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TECHNICAL REPORT
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NON-REVERSIBLE COMPRESSION OF INTERMEDIATE MOISTURE FRUIT BARS

by

Abdul R. Rahman
Glenn Schafer
Patricia Prell
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July 1971

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory
FL-137

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Foreword

Compressed dehydrated foods offer significant reduction in volume and weight. In addition, they offer higher caloric value per unit volume than the uncompressed product and can be consumed without any further preparations which is the utmost in convenience. Therefore, such foods are of significant value in the Armed Forces since they provide definite logistic advantages not only in operational rations, especially where resupply cannot be assured for several days, but also where space is critical such as in submarines and space capsules.

This report covers developmental studies of nonreversibly compressed fruit products such as dates, figs, raisins, nuts and combination thereof. This work was performed under Project 1J6-62708-D553, Food Processing and Preservation Techniques.

TABLE OF CONTENTS

Foreword	ii
List of Tables	iv
Abstract	v
Introduction	1
Experimental Procedure	2
Results & Discussion	4
Literature Cited	10

LIST OF TABLES

Table		Page
1	Formulae of Fruit Bars	5
2	Average Ratings (Technological Panel) of Quality of Fruit Bars as Affected by Storage at 100°F.	6
3	Average Ratings (Technological Panel) of Quality of Fruit Bars as Affected by Storage at 70°F.	7
4	Average Ratings (Technological Panel) of Quality of Fruit Bars as Components of a Food Packet After Prolonged Storage at 100°F.	8
5	Texture of Date Bars	9
6	Bulk Density and Caloric Value of Fruit Bars	9

Abstract

Edible, compressed fruit bars were successfully developed by reducing the moisture content of the fruit ingredients such as dates, figs, maraschino cherries and others to approximately 8 percent (a range of 7 to 14 percent is applicable) and the incorporation of approximately 2 percent lecithin to enhance the texture. The bars were stable during storage for 6 months at 100°F. The 4 test bars were also stable during storage for 12 months at 70°F.

Introduction

Compressed foods which can be eaten "out-of'hand" are of significant importance in feeding the Military man in emergency and stress situations. The need for such acceptable and stable foods has been expressed by the Armed Services. The United States Marine Corps specifically requested the development of 4 menus for an emergency food packet for use in combat type operations or during escape and evasion situations when resupply cannot be established for periods up to three days and no water restriction will be imposed. Several nonreversibly compressed fruit bars were developed which have considerable promise for meeting such requirements. Other food items have been previously developed and included in the Military feeding systems, such as Cereal, Premixed, Compressed, (MIL-C-3483) and Corn Flake Bar, Survival-Type, (MIL-C-35074). However, the need exists for greater variety of food bars including meats, fruits, vegetables, dairy products and others.

Nonreversibly compressed foods which can be eaten without rehydration, such as cereal bars and beef jerky bars, also have been successfully developed (Helmer and Tuomy, 1969). Various foods such as fruits, vegetables, meats, and combination items have been reversibly compressed and subsequently restored to their normal appearance and texture through rehydration. Research on the variables affecting the compression of foods has not been extensive.

Fitzmaurice, et al. (1969) indicated that compressed bars produced from freeze-dried meat balls and pork sausage links show promise for use in operational rations. Compression ratios of 3.7:1 for meat balls and 4.5:1 for pork sausage links were obtained. Reduction in volume of up to 8-fold was obtained by compressing dehydrated vegetables (Gooding and Rolfe, 1956). Hamdy (1961) stated that the achievement of acceptable products from the compressed form varies considerably. Ishler (1962) in his patented process reported that spraying the rehydrated food with water, glycerine or propylene glycol before compression produced bars with excellent rehydration characteristics. Brockmann (1966) reported that freeze-dried foods properly preconditioned can be compressed with little or no fragmentation and that most foods so compressed can be restored to their precompression characteristics. Rahman, et al. (1969) reported that freeze-dried peas, corn, sliced onions, spinach, carrots, and green beans were successfully compressed and compression ratios of 4:1, 4:1, 5:1, 11:1, 14:1, and 16:1 were obtained respectively. Compressed discs approximately 3-3/4 inch diameter have been developed from freeze-dried blueberries and red tart pitted (RTP) cherries. They can be successfully rehydrated and used in the preparation of pies (Rahman, et al. 1969). However, the products mentioned above are designed to be rehydrated rather than to be eaten "out of hand".

Experimental Procedure

Material

Food ingredients used during the course of these studies such as dates, figs, maraschino cherries, golden raisins, sesame and nuts were locally purchased. During preliminary work, products such as apricots, prunes and brown raisins were also studied, but were found to discolor excessively during storage at 100°F. The dates, figs and maraschino cherries were chopped into pieces of approximately 1/4". All fruits were then dehydrated to a practical range suitable for compression. This step was necessary since it was impractical to compress fruits with original moisture ranging between 15 and 35 percent due to excessive extrusion of pulp.

Successful compression of intermediate moisture fruits (15-30% moisture) was accomplished when the moisture content was reduced by dehydration to 7-14 percent. The bars were hard and difficult to chew when the moisture content was reduced below 7 percent. All fruits used in these studies were dehydrated to approximately 8 percent before compression. The bars were formulated as shown in Table 1.

Compression

43 gms. of thoroughly mixed ingredients were compressed into 1 x 3 x 1/2" bars with a hydraulic laboratory press (Carver) using a compression force of approximately 200 pounds per square inch. The molds were sprayed with a food grade lubricant (Lecithin) in order to reduce sticking and to facilitate removal of the bars.

After compression the bars were sealed in a flexible pouch (polyester 0.5 mil/aluminum foil 0.35 mil/polyolefin 3.00 mil) at a vacuum of approximately 27 inches of mercury. Initially, 14 different fruit bars were formulated. Preliminary testing indicated that the bars were difficult to bite and some fragmented readily, especially the date bars. Lecithin at a 2 percent level was found to improve the texture significantly (Table 5).

Bulk density

Bulk density was measured by dividing the weight of the loose (or compressed) product by its respective volume to yield grams per cubic centimeter. Compression ratio was determined by dividing the volume of the uncompressed product by its compressed volume.

Sensory evaluation

Sensory evaluations of product quality conducted by 10 trained technologists who were screened and trained were carried out in two phases. Phase I, representative samples of each of nine bars shown in Table 2 were stored at 100°F. They were tested at 0, 1-1/2, 3 and 6 month intervals. During each test session, the panel members were given 2 samples, 1/2 bar each, in a balanced random order. Since the bars were to be judged independently, attempts were made to always serve nonrelated items. Sensory panel evaluation for color, flavor, and texture were conducted using the trained panel and a 9 point quality rating scale (1 - extremely poor; 9 - excellent) (Pilgrim and Peryam 1958).

Phase II. Since the United States Marine Corps requested the development of 4 menus for an Emergency Food Packet, only four fruit bars were selected (Table 3) so that one bar could be included in each menu. Each of the four, flexibly packaged bars was packed together with other food components in a second pouch and hermetically sealed to form a packet. The packets were stored at 100°F. for up to 12 months or at 70°F. for up to 24 months. No direct comparisons between the foods stored at 70°F. and those stored at 100°F. were made. However, standards of the fruit bars (stored at 40°F.) were presented to the panel at each session for comparison. The study was designed so that on each day of testing all four menus were evaluated. Each panel member received the components of a single menu in a balanced random order, testing all 4 different menus in a four day period.

Texture

The Instron Universal Testing Apparatus, Floor Model TT-DM with a 500 Kg cell was used. The samples were penetrated to 50% of initial thickness at a speed of 2 cm/min. using a cylindrical 0.75 cm punch. Results were expressed as (1) firmness, which is the force at 50% penetration. (2) toughness, which is the work expended for a 50% penetration, and (3) maximum force in Kg, which is used as an empirical measurement of "hardness".

The caloric value was determined by the Parr Oxygen Bomb Calorimeter. Moisture content was determined in accordance with the A.O.A.C. method using vacuum oven. The results were statistically analyzed and the least significant difference was determined as applicable.

Results and Discussion

During these studies all fruits were dehydrated to a moisture content of approximately 8 percent before compression. However, preliminary work indicated that fruits such as dates, figs and raisins can be successfully compressed when the moisture content ranged from 7 to 14 percent.

Results of the technological panel evaluations, as shown in Table 2, indicate that there is no significant difference in color, flavor and texture of nine different fruit bars before and after storage for 6 months at 100°F. All ratings ranged between 5 and 7 (fair to good) however most of the ratings ranged between 6 and 7. Four fruit bars were selected for further quality evaluations as components of the Marine Corps Food Packet, namely date cherry bar, date fig almond cherry bar, raisin bar and date sesame bar. As shown in Table 3 the color, flavor and texture of date cherry, date fig, date sesame and raisin bars stored for 12 months at 70°F. as determined by a technological panel did not change. However, after 24 months of storage, the flavor of the date sesame bars and the raisin bars was rated significantly lower than initially, although the ratings were above 6 which is considered a good quality product. In addition, the texture of the date cherry, date sesame and raisin bars was significantly lower than initially, although still above 6. No significant change was exhibited in the color of the bars throughout the storage period.

When the packaged fruit bars were combined with other food components in a secondary packet to form a single meal and stored at 100°F. for six months, the color and flavor of the raisin bars exhibited significantly lower ratings than initially (Table 4). The rest of the bars were unchanged.

After 12 months of storage, the color and flavor of date cherry, date fig and raisin bars received significantly lower scores, whereas, the date sesame showed a significantly lower score for color only. Texture, except for the raisin bar, was not affected.

Results of subjective as well as objective tests on the texture of date bars as shown in Table 5 indicate that the addition of lecithin significantly improves the texture of the bar. Therefore, the addition of lecithin was incorporated in the formulations of all bars during the course of these studies.

The compression ratios of the fruit bars ranged from 2 to 1, to 3 to 1. (Table 6). This is a considerable reduction in volume which ultimately results in savings in packaging materials, storage space and perhaps shipping costs. The caloric value of the four bars ranged between 3.7 and 4.6 cal. per gram. The uncompressed products ranged between 1.6 and 2.8 cal. per cc whereas in the compressed product this range was significantly increased to between 5.0 and 5.8 per cc. (Table 6).

Table 1 - Formulae of Fruit Bars

1. Date Cherry Bar

Dates	49%
Maraschino Cherries	49%
Lecithin	2%

2. Date Fig Almond Bar

Dates	39%
Maraschino Cherries	25%
Figs	24%
Almonds	10%
Lecithin	2%

3. Dates Sesame Bar

Dates	78%
Blanched Sesame Seed	20%
Lecithin	2%

4. Raisin Bar

Raisins	98%
Lecithin	2%

5. Date Cherry Orange Bar

Dates	53%
Maraschino Cherries	30%
Orange Peel	15%
Lecithin	2%

6. Date Fig Bar

Dates	49%
Figs	49%
Lecithin	2%

7. Date Sesame Bar

Dates	78%
Sesame	20%
Lecithin	2%

8. Fig Cherry Pear Orange Bar

Fig	68%
Cherry	15%
Pear	10%
Orange Peel	5%
Lecithin	2%

9. Raisin Bar

Golden Raisins	98%
Lecithin	2%

Table 2 - Average Ratings (Technological Panel) of Quality of Fruit Bars as Affected by Storage at 100°F.

Product	Time of Storage in Months	Color	Flavor	Texture
Date Almond Coconut	initial	7.5	6.9	6.8
	1 1/2	7.5	7.4	7.1
	3	7.3	6.8	6.8
	6	7.2	7.0	6.9
		*NS	NS	NS
Date Cherry	initial	7.1	6.6	6.8
	1 1/2	7.3	7.3	6.3
	3	7.5	7.2	6.4
	6	7.3	7.2	6.7
		NS	NS	NS
Date Cherry Orange	initial	7.3	7.1	6.6
	1 1/2	7.2	6.9	6.3
	3	7.3	7.2	6.7
	6	6.8	6.6	6.9
		NS	NS	NS
Date Fig Cherry Almond	initial	7.3	6.8	6.6
	1 1/2	7.5	7.2	7.0
	3	7.1	7.3	7.0
	6	6.9	6.8	6.8
		NS	NS	NS
Date Fig	initial	7.3	7.4	7.1
	1 1/2	7.2	7.0	7.0
	3	6.8	7.0	6.8
	6	6.9	6.9	6.4
		NS	NS	NS
Date Macaroon	initial	6.8	6.2	6.8
	1 1/2	7.2	6.5	6.8
	3	7.0	6.8	6.7
	6	7.0	6.7	6.6
		NS	NS	NS
Date Sesame	initial	7.4	6.9	7.0
	1 1/2	7.1	6.2	6.9
	3	7.4	6.2	6.8
	6	6.8	5.5	6.8
		NS	NS	NS
Fig Cherry Pear Orange	initial	7.2	6.8	5.1
	1 1/2	7.2	6.6	6.0
	3	6.8	6.3	5.7
	6	6.1	5.8	6.3
		**S	NS	NS
Raisin	initial	7.3	7.2	6.8
	1 1/2	7.1	6.7	6.8
	3	7.3	6.4	7.0
	6	6.6	6.5	6.9
		NS	NS	NS

* NS = Not significant at the 5 percent level.
** S = Significant at the 5 percent level.

Table 3 - Average Ratings (Technological Panel) of Quality of Fruit Bars as Affected by Storage at 70°F.

Item	Conditions	Color	Flavor	Texture
Date Cherry	initial	7.3	7.1	7.0
	12 mo.	6.6	6.8	6.7
	24 mo.	6.6	6.2	6.1
	LSD	NS	NS	0.6
Date Fig Cherry Almond	initial	7.2	7.2	7.0
	12 mo.	7.0	6.9	6.7
	24 mo.	6.9	6.6	6.6
	LSD	NS	NS	NS
Date Sesame	initial	7.2	7.0	7.1
	12 mo.	6.8	6.9	7.1
	24 mo.	6.6	6.2	6.3
	LSD	NS	0.6	0.6
Raisin	initial	7.1	7.1	7.0
	12 mo.	6.6	6.8	6.9
	24 mo.	6.4	6.4	6.4
	LSD	NS	0.4	0.4

Table 4 - Average Ratings (Technological Panel) of Quality of Fruit Bars as Components of a Food Packet After Prolonged Storage at 100°F.

Item	Storage Conditions	Color	Flavor	Texture
Date Cherry	initial	7.1	7.2	7.0
	6 mo.	6.6	6.9	6.6
	12 mo.	5.8	5.8	6.4
	LSD	0.6	0.9	NS
Date Fig Cherry Almond	initial	7.4	7.2	7.2
	6 mo.	6.8	6.5	6.5
	12 mo.	5.9	6.2	6.5
	LSD	1.0	0.8	NS
Date Sesame	initial	7.2	6.9	6.9
	6 mo.	6.6	6.3	6.7
	12 mo.	5.9	5.9	6.3
	LSD	0.9	NS	NS
Raisin	initial	7.2	6.9	7.0
	6 mo.	5.0	5.9	6.5
	12 mo.	3.3	5.3	6.2
	LSD	1.4	0.9	0.6

Table 5 - Texture of Date Bars

Product	Firmness Kg/cm	Toughness Kg/cm	Maximum Force Kg/cm	Tech. Panel Ratings for Texture
Date bar treated with lecithin	5.1	3.9	5.6	6.2
Date bar without lecithin	6.9	5.1	7.4	4.6

Table 6 - Bulk Density and Caloric Value of Fruit Bars

Fruit Bar	Uncompressed		Compressed		Compression Ratio	Calories per gram
	Bulk density gm/cc	Calories per cc	Bulk density gm/cc	Calories per cc		
Date Cherry	0.43	1.6	1.32	5.0	3.0	3.8
Date Fig	0.49	2.1	1.26	5.5	2.6	4.4
Date Sesame	0.62	2.8	1.27	5.8	2.0	4.6
Raisins	0.57	2.0	1.54	5.7	2.7	3.7

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13. ABSTRACT

Edible, compressed fruit bars were successfully developed by reducing the moisture content of the fruit ingredients such as dates, figs, maraschino cherries and others to approximately 8 percent (a range of 7 to 14 percent is applicable) and the incorporation of approximately 2 percent lecithin to enhance the texture. The bars were stable during storage for 6 months at 100°F. The 4 test bars were also stable during storage for 12 months at 70°F.

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