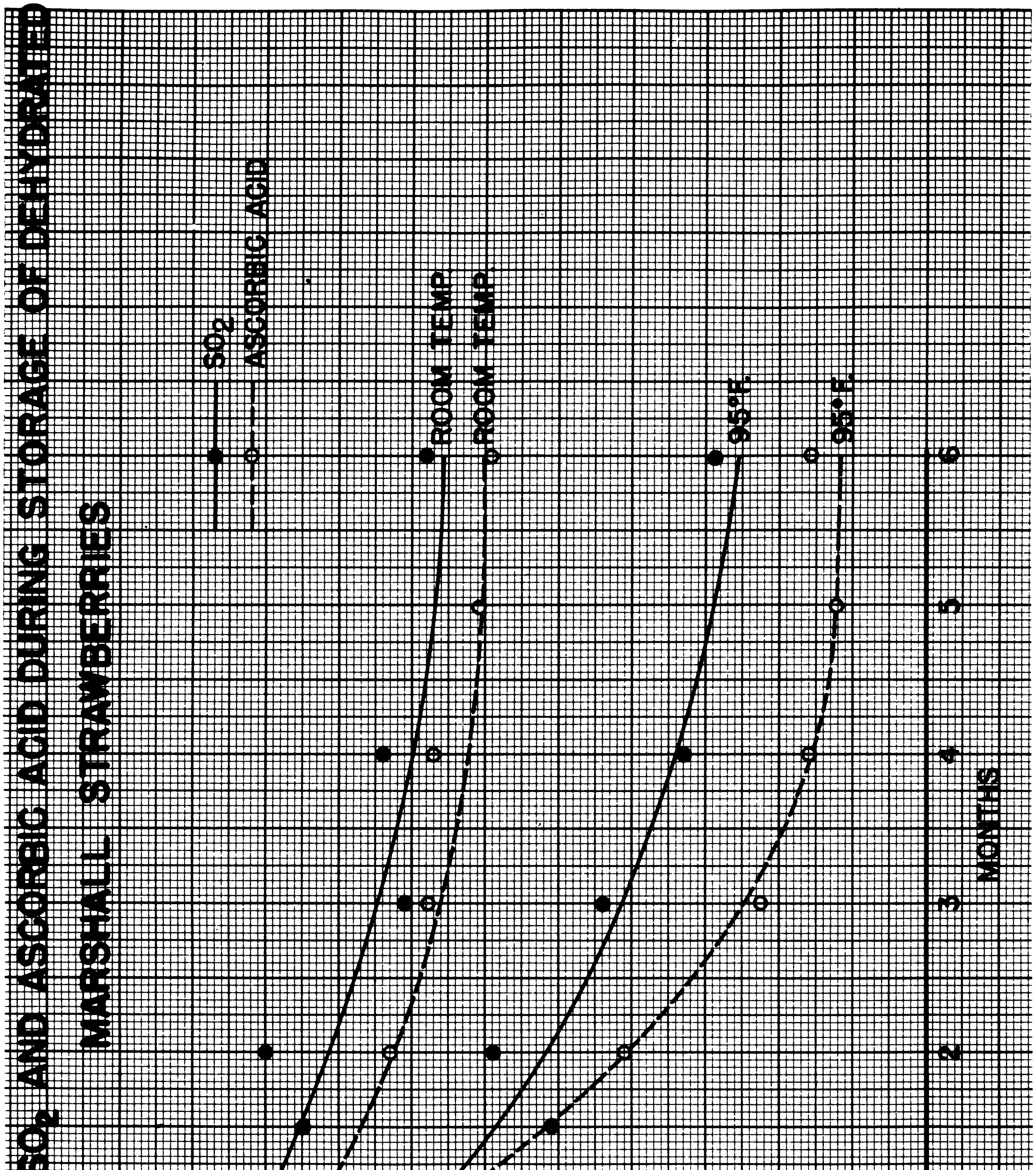
1. High temperatures accelerate the losses of Vitamin C during storage from unsulfured strawberries but not as much as those from sulfured fruits.

2. The initial applications of sulfur dioxide gave no increase in the per cent of ascorbic acid retention when the berries were stored at high temperatures.

3. Sulfured dehydrated strawberries when stored at room temperatures retained three to four times as much Vitamin C as unsulfured fruits.

Comparisons of ascorbic acid retention in strawberries and the retention of sulfur dioxide in the same lots of berries, as the accompanying graph (Figure 1) illustrates, show that the higher the amounts of Vitamin C retained, the greater are the quantities of sulfur dioxide retained. Our tests indicate last year's strawberries contained more milligrams of ascorbic acid per 100 grams of fresh fruit than was true this year, but losses of the vitamin in storage followed essentially the same trends both years.

It appears from our results that unless dehydrated strawberries which are to be shipped to the tropics are used within three or four months after being subjected to high temperatures (something that appears impossible) then it is useless to pretreat with sulfur dioxide, for Vitamin C retention. Too much of the initial concentration of ascorbic acid is lost during dehydration so that practically none remains when the food is utilized. Of course, where storage conditions are much more favorable, sulfur dioxide should prevent some of the losses of Vitamin C.



RETENTION OF SO_2 AND ASCORBIC ACID DURING STORAGE OF DEHYDRATED
MARSHALL STRAWBERRIES
SO_2
ASCORBIC ACID
ROOM TEMP.
ROOM TEMP.
95°F.
95°F.
%
100
90
80
70
60
50
40
30
20
10
2
3
4
5
6
MONTHS

Figure 1

Rehydration and Utilization Tests:

Holding to the theory that high moisture contents in dehydrated foods favor chemical decomposition, our original purpose was to reduce moistures to as low levels as were consistent with the methods we employed. These in some cases might be as low as five or six per cent. Our experiments in the rehydration of the fruits, particularly of Montmorency cherries, have suggested that perhaps these low moistures are not desirable. We have found that the higher moisture levels facilitate the reconstitution of the fruits.

While satisfactory rehydration was achieved with strawberries which were made into preserves, in no case were we able to obtain perfect rehydration with cherries. For pies and sauce Lamberts and Royal Annes refreshed to yield a fairly satisfactory product but most of the samples of Montmorency cherries remained tough and more or less shriveled. The dehydration procedure toughens the skin and makes difficult the penetration of water and sugar. To obtain a tenderized product from cherries pressure cooking the fruits five to ten minutes at 227° F. or else simmering slowly for 30 minutes or more appears necessary. Lengthy pressure cooking or processing at higher temperatures results in darkening of the colors of the fruits. However, some sort of precooking is needed to tenderize the dehydrated cherries when preserves are made of them. Because of the tough skins, putting the cherries through some kind of food chopper, is necessary. Even then precooking is desirable. The chopping permits the sugar to come into more intimate contact with the fruits. Montmorency cherries, we found, after having been cooked until tender and appearing quite plump upon rehydration, shriveled extensively upon the addition of sugar. The skins of the fruits, acting more or less as a differential membrane, prevent any rapid absorption of sugar. In the case of strawberry preserves, this results in pronounced shriveling of the fruits, which, although immersed in an excessively sweet syrup, remain sour and tough and the final product is not a satisfactory preserve.

Montmorency cherries, if utilized in pies or in such desserts where the fruits themselves are not too evident, should find application. Their rehydrated appearance is not at all pleasing so that for lack of eye appeal, it is doubtful if the men in the army would eat them. Unless Montmorency cherries are chopped before being made into jam or preserves, they will not make an attractive product. The sweet varieties, we found, are much more suitable for preserves. Royal Annes, especially, yield an attractive preserve which is at the same time of good quality.

Excellent preserves, possessing a beautiful natural color and good flavor, have been prepared from dehydrated strawberries which have been given a pretreatment with sulfur dioxide. Slow boiling of the berries for about 30 minutes before adding sugar is necessary to insure proper rehydration. This also aids in the removal of excess sulfur dioxide when it is present. Soaking the berries in warm water before cooking does not seem to hasten the rehydration process to any great degree. We have found that the addition of citric acid at the beginning of the cooking period improves both the color and the flavor of the finished product. Cooking with a tight cover on the kettle also aids in color retention. Upon adding sugar, the cooking should proceed slowly for a short time to permit better penetration of the sugar into the berries. Following this, rapid boiling to the end point is possible without undue destruction of the red color.

Fruit Bars from Dehydrated Cherries:

The preparation of a fruit bar, using as one of the principal ingredients dehydrated Montmorency cherries, seemed to offer a useful means of utilization of a product which does not lend itself very well to the making of sauce, pies, or preserves. In compounding any fruit bar it was necessary to keep in mind that to be suitable for inclusion in the army emergency rations, the bar must possess (1) high food value, (2) an appetizing appearance, (3) good flavor, (4) low moisture content, (5) low sugar concentration, and (6) a high degree of resistance against attacks by microorganisms and insects.

The experiments in compounding a fruit bar which would satisfactorily meet all these specifications have included many tests in which different kinds of ingredients were mixed in varying proportions. We have tried to utilize as large a percentage of Montmorency cherries as possible. This has been difficult because to compensate for their rather high acidity it has been necessary to add other materials to improve the palatability of the final product. The lack of body in these cherries, furthermore, requires the inclusion of such ingredients as sugars, molasses, and other fruits.

In attempting the compounding of a fruit bar high in food values, we mixed all ingredients after taking into consideration the nutritional values of cherries as shown by the work of other investigators. We did not attempt complete analysis to determine the food values of sweet and sour cherries. The data we were able to find indicates these cherries compare favorably in nutritional values with other dehydrated fruits. Cherries possess a comparatively high caloric value and the calcium, iron, and thiamine chloride values seem to be adequate.

Probably there is a deficiency in ascorbic acid and certainly these fruits lack vitamin A. Because the addition of dehydrated apricots will improve the vitamin A content and at the same time will provide goodly amounts of the other necessary nutritional ingredients, these have been used in our recipe for making cherry bars. We even added powdered dehydrated squash and carrots to increase the vitamin A content. The immediate results were a bar of fair palatability but upon storage at 95° F their eating qualities deteriorated to the extent that we do not recommend the inclusion of these vegetable materials.

Molasses, we found, adds considerably to the food value of the bar. Honey, corn syrup, and maple syrup all contribute in the same way, and besides these greatly improve the flavor characteristics. By substitution of molasses, which is high in calcium, we believe, it is possible to leave out figs, a fruit which some persons find undesirable. Bars in which the above mentioned sweetening agents were used were stored at 95° F, and at room temperatures to study their retention of moisture and quality characteristics. These have been in storage about three months. Composite results of examinations by six persons are shown in Table VII.

Table VII

Results of Color, Quality, and Flavor Tests on Fruit Bars

Special Materials Added to Bar	Storage Temperature	Color	Quality and Flavor
Maple syrup	Room	Red	Fair to good
	95°F	Dark red	Poor to fair
Molasses	Room	Quite dark red	Fair to good
	95°F	Very dark brown	Mostly poor
None	Room	Dark red brown	Off flavor
	95°F	Dark brown	Off flavor
Sodium alginate	Room	Dark red brown	Poor flavor
	95°F	Dark brown	Very poor flavor
Sodium alginate and avenex	Room	Dark red brown	Poor flavor
	95°F	Dark brown	Very poor flavor
Gelatin and avenex	Room	----------	----------
	95°F	Brown	Poor flavor
Agar as binder	Room	Bright red surface oxidized	Good flavor (best of lot)
	95°F	Slightly darker red	Fair to good flavor
Squash	Room	----------	----------
	95°F	Red color, surface darker	Taste of squash not desirable
Carrot	Room	----------	----------
	95°F	Red color, surface darker	Bitter, not acceptable

Any of the above fruit bars which were in storage three or more months were decidedly inferior to a bar which was made about a month ago. The latter was characterized by a freshness of flavor and color that one did not find in any of the stored samples. This limited test seems to show that profound deteriorative changes occur even at room temperature. At high temperatures the changes are so rapid that the bars soon become undesirable as food. Also, most of the ingredients added to the standard formula produced a bar with no improved characteristics or one which was inferior.

In preparing a fruit bar which would possess a distinctly tart flavor there was danger in making the product too acid for most palates. After numerous trials and a final alteration of the recipe first reported, we have compounded a product, which it is believed, has desirable characteristics. It was prepared by use of the following formula:

	% by weight	% moisture of ingredients	% dry material
Sweet cherries (Lambert)	38.0	5.2	31.0
Sour cherries (Montmorency)	19.0	5.95	15.2
Raisins (Thompson Seedless grapes)	9.5	6.85	7.5
Apricots	13.3	15.45	9.6
Argose	19.2	3.05	15.7
Salt (Leslie iodized)	0.5		0.5
Vanilla (Schilling)	0.25		0.25

	% by weight	% moisture of ingredients	% dry material
Oil (Standard white petroleum oil # 9)	0.125		0.125
Paraffin (Parowax)	0.125	____	0.125
	100.000	7.00	80.000
Water added to raise moisture level of finished bar to 20%		13.00	
		20.00	

*Chemical analyses made on samples of a bar containing two per cent more sweet cherries, one per cent more sour cherries, 0.5 per cent more raisins but 0.7 per cent more apricots and 4.2 per cent less argose than our final recipe, showed the following:

Thiamin (Vitamin B_1):	0.231 mg. per 100 grams
**Ascorbic acid (Vitamin C)	15.20 " " " "
**Crude carotene (Vitamin A)	3.40 " " " "
Ash:	
Fruit bar	2.15 per cent
Lambert cherries	1.58 " "
Montmorency cherries	2.62 " "

Calories:

Fruit bar	364	per 100 grams
Lambert cherries	366	" " "
Montmorency cherries	355	" " "

*These analyses were made upon our original bar before the formula was altered to reduce the total acidity.

**Difficulties in obtaining satisfactory extractions resulted in pigmented solutions upon which it was hardly possible to make satisfactory determinations. Therefore, the carotene value should be regarded as a maximum figure.

Comparison of Wrapping Materials for Fruit Bars:

Sixteen days storage of fruit bars at 80°F., with constantly circulating air, indicated that pliofilm retains the largest amount of moisture, and is followed by glassine paper, waxed paper, and cellophane in the order named. However, the difference between the highest and lowest moisture retention was only one per cent. Pliofilm lost 2.2 per cent, glassine lost 2.3 per cent, wax paper lost 3.0 per cent, and cellophane lost 3.5 per cent moisture. All bars were enclosed in only one layer of the respective wrappings.

Efficiency of Certain Types of Packaging Materials:

Last year partial results were reported on the efficiency of several types of packaging material with and without wax coatings. Dehydrated cherries enclosed in these different packages, were held during a period of more than a year at room temperatures and under tropical conditions of temperature and humidity.

Hardboard packages with a gross weight of over 16,000 grams were coated by dipping into melted P-16C Darex Thermoplastic wax. Small fiberboard boxes and pressed bricks of cherries wrapped in cellophane were prepared, part of these were left uncoated and the remainder were dipped into a non-thermoplastic wax. Difficulty was encountered in handling these and in obtaining an even coating without redipping and using excessive amounts of the wax. It was necessary to protect the contents of the unwaxed packages against attacks by meal moth. To do this the packages were confined in friction top tin cans. Therefore, on these the loss or gain in weight was not the same as would have been the case if the samples had been exposed to the atmosphere at room temperatures. A tabulated summary of the findings is as shown in Table VIII.

Table VIII

Per Cent Gain in Weight of Different Packages

Stored Under Tropical Conditions:

MSAT-130 Cellophane	Wrapped 2½-3lb.	Fiberboard 2½-3lb.		Hardboard dipped in P-16C Darex
Undipped	Dipped in wax	Undipped	Dipped in wax	Thermoplastic Wax 20-30 lb.
6.273	1.027	xx	0.132	0.557
2.847	1.042		4.32	0.482
10.370	0.767		2.28	0.453
4.428	0.552			1.440
5.900	0.546			1.540
6.273	0.619			1.690
5.556	0.676			0.715
2.641	0.748			0.982
*5.536	0.751			
	0.893			
	0.833			
	0.993			
	0.787			

Stored at Room Temperatures:

2.96	0.683	1.490	0.0162
3.97	0.565	0.211	0.0173
3.67	0.624	0.85	0.2033
			0.0102
			0.5320
			0.0619
			0.1299
			0.1387

*Averages are underlined

xxPackages rapidly absorbed up to 22% moisture and molded badly.

While in several instances the above results are based upon too few packages of the better types of packaging materials, enough tests were run to offer conclusive data. The results seem to show that:

1. MSAT-130 cellophane, unprotected by a wax dip permitted considerable absorption of moisture when exposed to tropical temperatures and humidities. Even at room temperatures the per cent of absorption was more than half that at high temperatures.
2. MSAT-130 cellophane which was coated heavily with a non-thermoplastic wax absorbed less than one per cent moisture. Little difference was found between the packages stored at room temperatures and those kept under tropical conditions.
3. Ordinary fiberboard packages such as used for frozen foods, while satisfactory under room temperature conditions, were worthless under tropical conditions since, the cherries after

a few months had absorbed as much as 22% of their weight of moisture and molded badly. Dipping such a package in a non-thermoplastic wax prevented molding of the fruit but still allowed over two per cent absorption of moisture.

4. Hardboard cartons containing 20 to 30 pounds of cherries, that were coated with Darex P-10C Thermoplastic wax, showed almost negligible absorption of moisture at room temperature storage and averaged less than one per cent absorption under tropical conditions.

Without wax coating the cellophane wrapped packages, although free of insect infestation at the time of packaging, after a few months storage were ruined by meal moth. These gained entrance apparently through the wrapping material. At 95° F. non-thermoplastic wax softened and presented the problem of sticking to the shelves of the storage chamber, thereby exposing the contents of the package more intimately to the surrounding atmosphere. The thermoplastic wax showed less tendency to soften at this temperature.

Preparation Losses and Production Costs for Dehydrated Cherries and Strawberries:

Due to the inefficiency incident to the processing of small lots, the figures we submit on the costs will probably be considerably higher than would be encountered in actual commercial operations. The figure of two and one-half cents per pound for overhead on dehydrated cherries was estimated, using as a basis the one-half cent per pitted pound which the Willamette Cherry Growers Association, Salem, Oregon, charged as overhead. In figuring costs, however, the most important items are the original price of the fresh fruit and the drying ratio.

1. Montmorency cherries:

A. Fresh Fruit Costs:

Gross weight, fresh fruit — 14,123 pounds

Losses, charged back		6.63%
	pits to grower	9.00
	shrinkage	0.89
Total losses		15.52%

100.00-15.52=84.48% pitted cherries

14,123 x 0.8448 = 11,931 pounds of pitted cherries

11,931 x $0.12 = $1431.72 Total cost of fruit

B. Labor Cost of Pitting, etc. (assumed by Cooperative Association)

Washing, sorting and pitting	$0.01091	$ 130.16
Overhead	.005	59.66
Total		$ 189.82
11931 lbs. pitted at $0.12		1431.72
Cost of preparation		189.82
Total returns to grower or cooperative		$1241.90

This, on the basis of 13,187 pounds of fresh cherries after culls are charged back to the grower, equals $0.09418 per pound of fresh fruit.

C. Cost of Dehydrating Pitted Cherries:

1. Cost of labor for tunnel drying, for firing boiler, fuel (440 gallons of oil at $0.0318)	$ 115.00

2. Labor of traying, sulfuring, packaging, etc. (240 hours at $0.85) — $ 204.00

Resulfured -

3. Washing, resulfuring and packaging (144 hours at $0.85) — 122.40

4. Overhead, estimated at $0.025 per pound dehydrated fruit — 49.25

for 1970#, or $.25 per dry lb.

Total dehydration costs — $ 490.65

D. Total Cost of Preparing Dehydrated Montmorency Cherries:

1. 11,931 pounds fresh pitted at $0.12 — $1431.72

why exclude item B, entirely?

2. Dehydration costs — 490.65

Total — $1922.37

The dehydrated fruits after washing and processing by steaming weighed 1970 pounds and contained approximately 14% moisture giving a drying ratio of 6.05:1, pitted basis.

The per pound cost $\frac{\$1922.37}{1970}$ = $0.9758 per pound.

II. Lambert Cherries:

A. Fresh Fruit Costs:

Gross weight fresh fruit -- 12,063 pounds

Losses, charged back:

Pitting	7.81%
Culls	3.60
Shrinkage	1.92
Total losses	13.33%

100.00 - 13133 = 86.67% pitted cherries

12,063 x 0.8667 = 10,455 pounds pitted cherries

10,455 x $0.16 = $1672.80 total cost of fresh fruit

B. <u>Labor Cost of Pitting etc. (assumed by cooperative)</u>:

1.	Labor cost per pitted pound	$0.01698	$ 177.52
2.	Machine rent per pitted pound	0.01100	115.00
3.	Overhead " " "	0.00500	52.27
	Total preparation costs	0.03298	$ 344.79
	10,455 pounds fresh pitted at $0.16		$1672.80
	Preparation costs (assumed by cooperative)		344.79
			$1320.01

On a basis of 11,629 pounds of fresh cherries after culls were deducted and charged back to the grower the returns equal $0.1142 per pound.

C. <u>Cost of Dehydrating Pitted Cherries</u>:

1.	Labor cost of tunnel drying, firing boiler, fuel (440 gallons oil at $0.0318) etc.	$ 115.00
2.	Labor cost for traying, blanching, sulfuring, packing, etc. (240 hours at $0.85)	204.00
3.	Overhead, estimated at $0.025 per dehydrated pound	50.45
	Total	$ 369.45 or $.1835 per dry lb.

not [illegible]

D. <u>Total Cost of Preparing Dehydrated Lambert Cherries</u>:

1.	10,455 pounds fresh pitted fruit at $0.16	$1672.80
2.	Total dehydration cost	369.45
	Total cost	$2042.25

The dehydrated Lambert cherries weighed 2018 pounds with a moisture content of approximately 8.6%, giving a drying ratio of 5.18 : 1, pitted basis.

The per pound cost $\frac{\$2042.25}{2018} = \$1.012$

III. Royal Anne Cherries:

A. Fresh Fruit Costs:

Gross weight fresh fruit -- 2000 pounds

Losses, charged back:

Pitting	7.50%
Shrinkage	16.50
Total	24.00%

100.00 - 24.00 = 76%

2000 x 0.76 = 1520 pounds pitted fruit

1520 x $0.12 = $182.40

B. Cost of Preparing Pitted Royal Anne Cherries:

Cost of stemming, pitting and sorting	$ 23.18
Overhead, 10%	2.32
Total	$ 25.50

C. Cost of Dehydrating Pitted Royal Anne Cherries:

small lot: insufficient

1. Labor cost of tunnel drying, firing boiler, fuel (147 gallons oil at $0.03185) etc.	$ 38.33
2. Labor of traying, blanching, sulfuring, packing, etc. 20 hours at $0.85	68.00
3. Overhead, estimated at $0.025 per pound dehydrated	6.33
Total	$ 112.66 $.445 per dry lb.

D. Total Costs of Preparing Dehydrated Royal Anne Cherries:

Cost of fresh pitted cherries	$ 182.40
Cost of preparing fruit	25.50
Dehydration cost	112.66
Total cost of dehydrated cherries	$ 320.56

1520 pounds of fresh pitted cherries dried to 253 pounds, giving a drying ratio of 6:1, pitted basis. moisture content?

The per pound cost $\frac{\$320.56}{253} = \$1.267$

The per pound cost is undoubtedly exorbitantly high because of the inefficiencies incident to dehydrating a small lot in a plant geared to large scale production.

IV. Marshall Strawberries:

A. Fresh Fruit Cost:

4000 pounds at $0.205	$ 820.00
5742 pounds at 0.20	1148.40
9742 pounds fresh weight	$1968.40

B. Preparation Cost:

Washing, sorting, traying, etc. 166 hours at $0.725	$ 120.35

C. Dehydration Cost and Packaging:

Labor of two men for sulfuring and tunnel drying	$ 25.00
Labor for drying, scraping trays, 36 hours at $0.85	30.60
Fuel oil (1024 gallons at $0.03185)	32.61
Total costs	$ 88.21

not incl overhead, cans, taxes, or $.1105 per dry lb to 6.5% H_2O

D. Total Cost of Preparing Dehydrated Strawberries:

Cost of fresh fruit	$1968.40
Cost of preparation	120.35
Dehydration cost	88.21
Total	$2176.96

9742 pounds of strawberries dried to 798 pounds of approximately 6.5% moisture, giving a drying ratio of 12.2:1.

The per pound cost (dehydrated basis) $\frac{\$2176.96}{798} = \$2.728$. This figure, however, does not take into account overhead, cans, taxes, etc.

Summary and Conclusions

1. Oregon and the Pacific Northwest produce sufficient cherries and berries to warrant dehydration of considerable tonnages of these fruits.
2. Satisfactory commercial dehydration procedures and techniques have been developed for cherries and berries.
3. Blanching, while of benefit in aiding in the retention of sulfur dioxide, is detrimental to the appearance and nutritive qualities of dehydrated Montmorency cherries.
4. Losses of sulfur dioxide occur at room temperatures but much more slowly than at elevated temperatures. Most of these losses occur during the first few months of storage.
5. Color and flavor changes occur in both cherries and strawberries even at room temperatures over long periods of storage, but these changes are intense and rapid at high temperatures.

6. Resulfuring dehydrated cherries by vacuum replacement offers a speedy and effective means of increasing their sulfur dioxide content. The efficiency of this method is correlated with the moisture content of the fruit.

7. Resulfuring can be economically and effectively accomplished without vacuum replacement by increasing the moisture content of the dehydrated fruit or by lengthening the time of exposure to the sulfur dioxide or both.

8. When they are stored at room temperatures, three to four times as much vitamin C is retained in dehydrated strawberries pretreated with sulfur dioxide as in those which are untreated. However, sulfur dioxide does not aid in the retention of vitamin C in strawberries stored at high temperatures.

9. The higher the amounts of sulfur dioxide retained in dehydrated strawberries the greater the quantities of ascorbic acid retained.

10. The rehydration of strawberries is effective enough to permit the preparation of excellent preserves.

11. Entirely satisfactory rehydration of dehydrated cherries has not been attained although it is sufficient to permit these fruits being used for sauce or pies.

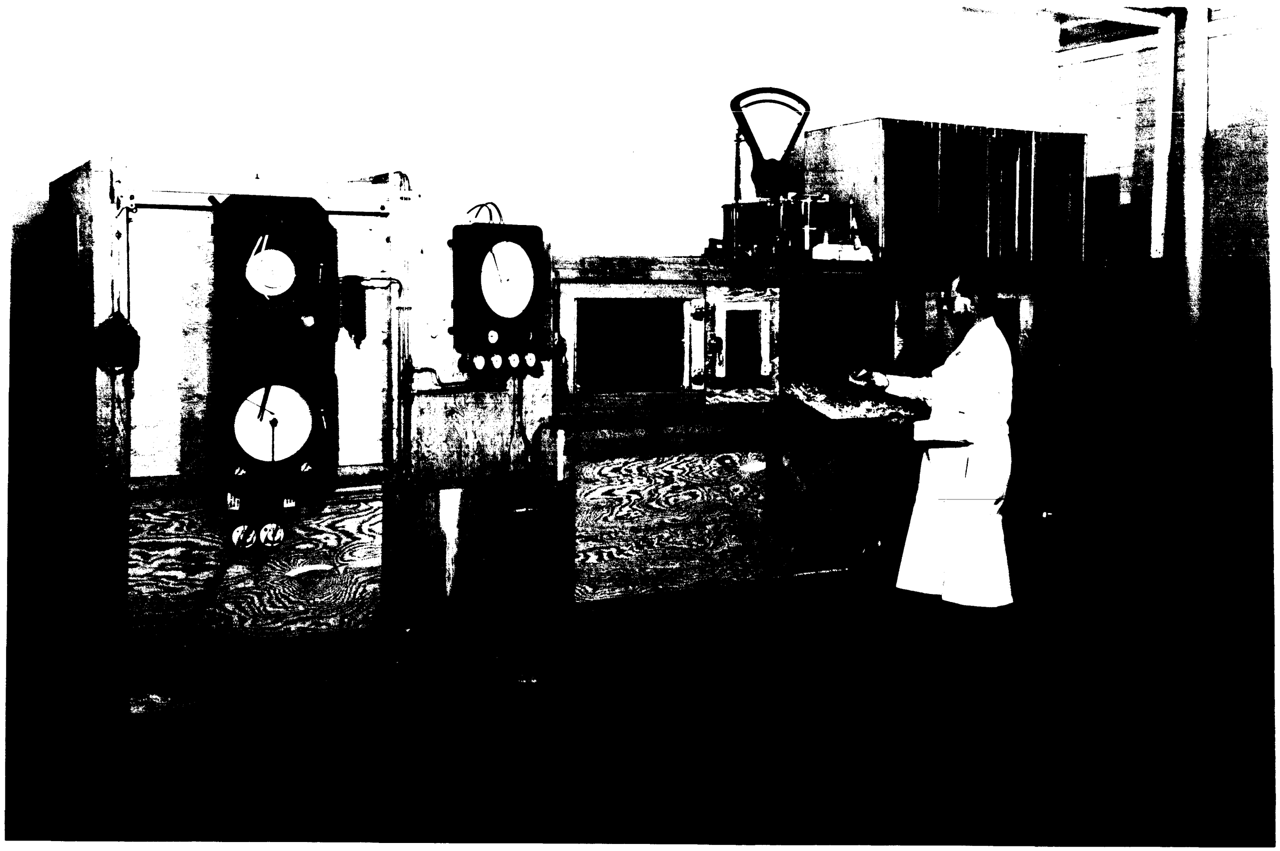
12. A fruit bar for K rations with good color, flavor and high nutritive values has been developed from dehydrated cherries.

13. Wax coatings of two kinds when used on different types of packaging materials were found effective in preventing any except minor moisture exchanges. Uncoated MSAT-130 cellophane permitted considerable absorption of moisture when exposed to tropical humidities and temperatures.

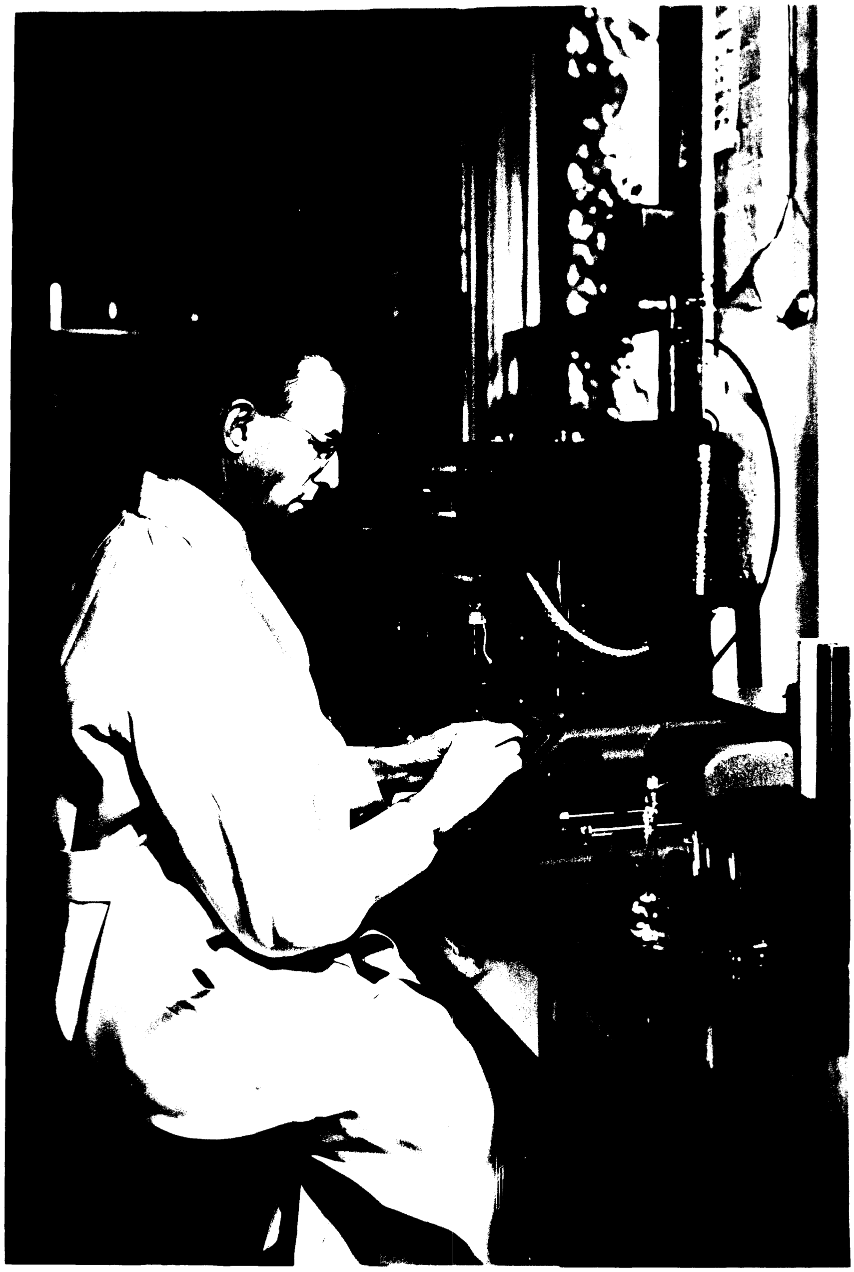
14. Production costs of dehydrated cherries and strawberries are unusually high due principally to the increased costs of the raw products over those of past years.

Exterior View of Tropical Chamber

Interior View of Tropical Chamber

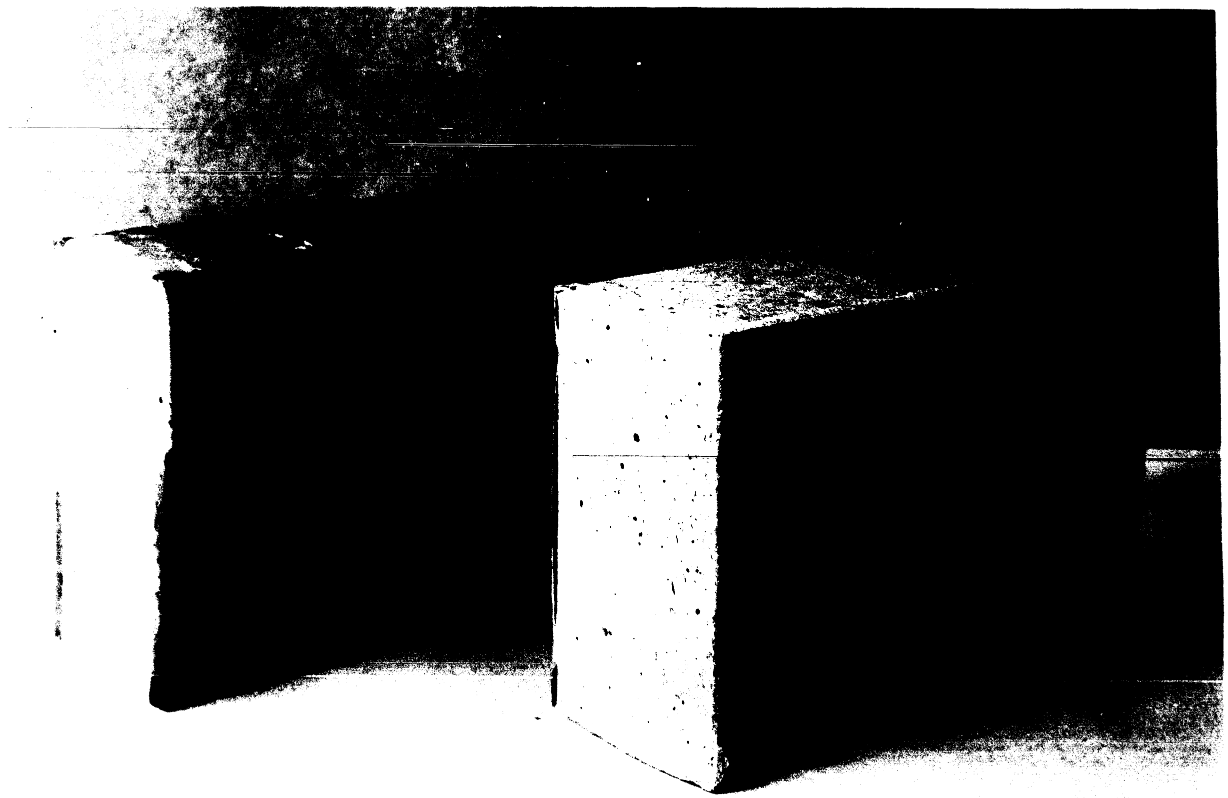


Laboratory Dehydrator Used in Preliminary Tests

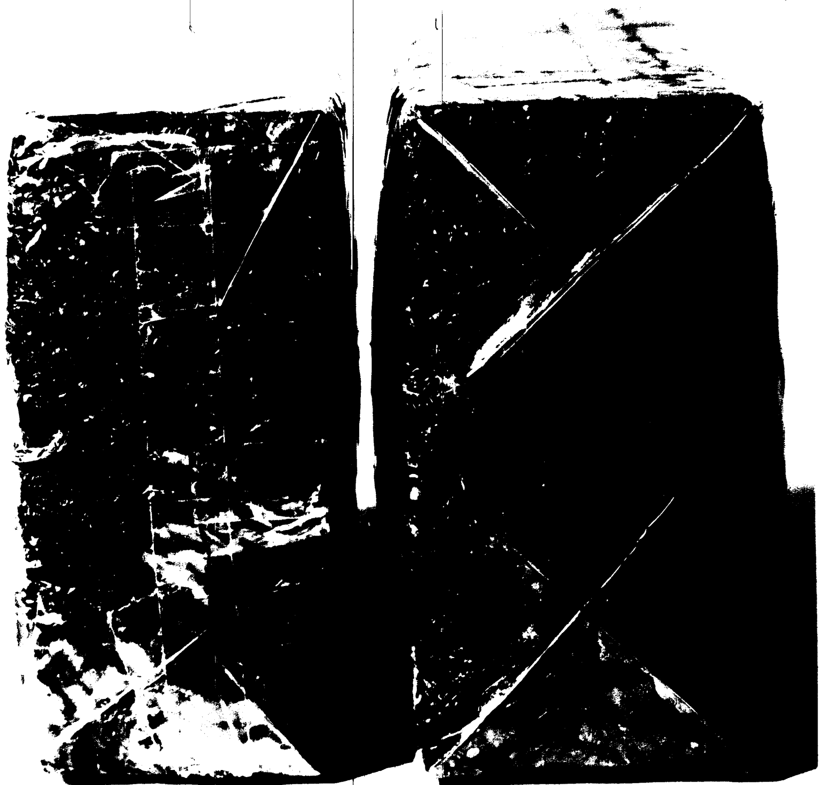


Fisher Electrophotometer Used for Vitamin C Assays

Friction Top Can Used for Overseas Shipments and
Small Jar Used for Check Sample

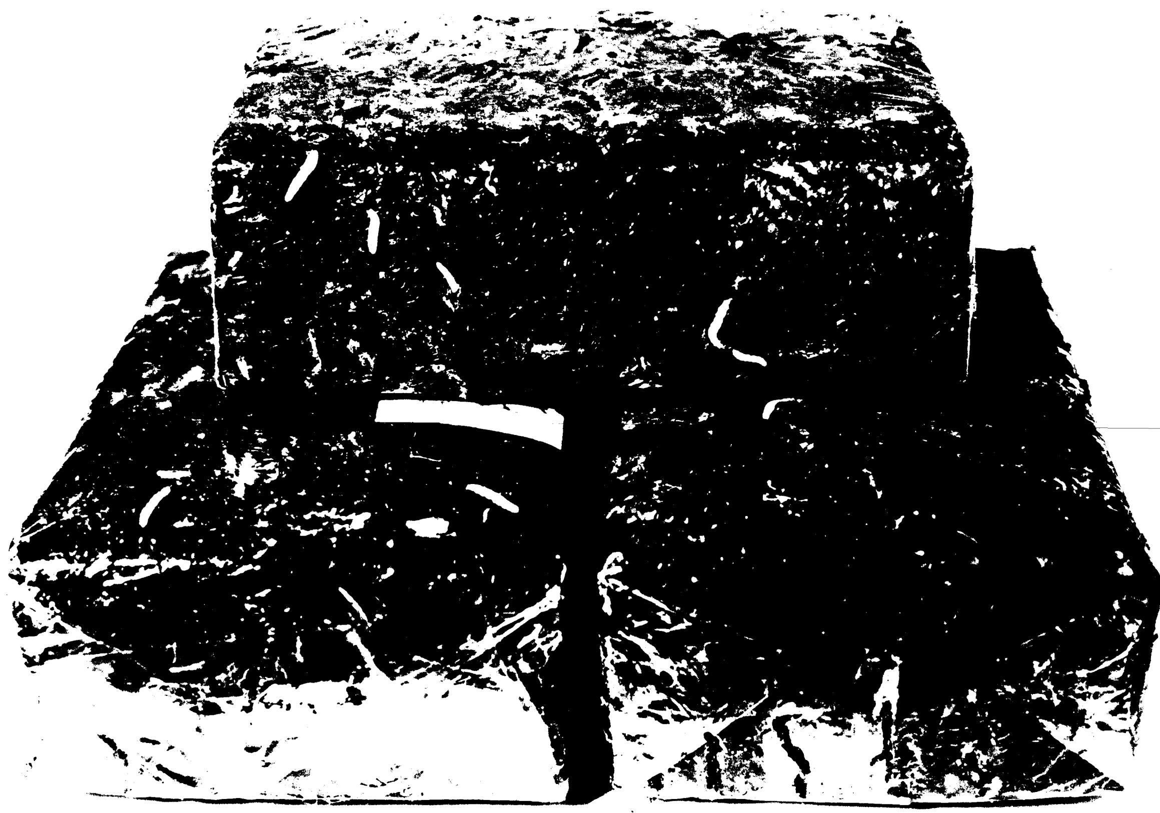


Non Coated Fiberboard Package and One Coated with Darex Thermoplastic Wax



Bricks of Pressed Dehydrated Cherries Wrapped in MSAT-130 Cellophane Absorb Moisture when Stored Under Tropical Conditions

Cellophane Wrapped Packages Dipped in Wax to Prevent Moisture Exchange



Cellophane Does Not Prevent Meal Moth Infestation of Insect Free Cherries