

TECHNICAL REPORT

70-52-FL

**STUDIES OF REVERSIBLE COMPRESSION  
OF  
FREEZE DRIED RTP CHERRIES AND BLUEBERRIES**

by

Abdul R. Rahman

George R. Taylor

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and

Donald E. Westcott

February 1970

UNITED STATES ARMY  
NATICK LABORATORIES  
Natick, Massachusetts 01760



Food Laboratory  
FL-105

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## FOREWORD

Compressed dehydrated foods offer significant reduction in volume and weight. Therefore, such foods are of significant value to the Armed Forces in reducing storage, packaging materials and transportation requirements. These factors are particularly important for military operations where a food supply must be carried by the soldier.

This report covers developmental studies of the reversible compression of fruits, i.e., those which can be compressed and subsequently restored to their normal appearance and texture by rehydration. This work was conducted under Project No. LJ6-62708-D553, Food Processing and Preservation Techniques.

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## ABSTRACT

Compressed discs, approximately 3-5/8 inch in diameter to fit No. 2-1/2 cans, of freeze-dried blueberries and red tart pitted (RTP) cherries have been produced. Technological evaluations of pies prepared from cherries and blueberries compressed at 100 to 1500 pounds per square inch, indicate no significant difference in flavor, texture and appearance from those prepared from the uncompressed counterpart. Compression ratios obtained for freeze-dried blueberries and cherries, respectively, were 1:7 and 1:8. Compression ratios were 1:13 and 1:12, respectively, when compared to loose frozen product.

## Introduction

Dehydration is a highly acceptable process for the preservation and reduction of weight of foods. For military usage it has become increasingly important to compact such foods to reduce packaging, handling, storage and transportation costs.

Various dehydrated fruits and vegetables have been compressed and subsequently restored to their normal appearance and texture through rehydration.

Most research has been directed toward compression of vegetables. During World War II the United Kingdom produced dehydrated cabbage and carrots in compressed blocks (Gooding and Rolfe 1957). Fairbrother (1968) reported on the compression of potato granules at a low moisture content and the compression of an instant bread mix. Hamdy (1961) indicated that acceptable products from the compression of foods were not always achieved. Reduction in volume of up to 8-fold was obtained by compressing dehydrated vegetables.

Freeze-dried foods properly preconditioned can be compressed with little or no fragmentation, and most foods so compressed can be restored to their pre-compression characteristics (Brockmann 1966).

Hamdy (1962) found that acceptable compressed freeze-dried spinach was obtained by increasing the plasticizing moisture content to 9 percent. Spraying dehydrated food with water, glycerin or propylene glycol before compression produced bars with excellent rehydration characteristics (Ishler 1962). Ishler also found that successful compressed food can be achieved by spraying freeze-dried cellular foods to 5-13 percent moisture, compressing, and redrying to less than 3 percent moisture. Lampi (1963) indicated that high pressures during compression resulted in high density food discs which were hard and difficult to rehydrate. The moisture level of the food prior to compression also affected rehydration.

Rahman *et al* (1969) indicated that freeze-dried peas, corn, sliced onions, spinach, carrots, and green beans were successfully compressed. Compression ratios of 1:4, 1:4, 1:5, 1:11, 1:14, and 1:16, respectively were obtained.

This work was initiated to determine the effect of compression on the texture and overall quality of freeze-dried fruits. In addition, compression ratios were determined to establish savings in costs of packaging materials, handling, storage and transportation.

## Experimental Procedures

Product Preparation. Individually quick frozen (IQF) blueberries and red tart pitted (RTP) cherries were locally purchased. Frozen cherries were partially thawed and then sulfited by dipping into a solution of sodium metabisulfite to yield a residue of approximately 500 ppm. Cherries were refrozen at  $-20^{\circ}\text{F}$ . and then freeze-dried at a platen temperature of  $120^{\circ}\text{F}$ . to a final moisture content of less than 2 percent. Volume was measured before and after freeze drying in order to determine shrinkage loss due to freeze drying. The freeze-dried cherries were subjected to dry heat, in an oven, at  $200^{\circ}\text{F}$ . for approximately 10 minutes and immediately compressed. The cherries become thermoplastic upon heating and can be compressed without shattering. A Carver Press was used with compression forces of 100, 200, 400, 800, 1000 and 1500 pounds per square inch with a dwell time of approximately 5 seconds to form either bars of  $3 \times 1 \times 1/2$  inches or discs  $3-5/8$  inches in diameter.

Frozen blueberries were freeze-dried at a platen temperature of  $120^{\circ}\text{F}$ . to a final moisture content of less than 2 percent. Volume was measured before and after freeze drying. Blueberries were compressed following the procedure used for the cherries.

Rehydration. Each bar of cherries was placed in approximately 500 ml of boiling water, boiled for 3 minutes, soaked for 30 minutes and then drained for 5 minutes. For blueberries the soak time was 10 minutes.

Compression Ratio. To determine compression ratios, the dehydrated fruits were compressed into discs  $3-5/8$  inches in diameter, to fit a No. 2- $1/2$  can, using approximately 400 psi. The compressed discs required to fill a No. 2- $1/2$  can, leaving approximately  $1/4$  inch headspace, were weighed. Uncompressed freeze-dried product of equivalent weight was packed loosely in No. 2- $1/2$  cans leaving approximately  $1/4$  inch headspace. The ratio of the compressed to loose products was then determined.

Bulk density was measured by dividing the weight of the loose or compressed product by its respective volume to yield grams per cubic centimeter. A calculated compression ratio was then obtained by dividing the bulk density of the compressed product by that of the uncompressed.

Shedding time was measured by placing the compressed product in hot water at approximately  $210^{\circ}\text{F}$ . and measuring the time at which all the individual pieces separated.

Texture was measured immediately after rehydration with the Lee-Kramer Shear press using the 5000-pound ring with 30 seconds downstroke.

Technological panel evaluations for flavor, texture and appearance were conducted by 10 trained judges, using a 9-point scale (1=extremely poor; 9=excellent). Pies baked from compressed as well as loose, freeze-dried fruits following the Armed Forces recipe were evaluated.

## Results and Discussion

Results of the technological evaluation of pies prepared from freeze dried blueberries and cherries which were compressed under pressures ranging from 100 to 1500 pounds per square inch (PSI) indicate that compression pressure does not significantly influence the flavor, texture and appearance of the pies (Tables 1 and 2). No differences were determined between uncompressed products and those made from any of the compressed product. Significant correlation was established between pressure of compression and bulk density as well as compression ratios. Bulk densities and compression ratios of the cherries and the blueberries increased with increasing compression pressure (Tables 3 and 4).

Compression ratios measured by actual fill of can were generally lower than those calculated from bulk densities. This is due to the allowances given to headspace, the space between compressed discs and can wall, and the space between the discs due to uneven surface caused by slight relaxation of the product after compression.

Figures 1 and 2 show the practical compression ratio of 1:8 for cherries and 1:7 for blueberries as measured by actual fill of the cans. However, if flexible packaging was used, higher ratios would be expected due to the elimination of spaces between the rigid can and the compressed product. Upon freeze drying the volume of cherries decreased by 35 percent and the blueberries by 47 percent. Therefore, when compressed product was compared with loose frozen products, the calculated compression ratio of cherries and blueberries were 1:12 and 1:13, respectively.

Requirements for a 9-inch pie were:

Cherries -- one compressed disc  $3\frac{5}{8}$  inch in diameter and  $\frac{1}{2}$  inch thick or uncompressed cherries equivalent to one No. 2- $\frac{1}{2}$  can (Fig. 3).

Blueberries -- one compressed disc  $3\frac{5}{8}$  inch in diameter and  $\frac{5}{8}$  inch thick or uncompressed blueberries equivalent to 1- $\frac{1}{3}$  No. 2- $\frac{1}{2}$  can (Fig. 4).

Significant correlation was established between compression pressure and rehydration ratio or texture of compressed cherries. Rehydration ratio decreased, whereas shear press values increased, as the compression pressure increased (Table 5). Such a trend was not evident in the compressed blueberries since the rehydration ratio as well as the shear press values fluctuated as the compression pressure increased (Table 6). However, these changes in the texture and rehydration ratio did not affect the quality of the cherries or the blueberries as indicated by the technological panel results. Shedding time ranged from 1 to 6 minutes for blueberries and 8 to 11 minutes for cherries, indicating that compressed cherries have a higher degree of cohesiveness.

### Conclusion

Freeze-dried RTP cherries as well as blueberries have been successfully compressed, resulting in a volume reduction of 8- and 7-fold, respectively. However, when compressed volume was compared with loose frozen product, a volume reduction of 12- and 13-fold was obtained. Pies prepared from the compressed products were equivalent in flavor, texture and appearance to those prepared from the uncompressed products.

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Table 1. Average Ratings (Technological Panel) of Cherry Pies prepared from Compressed RTP Cherries

Criteria	Compression Pressure Pounds per Square Inch						
	0	100	200	400	800	1000	1500
Flavor	6.6	6.1	6.3	6.3	5.8	6.6	6.0
Texture	6.4	6.0	5.8	6.1	5.5	6.1	6.0
Appearance	6.4	5.9	6.0	6.6	5.4	6.6	5.7

Table 2. Average Ratings (Technological Panel) of Blueberry Pies prepared from Compressed Blueberries

Criteria	Compression Pressure Pounds per Square Inch						
	0	100	200	400	800	1000	1500
Flavor	6.8	6.8	6.7	7.0	6.3	7.1	6.7
Texture	6.5	6.6	6.8	6.6	6.5	6.7	6.6
Appearance	7.2	7.1	7.3	7.1	7.2	7.1	7.3

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Table 3. Bulk Densities and Compression Ratios of Freeze Dried RTP Cherries Before and After Compression

Compression Pressure	Bulk Density gm/cc	Compression Ratios	
		Calculated from Bulk Densities	Measured by Actual Fill of Cans
0	0.10	—	—
100	0.91	9.1	5.3
200	1.03	10.3	7.4
400	1.06	10.6	7.8
800	1.14	11.4	8.4
1000	1.21	12.1	8.5
1500	1.27	12.7	8.5

- ∞ Correlation coefficient between compression pressure and compression ratio = .76  
 Correlation coefficient between compression pressure and bulk density = .70

Table 4. Bulk Densities and Compression Ratios of Freeze Dried Blueberries Before and After Compression

Compression Pressure	Bulk Density gm/cc	Compression Ratios	
		Calculated from Bulk Densities	Measured by Actual Fill of Cans
0	.12	—	—
100	0.70	5.8	4.4
200	0.87	7.2	5.4
400	0.94	7.8	6.0
800	1.11	9.2	7.0
1000	1.11	9.2	7.6
1500	1.17	9.7	7.6

Correlation coefficient between compression pressure and compression ratio = .91

Correlation coefficient between compression pressure and bulk density = .77

Table 5. Rehydration Ratio of Compressed Dehydrated RTP Cherries and Texture after Rehydration as Affected by Compression Pressure.

Compression Pressure PSI	Shedding Time Minutes	Rehydration Ratio	Shear Press Lbs.
0	—	2.8	67
100	8	2.4	71
200	10	2.3	67
400	11	2.1	115
800	9	2.1	119
1000	8½	2.0	140
1500	8	2.0	143

10 Correlation coefficient between compression ratio and texture = .90

Correlation coefficient between compression and rehydration ratio = .86

Table 6. Rehydration Ratio of Compressed Dehydrated Blueberries and Texture after Rehydration as Affected by Compression Pressure

Compression Pressure PSI	Shedding Time Minutes	Rehydration Ratio	Shear Press Lbs
0	—	3.1	165
100	1	2.9	275
200	1 3/4	3.0	290
400	1 3/4	2.9	285
800	2 1/2	2.9	245
1000	3 1/2	3.0	165
1500	6	3.1	150

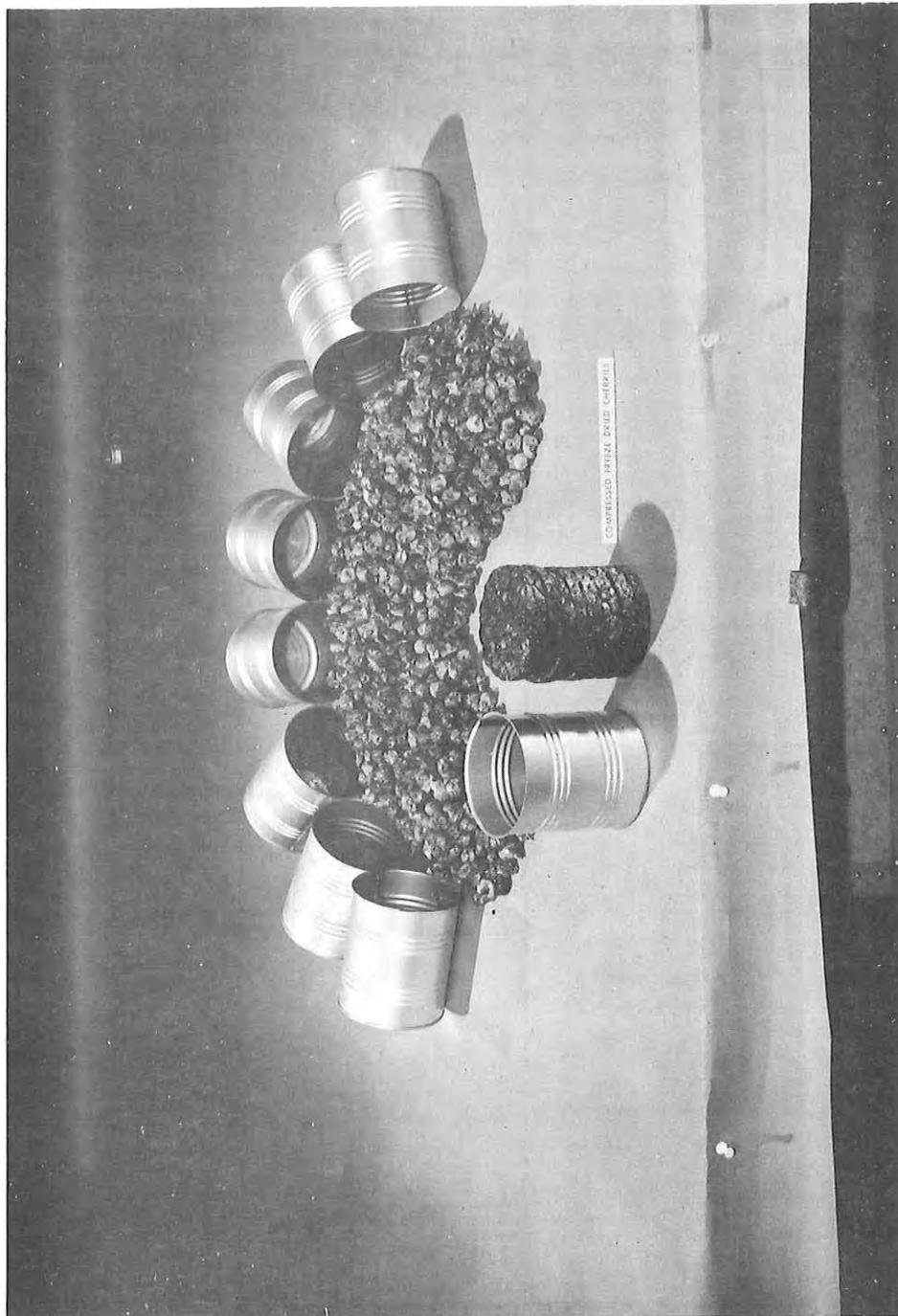


Figure 1. Practical compression ratio of freeze dried RTP Cherries 1:8



Figure 2. Practical compression ratio of freeze dried Blueberries 1:7



Figure 3. Comparison of bulk vs. compressed freeze dried RTP cherries required for 9-inch pie.

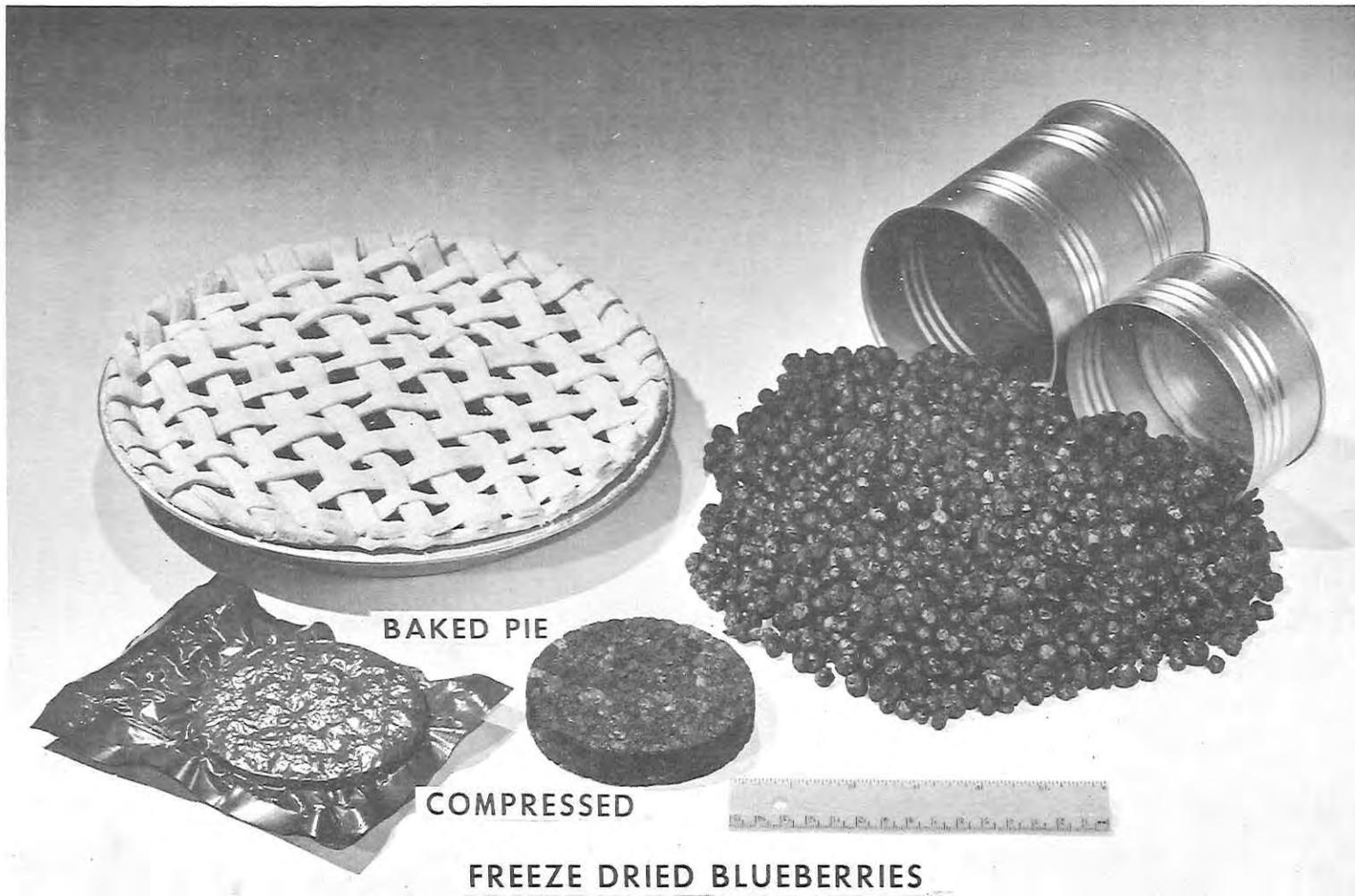


Figure 4. Comparison of bulk vs. compressed freeze-dried blueberries required for 9-inch pie.



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