AD 633580

TECHNICAL REPORT
66-32-FD

# STABLE BREAD STORABLE IN COLLAPSED S


by
C. A. Kennedy

General Foods Corporatio
White Plains, New York





Contract No. DA19-129-AMC-14

April 1966


UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

U.S. ARMY MATERIEL COMMAND

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C. A. Kennedy
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**Contract No. DA19-129-AMC-142 (N)**

**Project reference:**
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Food Division
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Natick, Massachusetts 01760

FOREWORD

In the development of operational feeding systems it is becoming increasingly important for logistic advantages to effect a reduction in food volume corresponding to the decrease in weight achieved by dehydration. Such a reduction in volume becomes a virtual necessity in the design of specialized rations for the soldier who must carry on his person his entire food supply for extended periods in which resupply is not feasible.

Considerable research effort has been expended in the area of fabricated food bars designed for direct consumption or for rehydration to yield familiar food items. Many foods are polymeric in nature and therefore capable, under suitable conditions, of retaining an elastic memory after dehydration and compression. Techniques have been devised for compressing dehydrated vegetables (peas) and shrimp which expand to their original form when rehydrated. This investigation seeks the development of techniques for compressing and dehydrating bread and other bakery products which can be rapidly reconstituted to products closely approximating the original form.

The investigation described in this report was conducted by the Central Research Laboratories of the General Foods Corporation, Tarrytown, New York, under contract number DA19-129-AMC-142(N). Mr. C. A. Kennedy served as Official Investigator and Mr. C. E. Flynn, Mr. J. J. Mancuso, Mr. A. G. Bonagura, and Mr. R. M. Sorge were collaborators.

The Project Officer for the U. S. Army Natick Labs was Dr. D. E. Westcott and the Alternate Project Officer was Mr. O. E. Mason, both of the Plant Products Branch, Food Division.

FERDINAND P. MEHRLICH, PhD
Director
Food Division

APPROVED:

DALE H. SIELING, PhD
Scientific Director

W. M. MANTZ
Colonel, QMC
Commanding

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## ABSTRACT

This final report describes a process by which full moisture baked goods can be freeze compressed and freeze dried. The compressed dry form is immersed in water to rehydrate and expand to resemble the fresh counterpart. Successful application was made to sliced white bread, sponge cake, devil's food cake and waffles. Sliceable jelly and peanut butter were formulated which were combined with the prior processed compressed bread to make complete compressed sandwiches. Difference testing of compressed bread indicated similarity to a control bread with respect to appearance and flavor with texture of the experimental classified as being slightly moist. Storage testing of the various compressed prototypes was conducted at 70°F., under cycling conditions of 0°F. to 70°F. and at 100°F. No appreciable change was noted at the 70°F. and cycling storage conditions for periods up to six months. Deterioration did occur at 100°F. which requires further investigation.

This is the final report of Phase II of this research project directed to the development of stable baked goods such as bread, sandwiches, cakes, and waffles which can be stored for extended periods in a collapsed state and then readily rehydrate and expand to yield organoleptically acceptable final products.

A process was identified to freeze compress at full moisture content crustless commercial bread slices to one-third their original thickness. The compressed frozen slices were successfully freeze dried and the compressed dimension maintained in the dry form. Rehydration and expansion of the compressed bread form is achieved by dipping it in water and allowing the moistened slice to stand about five minutes. The rehydrated bread slice has a dry resilient crumb resembling the fresh bread counterpart.

The freeze compression - freeze drying process was also applied successfully to sponge cake, devil's food cake and waffles. Due to their varying structures as compared to bread, change was required with respect to the length of dip time in water to achieve satisfactory rehydration and expansion characteristics.

Compressed bread slices were subjected to difference testing. Generally, it was found that the experimental bread rated well with respect to appearance and flavor. Texture differences were noted, however, with the experimental bread being identified as more moist and heavier to the touch. No data is available with respect to acceptance. It is believed that acceptance data should be obtained under some form of field use.

A formulation and technique was identified to prepare jelly and peanut butter sandwich fillings in a loaf form. The loaf can be sliced in a manner similar to processed cheese and provides a filling for compressed sandwich use.

Prepared compressed jelly and peanut butter sandwiches were made by placing the sliced sandwich fillings between compressed bread slices. Satisfactory rehydration and expansion was achieved by dipping the entire compressed sandwich form in excess water.

Storage testing of the various compressed prototypes was conducted at 70°F., under cycling conditions of 0°F. to 70°F. and at 100°F. No appreciable change was noted at the 70°F. and cycling conditions for periods up to six months. Deterioration at 100°F. of the compressed bread and sandwich forms was noted which requires further investigation.

Research work completed under Phase II satisfies the objectives defined in the specifications. No further exploratory or developmental effort is scheduled.

## INTRODUCTION

This is the final report of Phase II of the research program whose primary objective was the development of a stable bread type product which can be stored for extended periods in a collapsed state.

During the Phase I investigation (8 July 1963 - 7 July 1964) it was established that when baked bread slices were autoclaved prior to dehydration and compression they could be rehydrated by dipping for three seconds in excess water.

After standing for a period of 10 minutes the bread slices were noted to have recovered to their normal dimensions. In this work, however, two major deficiencies were noted. The dry compressed bread slice form did not retain the 4mm compression dimension but rather expanded during final drying to approximately 7 to 9mm. The rehydrated bread slice form was found to absorb too much water upon rehydration yielding a somewat soggy bread texture.

In the first report period of Phase II attempts to correct these deficiencies were made. This work screened several approaches and resulted in the development of a new compression and drying process to achieve the compressed-dehydrated bread slice form. The process designated as the Phase II (-28°F.) process resulted in a compressed-dehydrated crustless bread slice which maintained the 4mm thickness. On rehydration by dipping in water for 6 seconds and allowing the hydrated slice to equilibrate at room temperature for 5-10 minutes a fully expanded slice having a resilient crumb resembling the fresh bread was obtained. If the crust was left on the slice prior to processing, the compression and the rehydration of the crumb was the same but the crust portion remained hard and not fully hydrated.

Research effort completed during the second reporting period of Phase II was concerned in part with experiments toward making the Phase II process for compressed-dehydrated bread more concise and simple. This work resulted in the selection of conditioning and compression temperatures which are as close together as possible. The modified process was designated as the Phase II (0°F.) process.

Compressed bread slices after rehydration and expansion were subjected to difference testing. In general the experimental bread was favorably accepted on the basis of flavor and appearance, but determined to be less acceptable on a texture scale.

A formulation and technique was identified to prepare jelly and peanut butter sandwich fillings in a loaf form. The loaf can be sliced in a manner similar to processed cheese and provides a filling for compressed sandwich use.

Prepared compressed jelly and peanut butter sandwiches were made by placing the sliced sandwich fillings between compressed slices. Satisfactory rehydration and expansion was achieved by dipping the entire compressed sandwich form in excess water.

Research was also initiated during the second reporting period toward screening various cake structures to determine suitability for compression, dehydration and subsequent rehydration. This work which continued into the final reporting period resulted in the selection of sponge cake and devil's food cake structures for intensive exploration.

Work toward the compression and dehydration of the waffle form was initiated during the final period. This work resulted in the successful application to waffles of the processing steps which were defined earlier for bread and cake slices.

During the course of the exploratory work as acceptable product prototypes were made storage tests were initiated. Product was packaged in individual pouches under varying degrees of vacuum and placed at 70°F., under cycling conditions of 0°F. to 70°F. and at 100°F. Results of these storage tests are contained in the sections of this report detailing the exploratory work conducted on each prototype.

## RESULTS AND DISCUSSION

During the Phase I investigation it was found that autoclaving bread at 10 psig for ten minutes was a very promising means of firming the bread structure. When bread which was baked at the General Foods Technical Center was autoclaved, dried in a forced air oven to 13 - 15% moisture, compressed to 4MM between plates at room temperature and further dried to 8 - 10% moisture in a forced air oven, it could be rehydrated and expanded by dipping in water for 3 seconds. This procedure is identified as the Phase I process in this report (See Appendix). However, two deficiencies were noted: (1) the rehydrated bread absorbed too much water yielding a somewhat soggy bread texture and (2) the compressed bread would expand from 4MM to approximately 7 to 9MM during the final drying step.

The work done during Phase II was directed at correcting these deficiencies. In addition, the compressed - dehydrated bread was used to prepare compressed sandwiches which expand to normal size upon rehydration. Two compressed - dehydrated cake types as well as waffles which expand upon rehydration and are organoleptically acceptable were also explored.

### I. Phase I - Procedure Modifications

When the data obtained on the Phase I Process was examined, at least three possible means of correcting the above-mentioned hydration and expansion deficiencies were noted. These areas of investigation were: 1) modification of the bread formula, 2) applying coatings to the bread slices and 3) modification of the dehydration and compression process.

The work done in these areas are reported below:

#### A. Effect of Formulation Modifications

The effect of some ingredient variations of the standard bread formula (See Appendix) was examined in conjunction with the compression and rehydration process of Phase I as outlined above. In one modification the Carrageenan, Seakem Type 7 was omitted and in another it was replaced with sodium alginate 100 cps. In addition, Vital Wheat Gluten-Pro 80*, was added to the above modifications at the rate of 5% based on flour weight. None of these modifications had any significant beneficial effect on controlling the soggy texture of the rehydrated bread. However, the modifications caused varying volume and textural differences in the freshly baked loaves. Work which was done in this area while limited, did not appear to hold promise of achieving the improvements desired. Accordingly, this approach was not pursued further and the other approaches were investigated.

#### B. Effect of Coatings

Since the problem associated with the rehydrated bread was one of moisture absorption, several ingredients were sprayed on the standard bread slices at various steps in the process to alter the rate of moisture absorption. The material sprayed at the rate of 0.2 gm and 0.4 gms per slice were:

*Vital Wheat Gluten-Pro 80, Hurron Milling, Over 80% protein, less than 12% moisture.

a 6% solution of gelatin, a 2% solution of sodium alginate 100 cps., glycerine, Wesson Oil and Myvacet 9-40. The slices were sprayed at the following steps in the Phase I process: (1) prior to autoclaving, (2) prior to the initial air drying step, (3) prior to compression and (4) after the final air drying step.

These samples on rehydration by dipping in water for 3 seconds and equilibrating for 10 minutes at room temperature showed no significant difference over standard untreated slices.

This effort indicated that altering the moisture absorption characteristics of compressed bread by the application of coatings would be a major task. Much variation in the general quality of laboratory baked bread was noted, particularly in the crumb structure. The crumb was generally coarse and open with numerous holes in the bread slice. Such variation will cause differences in moisture penetration which would be difficult, if not impossible, to control by the application of coatings. Accordingly, this approach was abandoned in order to concentrate on an evaluation of process modification as a means of achieving improvements in the texture of the rehydrated compressed bread slice.

C. Phase I - Process Modification

In order to control water absorption and to find ways of preventing the slices from expanding after compression, the compression and dehydration processing steps were investigated.

1. Compression

It was noted that if a slice of bread, either autoclaved or not autoclaved, was pressed between freezing plates it could be compressed and maintained in a compressed frozen form. If the frozen compressed bread slice was allowed to thaw at room temperature it would expand to its original thickness and texture. This indicated that it was possible to compress bread at its original moisture content without permanently altering its structure.

2. Dehydration

The compression technique mentioned above (hereafter termed freeze compression) resulted in a frozen slice of compressed bread. Therefore, a method of dehydration which would allow the slice to remain frozen while being dried had to be used. The technique which appeared most appropriate was freeze drying. Freeze drying also has the advantage of being a mild form of drying and provides a minimum tendency to alter the structure of the slice.

II. Initial Freeze Compression and Drying Experiments

To evaluate the effect of freeze compressing and freeze drying bread slices the following was done:

A. Freeze Compression Process - Standard Bread

Laboratory baked standard bread slices 12MM thick were autoclaved for ten minutes at 10 psig, wrapped in aluminum foil and conditioned overnight at 15°F., 35°F., 50°F. and 70°F. The conditioned slices were then compressed to 4MM in -30°F. and 0°F. constant temperature rooms using a Carver Press and plates which were equilibrated at the appropriate temperatures. The frozen, compressed slices were then freeze dried in a small laboratory type freeze dryer unit.

The resulting dry compressed bread slices were evaluated by dipping them in water for three seconds followed by standing at room temperature for 10 minutes. Evaluation of the slices indicated that insufficient moisture had been absorbed and accordingly duplicate bread slices were dipped for 6 seconds and allowed to stand 10 minutes. Rehydrated samples were evaluated for general texture qualities, and results are shown below in Table I.

TABLE I

Results of Initial Freeze Compression Experiments - Standard Bread

| Processing Conditions | | | Rehydration |
|---|---|---|---|
| Conditioning Temperature °F. | Plate Temperature °F. | Thickness After Drying MM | Comments |
| 15 | -30 | 8 | Not uniformly hydrated - where fully hydrated the crumb was dry and resilient. |
| 35 | -30 | 8 | Uniformly and fully hydrated to a dry resilient crumb. Crust not fully hydrated. |
| 50 | -30 | 6 | Poor hydration. |
| 70 | -30 | 4 | Poor hydration. |
| 15 | 0 | 6 | Not uniformly hydrated - where hydrated expanded to 10MM and was slightly soggy. |
| 35 | 0 | 7 | Not uniformly hydrated - where hydrated expanded fully and was slightly soggy. |
| 50 | 0 | 6 | Uniformly and fully hydrated to a slightly soggy texture. |
| 70 | 0 | 4 | Poor hydration. |

It can be seen from the data that overnight conditioning at 35°F. and compression at -30°F. resulted in bread slices which exhibited the most satisfactory rehydration. The rehydrated bread slice became fully hydrated in the crumb area to a dry resilient texture which approximated that of fresh bread. The crust portion hydrated at the surface only with the inner sections remaining crisp and dry. The overall quality was considered very promising, indicating that exploratory work should continue with the freeze compression process. The final thickness of the dry bread slice form was generally greater than 4MM. The freeze dryer used was not equipped with refrigerated plates thereby causing the slices to thaw slightly and expand during drying. It was anticipated that with proper freeze drying technique expansion would be eliminated.

B. Freeze Compression Process - Various Bread Types

The freeze compression process was applied to the following bread types: 1) Phase I standard bread, 2) Phase I standard bread formula which was modified by adding Vital Wheat Gluten-Pro 80 at the rate of 5% based on the flour weight. During the Phase I program this bread was preferred for compression, 3) Bond Pullman - a commercially prepared uniformly baked loaf of moderate soft texture prepared by a standard baking process and 4) Finast Pullman - a commercially prepared loaf of very uniform soft texture prepared by a brew-ferment continuous bread process. The commercial bread was processed because of the large variation in laboratory baked bread and to determine if commercial bread would have improved rehydration characteristics, particularly in the crust area.

Twelve millimeter thick slices of these breads were autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil and conditioned overnight at 35°F. The conditioned slices were freeze compressed at -30°F. to 4MM and freeze dried.

Guided by the earlier results a rehydration time of 6 seconds in water was selected for the standard bread, Bond Pullman and Finast Pullman. Evaluation of the standard bread modified with Vital Wheat Gluten indicated that a longer rehydration time was required and subsequently a 9 second dip was selected. The evaluation of the general texture qualities of these rehydrated samples are reported in Table II, which follows.

TABLE II

Results of Initial Freeze Compression Experiments

Various Types of Bread

| Bread Sample | Thickness of Dehydrated Slice (MM) | Rehydration: Length of Dip (Sec.) | Rehydration: Comments |
|---|---|---|---|
| Standard | 8 | 6 | Fully hydrated dry crumb. Crust not fully hydrated. |
| Standard with added Wheat Gluten | 4 to 6 | 9 | Similar to standard loaf, but not hydrated in crumb area approximately 1 inch from the upper crust. |
| Bond Pullman | 6 | 6 | Fully expanded slightly soggy crumb. Crust not fully hydrated. |
| Finast Pullman | 8 | 6 | Fully hydrated slightly soggy crumb. Crust not fully hydrated, but best of series. |

This work indicated that commercial breads as well as laboratory baked breads appear satisfactory for processing by the freeze compression technique. It was also believed that the uniform texture of the commercial bread might have a beneficial effect on the overall hydration characteristics of the processed compressed bread. Generally, it was observed that the crumb portion of the commercial breads were more uniformly hydrated and of better texture. Lack of crust hydration was a problem consistent throughout the series. Generally, however, the commercial breads indicated better performance with respect to hydration in the crust area with the Finast Pullman showing the largest degree of rehydration.

## III. Equipment Refinement for the Freeze Compression Process

The preliminary results of the freeze compression technique demonstrated the feasibility of the process. This work also suggested several process modifications which would lead to better control of the operation.

These modifications are explained below:

### A. Compression-Freezing Plates for Carver Press

To alleviate the problems associated with compressing the bread slices in a -30°F. room and to have better control of temperature a set of plates were designed for the Carver Press. (See Appendix - Pictures XVII and XVIII). These plates can be charged with dry ice and stabilize at a temperature of about -28°F.

The plates are also so designed that they can be maintained at any desired temperature by circulating a pure ethylene glycol solution through them which will maintain selected experimental temperatures.

### B. Freeze Dryer

As the freeze dryer previously used did not maintain the bread slices in a frozen form during dehydration, thereby allowing them to expand, a more efficient dryer was secured. The one selected was a Stokes Model #2004Lx3 freeze dryer which was equipped with refrigerated plates. These plates helped the bread to remain frozen while the vacuum was being drawn in the chamber.

## IV. Freeze Compression of Bond Pullman Bread

Work done in Section IIB showed that Bond bread gave satisfactory rehydration results. Further, since it is readily available it was decided to use this bread for further experimentation. This work includes the effect of conditioning temperature and the effect of crust removal.

### A. Effect of Conditioning Temperature Prior to Compression

The initial freeze-compression work reported in Section II indicated that the compression temperature had an effect on the texture of the rehydrate standard bread slices. To determine if this effect still held for the Bond Bread processed using the modified equipment the following was carried out:

Twelve millimeter Bond bread slices were autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil, conditioned overnight at 0°F., 15°F., 35°F. and at room temperature.

The conditioned slices were freeze-compressed to 4MM between the plates charged with dry ice and then freeze dried in the Stokes unit to about 10 - 11% moisture. Bread slices were rehydrated and evaluated with results shown in Table III below.

TABLE III

Effect of Conditioning Temperature Prior to Compression of Bond Pullman Bread

| Conditioning Temperature °F. | Thickness After Drying MM | Rehydration* |
|---|---|---|
| 0 | 6 | Fully hydrated slightly soggy crumb. Crust almost fully hydrated. |
| 15 | 5 | Fully hydrated, dry firm crumb. Crust not fully hydrated. |
| 35 | 4 | Similar to 15°F. conditioned sample. |
| Room Temp. | 4 | Poor hydration. |

* Dipped in excess water for 6 seconds and left at room temperature for 10 minutes.

Data in Table III confirm what was determined in Section IIA where the standard bread was evaluated over the same range of conditioning temperature. It appears that a conditioning temperature of 15°F. to 35°F. yields the best crumb texture and this range of temperature will require further exploration to determine the optimum conditioning requirements for this process.

It is interesting to note that the crust of the 0°F. conditioned sample was almost fully hydrated. It is believed that this is due to the fact that the crust shattered on compression, thereby providing channels for water entry into the crust. This approach, of providing channels for water entry was explored further and is reported below.

B. Crust Rehydration

A problem associated with the freeze compression technique is the failure of the crust to rehydrate. This failure is due to the inability of the water to penetrate to the inner portions of the compressed crust area. The work done above where the bread was conditioned to 0°F. prior to compression indicated that if channels were provided for water entry the crust does hydrate. In an effort to improve crust rehydration such modifications as making lateral cuts into the crust at approximately 1/8" interval or placing 1/8" holes into the crust and adjacent crumb were attempted. It was also determined that if the crust is dipped in water prior to the freeze compression some shattering of the crust is noted on compression (due to the expansion of the ice formed). Each of these approaches was evaluated and no significant improvement in crust hydration was noted.

As these approaches did not appear fruitful an obvious thing to do was to remove the crust. Subsequently, samples of crustless Bond Pullman bread were processed by compressing the autoclaved and conditioned slices between plates charged with dry ice (as described in Section V). When these were shown to representatives of the Natick Laboratories, at a meeting held at the Technical Center on January 14, 1965, it was decided that they performed satisfactorily. We were instructed at that time to direct attention to the other objectives of the project and not attempt to modify the hydration characteristics of the compressed dehydrated crust.

## V. Phase II (-28°F.) Process - Freeze Compression

Based on the work reported above the following process was standardized and designated as the Phase II (-28°F.) process:

Twelve millimeter thick brea˜ slices are autoclaved at 10 psig for 10 minutes, wrapped in aluminum fo. and conditioned overnight at 35°F. The conditioned slices at their full moisture content are compressed to 4MM between plates charged with dry ice. On compression the slices are frozen and then freeze dried to 10% moisture.

## VI. Comparison of Dehydrated Compressed Bread Prepared by the Phase I and Phase II (-28°F.) Process

In order to demonstrate the advantages and disadvantages associated with the Phase I and Phase II (-28°F.) processes for the dehydration and compression of bread slices the following was done.

Four bread types were processed by the two processes. The breads processed were (1) Standard, (2) Standard modified by adding vital wheat gluten at the rate of 5% of the flour (3) Bond Pullman and (4) Finast Pullman. In addition, Bond Pullman bread was processed utilizing the Phase I (-28°F.) process after its crust was removed.

The prepared dehydrated compressed bread slices we : evaluated as follows:

a) The breads prepared by the Phase I process at a dehydrated moisture content of 9 - 10% were dipped in 72°F. water for 3 seconds, and placed on an elevated wire mesh screen to stand for 10 minutes. The moisture content of these samples was obtained by placing the entire slice in a vacuum oven at 158°F. for 18 hours.

b) Same procedure as for (a) except the moisture content of the crumb and crust area was obtained separately. After the bread slices were hydrated the area approximately 3/8" from the edge was removed and considered as the crust area. The remaining portion was considered the crumb area.

c) The bread slices prepared by the Phase II (-28°F.) Process were dipped in 72°F. water for 6 seconds and handled as in (a) and (b) above.

d) The hydrated slices were evaluated as to general expansion and texture qualities.

e) Photographs were taken of each bread type showing both a top view and angle view of the fresh unprocessed bread slice, the compressed-dehydrated form and the final rehydrated bread slice.

The data obtained is tabulated in Tables IV and V. In addition, Pictures I through VI are included which show the effect of rehydrating the compressed-dehydrated standard bread and the Bond Pullman, with and without crust. These have been selected because they are considered typical of what is obtained when laboratory and commercially baked breads are processed.

## TABLE IV

## Standard and Modified Standard

| | Dehydrated Form | | Rehydrated Form | | | | |
|---|---|---|---|---|---|---|---|
| Sample Process | Compression Thickness MM | Moisture % | Expansion Thickness MM | Whole Slice Moisture % | Crumb Moisture % | Crust Moisture % | Comments |
| Phase I Standard | 7 Shattered Crust | 9.5 | 10 | 61.3 | 61.5 | 61.5 | Uniform hydration to a soggy texture. |
| Phase II (-28°F.) Standard | 5 Slightly Shattered Crust | 9.2 | 10 | 44.7 | 46.6 | 48.0 | The crumb hydrated to a dry texture. Moderate hydration of the crust. |
| Phase I Modified Standard | 7 Shattered Crust | 9.0 | 12 | 58.8 | 56.7 | 55.7 | Fully hydrated to a soggy texture. |
| Phase II (-28°F.) Modified Standard | 4 Slightly Shattered Crust | [illegible].2 | 11 | 43.4 | 44.1 | 34.5 | Only center portion of crumb hydrated to a dry resilient texture remainder and crust not fully hydrated. |

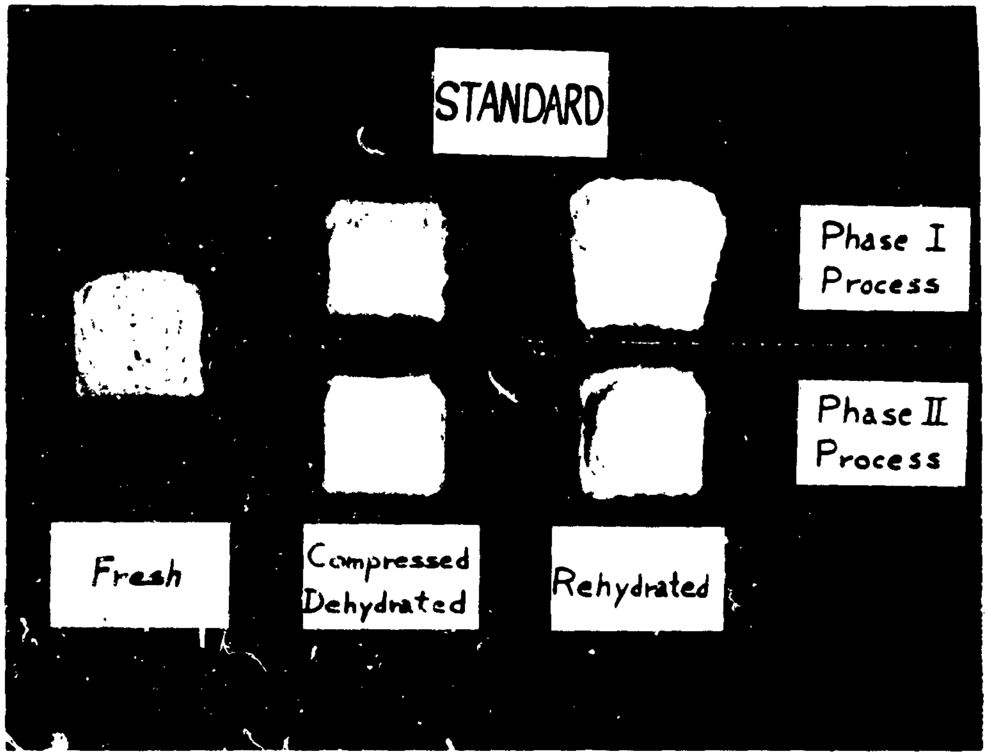
**TABLE V**

**Finast, Bond and Bond w/o Crust**

| Sample Process | Dehydrated Form: Compression Thickness MM | Dehydrated Form: Moisture % | Rehydrated Form: Expansion Thickness MM | Rehydrated Form: Whole Slice Moisture % | Rehydrated Form: Crumb Moisture % | Rehydrated Form: Crust Moisture % | Comments |
|---|---|---|---|---|---|---|---|
| Phase I Finast | 7 - 8 | 9.0 | 8 - 10 | 53.0 | 61.4 | 47.1 | Very soggy crumb texture crust fully hydrated except for one portion and the crumb area associated with it. |
| Phase II (-28°F.) Finast | 4 | 9.7 | 8 | 53.5 | 57.9 | 36.2 | Soggy crumb texture not fully hydrated crust. |
| Phase I Bond | 7 - 8 with shattered crust | 9.1 | 12 | 55.8 | 54.4 | 58.1 | Slightly soggy crumb texture with a dry area under the top crust. |
| Phase II (-28°F.) Bond | 4 | 9.2 | 11 | 43.5 | 48.9 | 27.6 | Dry resilient crumb texture. Not fully hydrated crust. |
| Phase II (-28°F.) Bond without crust | 4 | 9.5 | 11 | - | 51.5 | - | Fully hydrated to a dry resilie[illegible] texture. |

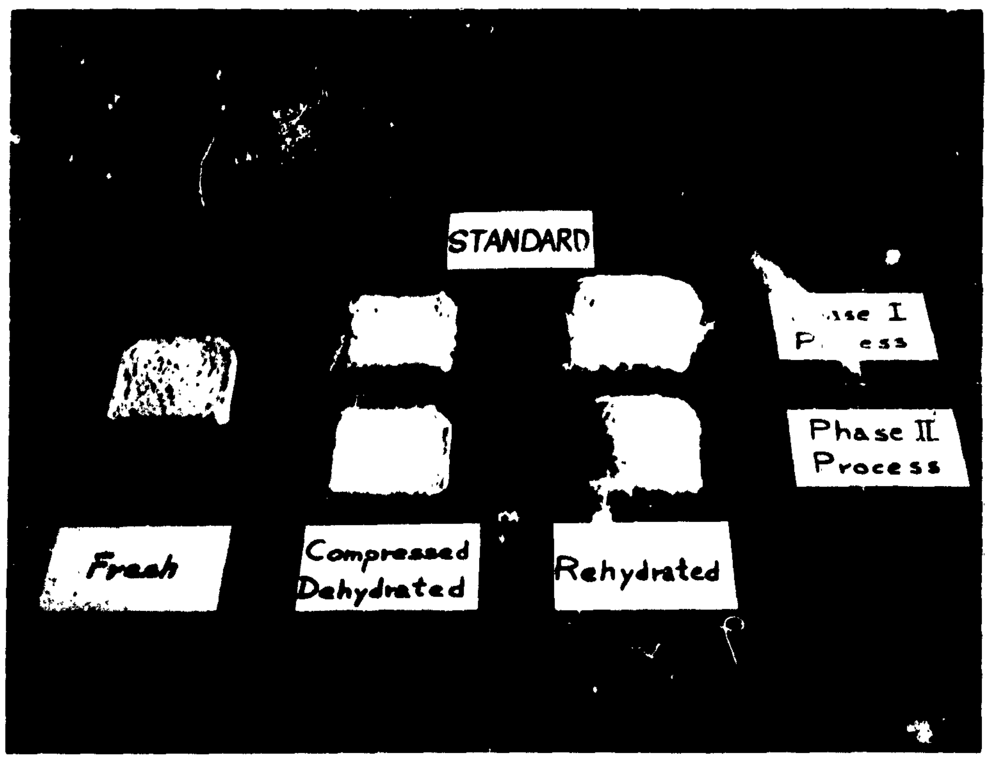
Picture I

Top View



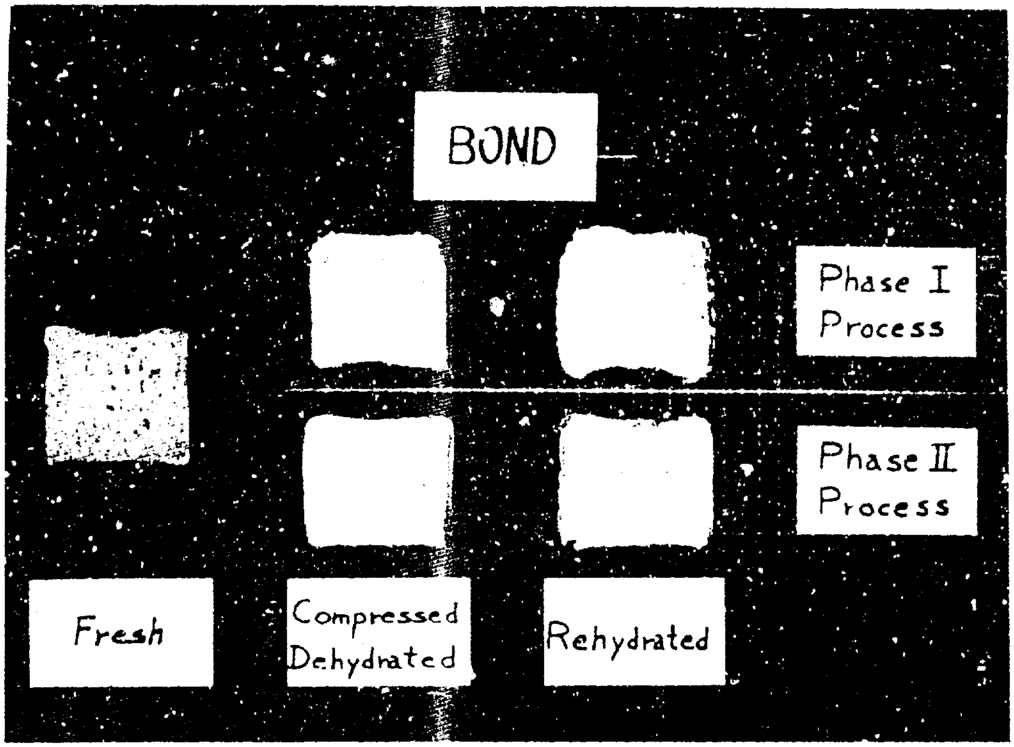

Picture II

Angle View



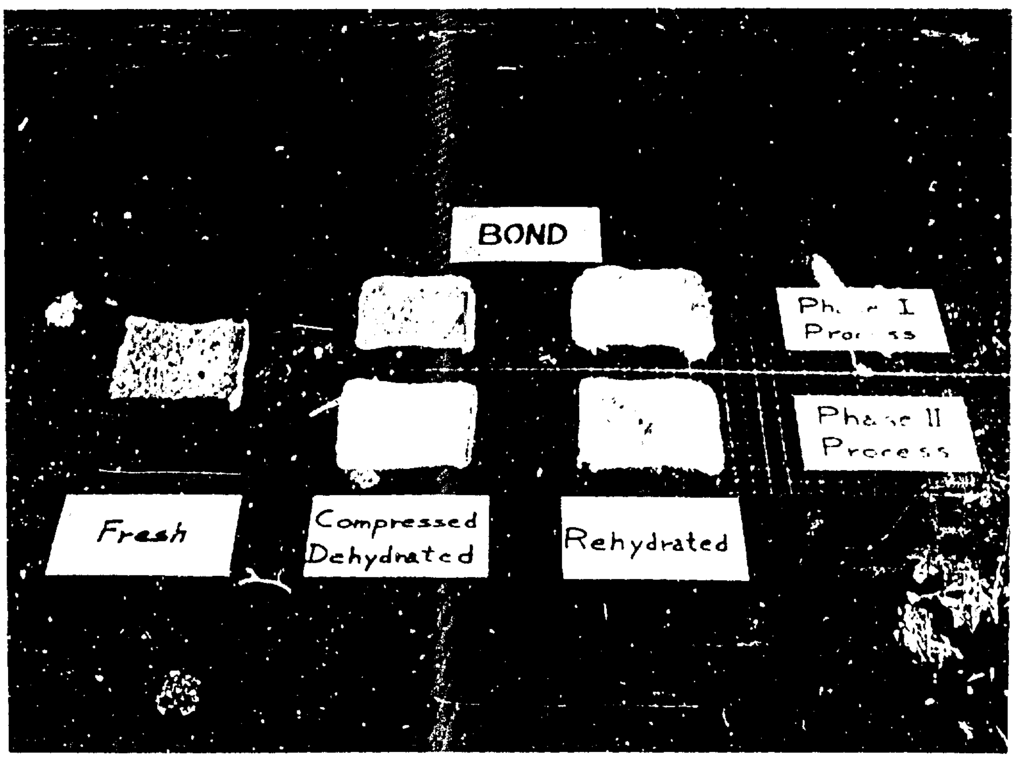
Picture III

Top View



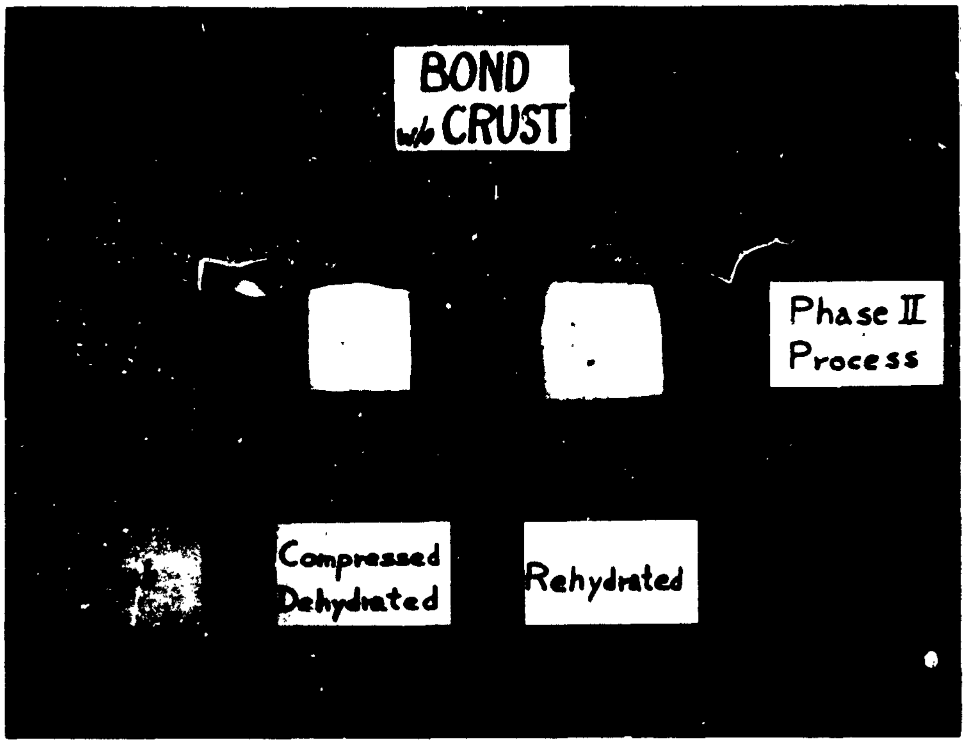

Picture IV

Angle View



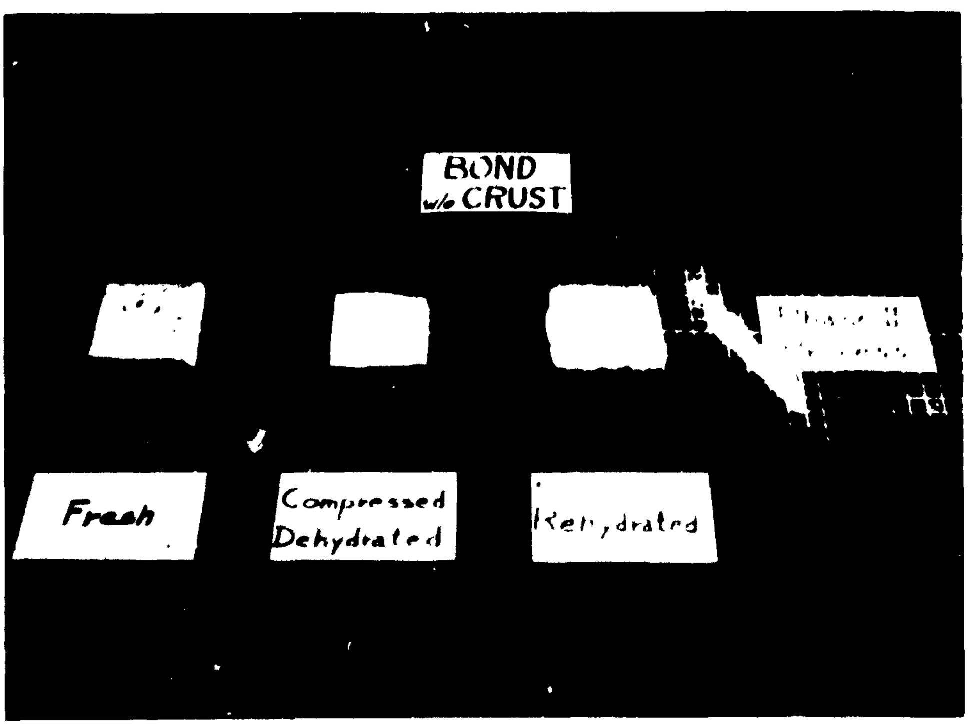
Picture V

Top View




Picture VI

Angle View



Examination of Tables IV and V and Pictures I through VI show that the dehydrated form obtained by the Phase II (-28°F.) Process is more uniform and fully compressed than that obtained using the Phase I Process. Upon rehydration the Phase II (-28°F.) Process bread slices are lower in moisture content than bread processed by the Phase I technique. This substantiates that the Phase II (-28°F.) processed bread has a wider tolerance to dipping time,since they were dipped for 6 seconds instead of 3 seconds and still have a more resilient dry crumb quality.

The data further indicates the relatively poor hydration characteristics of the crust area. Moisture analyses of the crust portion versus the crumb area indicate 10 to 20 per cent less moisture absorption.

Pictures V and VI and Table V indicate that when the crust is removed from Bond Pullman a uniform fully rehydrated bread slice is obtained. The absence of crust permits full expansion in all directions thereby eliminating the rise of crumb as was shown in the earlier pictures.

## VII. Storage Testing of Phase II (-28°F.) Processed Crustless Bond Bread

To determine if the Phase II (-28°F.) processed crustless Bond bread would show any adverse effects with time, a storage test was initiated. The test was performed as follows:

Crustless Bond bread slices were processed to the dry compressed form following the Phase II (-28°F.) Process described in Section V. Samples were vacuum packed in pouches consisting of cellophane/polyethylene/ .00035 foil/polyethylene (130C-7P-35F-30P). The packaged samples were placed in conditioned storage rooms maintained at 70°F. and 100°F. Additional samples were cycled three times a week between 0°F. and 70°F.

The samples were evaluated for texture and appearance on a monthly basis for a period of six months. In addition, representative samples were examined bacteriologically prior to initiating the storage test as well as at its termination.

Table VI summarizes the monthly evalua'..on of these samples. The bacteriological results which are tabulated below indicate that the bread remained in excellent condition throughout the storage period.

| | | Storage Condition | | |
|---|---|---|---|---|
| | Zero Time | 6 Mo. @ 70°F. | 6 Mo. @ 100°F. | 6 Mo. Cycled 70°F. - 0°F. |
| Standard Plate Count | <10 | <10 | <10 | <10 |
| Thermophils | <10 | <10 | <10 | <10 |
| Coliforms | <10 | <10 | <10 | <10 |
| Mold | <10 | <10 | <10 | <10 |
| Yeast | <10 | <10 | <10 | <10 |
| Staphylococci | none detected | none detected | none detected | none detected |
| Fecal Enterococci | none detected | none detected | none detected | none detected |
| Streptococci | none detected | none detected | none detected | none detected |

## TABLE VI

## Storage Evaluation of Compressed Bread

### Rehydration Evaluation *

| Months of Storage | 70°F. Storage | 100°F. Storage | Cycle 0° - 70°F. Storage |
|---|---|---|---|
| 0 | Fully hydrated and expanded to a very slightly wet crumb. | Fully hydrated and expanded to a very slightly wet crumb. | Fully hydrated and expanded to a very slightly wet crumb. |
| 1 | Fully hydrated and expanded to dry resilient crumb. | Expanded to 8MM to a very dry crumb. | Hydrated and expanded to 10-11MM to a dry resilient crumb. |
| 2 | Hydrated and expanded to 10-11MM to a dry resilient crumb. | Expanded to 8MM to a very dry crumb and was tan in color. | Hydrated and expanded to 10-11MM to a dry resilient crumb. |
| 3 | Hydrated and expanded to 10-11MM to a dry resilient crumb. | Expanded to 8MM to a very dry crumb and was tan in color. | Hydrated and expanded to 10-11MM to a dry resilient crumb. |
| 4 | Hydrated and expanded to 10-11MM to a dry resilient crumb. | Expanded to 8MM to a very dry crumb and was tan in color. | Hydrated and expanded to 10-11MM to a dry resilient crumb. |
| 5 | Hydrated and expanded to 10-11MM to a dry resilient crumb. | Expanded to 8MM to a very dry crumb and was tan in color. | Hydrated and expanded to 10-11MM to a dry resilient crumb. |
| 6 | Hydrated and expanded to 10-11MM to a dry resilient crumb. | Expanded to 8MM to a very dry crumb and was tan in color. | Hydrated and expanded to 10-11MM to a dry resilient crumb. |

* Dip in water for 6 seconds - let equilibrate at room temperature for 10 minutes.

In addition to the texture and appearance as reported in Table VI, the storage samples were also evaluated organoleptically. All samples had no off-flavors and were considered acceptable from a flavor aspect.

As can be seen from Table VI, the samples stored under 70°F. and cycling conditions were acceptable up to the six month storage evaluation. Samples stored at 100°F. for two months were, however, substandard in appearance and texture on rehydration. It was believed that this may be due to (1) bread formula, (2) too high a compression force in package at 28 inches vacuum which may cause plasticization at elevated temperature, or (3) presence of oxygen in the stored package. Since commercial white bread was used there was no opportunity at this time to explore formula variation. Additional storage studies were initiated, however, to check the remaining possibilities. Compressed bread samples were packaged under 20 inches vacuum in an effort to limit plasticization and in addition were flushed with nitrogen before sealing to exclude oxygen.

The results of this supplementary test were similar to those initially obtained at 100°F. After four months in storage the rehydrated slices were slightly tan in color and were fully hydrated and expanded to about 10MM to a very dry resilient crumb. This indicates that the adverse effects are probably due to the effect of temperature. It is believed that adjustments in the bread formula in which a reduced sugar level is used will reduce the browning reaction. No baking and storage experimentation was conducted, however, to substantiate this belief.

## VIII. Phase II (-28°F.) - Process Modifications

In the Phase II (-28°F.) Process the bread slice is conditioned at 35°F. and compressed at -28°F. The large difference between these temperatures offered some degree of uncertainty as to the exact temperature of the slice during the compression procedure and also if we have reproducibility from slice to slice. In an attempt to investigate temperature effects, to better control the processing conditions as well as to simplify the process, if possible, the following was done:

A. Determine the temperature at which the bread slice will freeze and remain compressed.

B. Determine the conditioning temperature closest to the selected compression temperature which will still yield an acceptable finished product.

C. Determine if wrapping of bread slices prior to being conditioned is required.

A. Freezing Point of Bread on Compression

To determine a single temperature at which fresh non-autoclaved bread can be conditioned and compressed which will in addition maintain the compressed thickness, the compression plates described in Section III A were connected to a Carrier Compressor fitted with a variable thermostat and a pump to circulate ethylene glycol of any selected temperature between room temperature and -11°F. Bread slices were placed between the separated plates which were maintained at temperatures of 11°F., 5°F., 0°F. and -5°F. After a conditioning interval of one hour the plates were closed so as to compress the slice of bread to 4MM and the compression force was maintained for two minutes. The plates were then opened and the compressed bread form, while still in contact with the bottom plate, was examined for deformation or breakage. In addition, thickness measurements were made to determine if the compression thickness was maintained. Results are tabulated below:

| Temperature (°F.) | Comments |
|---|---|
| 11 | The bread appeared frozen, but expanded slightly to 5MM. |
| 5 | The bread froze and maintained its 4MM thickness. |
| 0 | The bread froze and maintained its 4MM thickness. Some shattering was noted in crust area. |
| -5 | Similar to 0°F. sample. |

It can be seen from the above that fresh bread can be compressed and its form maintained at temperatures below 5°F. As the temperature was lowered to 0°F. crust shattering was obtained.

At the project review of 1/14/65, Dr. D. Westcott agreed that the performance of crustless bread was very acceptable. Since the crust area was to be removed the crust shattering experienced at 0°F. was not considered significant. Accordingly a 0°F. compression temperature was selected for further processing work which provided a degree of tolerance to insure that the compressed bread form was locked at the 4MM thickness for the subsequent drying process.

B. Optimum Conditioning Temperature

In Section VIIIA, 0°F. was selected as an operable compression temperature. To determine if bread slices could be conditioned and compressed at the same temperature and still have desirable hydration properties the following experiment was performed:

Twelve millimeter thick slices of Bond bread were autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil and conditioned at 0°F. for 1, 2, 4 and 18 hours. The conditioned slices were freeze-compressed to 4MM between plates equilibrated at 0°F., freeze dried and equilibrated to approximately 10% moisture. On rehydration using the 6 second dipping procedure the slices in general were slightly soggy and had a gummy and tacky feel rather than the dry resilient texture of the Phase II (-28°F.) Process slice. This indicated that we cannot condition and compress the bread at the same temperature of 0°F. and still obtain bread which will rehydrate to the desired texture.

To determine an optimum temperature at which to condition crustless bread prior to compression at 0°F. the following was done:

Twelve millimeter thick slices of Bond Pullman bread were autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil and conditioned overnight at 40°F. The following day the temperature of the bread slices were lowered to 35°F., 25°F., 15°F. and 5°F. allowing from 1 to 2 hours for them to equilibrate at the selected temperatures. The slices after being conditioned were compressed to 4MM between plates equilibrated at 0°F. and freeze dried and conditioned to approximately 10% moisture. The results of hydrating the slices by dipping in 72°F. water for 6 seconds and equilibrating at room temperature for 10 minutes is found in Table VII.

TABLE VII

Effect of Conditioning Temperature Prior to Compression at 0°F.

| Conditioning Temperature (°F.) | Comments |
|---|---|
| 35 | Full expansion - dry resilient crumb although not as dry as original Phase II (-28°F.) Process bread. |
| 25 | Full expansion - dry resilient crumb although not as dry as original Phase II (-28°F.) Process bread. |
| 15 | Full expansion - very slightly soggy resilient crumb. |
| 5 | Full expansion - slightly soggy resilient crumb. |

It can be seen from Table VII that conditioning at 35°F. and 25°F. result in acceptable products and when lower temperatures are used the rehydrated slice is slightly soggy. Although the 35°F. and 25°F. samples were satisfactory, they were not as dry as slices prepared by the Phase II (-28°F.) Process. Although the 35°F. and 25°F. temperatures gave essentially the same results, the 25°F. conditioning was selected, consistent with the idea of obtaining the conditioning temperature as close as possible to the compression temperature.

C. Effect of Conditioning Unwrapped Bread

The experiment as reported in Section VIIIB in which the conditioning temperatures were varied from 35°F. down to 15°F. was repeated with the exception that the bread slices were left uncovered during the conditioning period.

On inspection, after conditioning, the slices were found to have shrunk in their lateral dimensions. When the slices were compressed at 0°F. they were found to not maintain the 4MM compressed dimension, but expanded to 5MM. In addition, they were yellowish-tan in color, fragile and porous in appearance. On rehydration the slices were fragile along the edges, not fully expanded, slightly soggy and lacking the resilient texture of bread slices which had been wrapped during conditioning.

This work clearly indicated that the drying of the bread which occurred when the slices were equilibrated unwrapped, resulted in a finished product which did not rehydrate satisfactorily.

## IX. Phase II (0°F.) Process

For future reference the following process which utilizes the selected 25°F. conditioning and the 0°F. compression temperatures will be designated as the Phase II (0°F.) Process.

Twelve millimeter thick slices of crustless Bond bread are autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil and conditioned overnight at 25°F. The conditioned slices are freeze compressed to 4MM between plates equilibrated at 0°F. The compressed slices are then freeze dried and conditioned to approximately 10% moisture.

## X. Difference Testing of Compressed-Dehydrated Bread

While the Phase II (-28°F.) Process and the Phase II (0°F.) Process compressed bread were considered acceptable by the project workers, it was decided to obtain an overall evaluation of them by Technical Center personnel not directly associated with the experimental work.

In conjunction with the Product Evaluation Group of the Technical Center, two testing procedures were selected to obtain this evaluation. The first test selected was a triangle test, in which the respondent is to choose the odd sample. This is a very exacting test as the subject can make a direct comparison of the experimental and the control products. The second test was a single stimulus test, in which a respondent is to rate the product using a preference scale of descriptive words. In this test a direct comparison is not made of the experimental and the control products.

The first sample selected for evaluation was the Phase II (0°F.) Process bread and fresh Bond Pullman bread using the triangle test method. For this test a total of 24 male and female technical and non-technical workers were used. In over 90% of the responses the odd slice could be detected with the primary comment being that the experimental sample was moist and heavy to the touch; with no comments being made as to a detectable difference in the taste of the experimental as compared to the control slice.

Since the triangle test procedure resulted in no comments being made as to the flavor, appearance, etc., it was decided that the single stimulus test would be used to obtain a word picture of the experimental sample without obtaining an overall acceptance of the product. Further the Phase II (-28°F.) Process bread was used rather than the Phase II (0°F.) Process bread. This was done as the project workers evaluated it as being slightly drier on rehydration than the Phase II (0°F.) Process bread (See Section VIIIB). For this test 19 male and female non-project workers were selected. Each respondent was contacted on two consecutive days and asked to evaluate either a half slice of the experimental or control sample on each day. To evaluate the bread slice the respondent used a preference scale of descriptive words which described the texture, flavor and appearance of the samples.

In general, the experimental bread was favorably accepted on the basis of flavor and appearance, but it was determined to be less acceptable on the texture scale. The overall opinion being that the experimental slice was heavier and wetter than the control slice.

It can be concluded from the results of these two tests that although the experimental bread slices fully rehydrate they are noticeably wetter although similar in flavor and appearance as compared to the control slice. Although these tests are included as a guide as to the general quality of the experimental products no firm results are available as to their acceptance in use. It appears that in order to obtain acceptance data the compressed bread products should be tested under some form of field condition.

## XI. Sandwich Fillings

Limited experimentation with regular jelly or peanut butter as fillings for compressed sandwiches proved them to be unsatisfactory. It was found that due to their plastic nature these fillings penetrated the pores of the compressed bread thereby interfering with sandwich rehydration. It was reasoned that if fillings could be made in a form similar to a sliceable cheese, the problems associated with required spreading and pore penetration could be overcome. Experimentation was conducted, therefore, to make a jelly and a peanut butter type filling in loaf form. A typical jelly and peanut butter loaf are shown in the Appendix (See Picture XIX) Following is a description of the work which was done.

### A. Jelly Loaf

Jelly as is commonly known is based on pectin as the gelling or thickening agent. Initial experiments were conducted in which the level of pectin was increased in an experimental jelly formulation in an attempt to obtain a loaf form of jelly. This proved unsuccessful, as a loaf form could not be made and accordingly a replacement was sought for the pectin. Experimentation with agar-agar proved satisfactory in that the desired loaf form of jelly was made and in addition was suitable for slicing. The composition and method of preparation of the jelly loaf is contained in the Appendix.

Sliceable jelly prepared as described was used in assembling compressed sandwiches which rehydrated satisfactorily. A storage test of compressed jelly sandwiches which will be more fully described later in this report indicated that at 100°F. the jelly released moisture or a syrup which was pressed into the compressed bread making rehydration of the bread very difficult. Accordingly, additional work was done with jelly in which an increased level of agar-agar was used to yield a firmer final product. In addition, a more rapid cooling technique was used which also added to the firmness of the final jelly loaf. This latter formulation and method of preparation is also contained in the Appendix. The modified jelly loaf was used to prepare compressed sandwiches for storage under 100°F. conditions to determine if the storage life of sandwiches has been extended.

### B. Peanut Butter Loaf

In order to have complete control of the formula, experimental work was done using peanut butter obtained by milling roasted peanuts with no additives. Commercial peanut butter is known to contain blends of added oils, sugars and salt.

Initial research effort was directed toward the inclusion of gelling agents such as agar-agar to the peanut butter. However, due to limitation with respect to available moisture and heating requirements, formation of loaves proved very difficult. Generally, it was found that excessive quantities of free oil migrated to the surfaces of a formed loaf and to the surfaces of slices cut from the loaf. The presence of such oil is undesirable, since its absorption by the compressed bread would make rehydration of the bread difficult.

Effort was then directed toward the formation of peanut butter loaves in which total fat content is reduced. Toward this end the milled peanuts were placed in a Carver Press fitted with a Standard Filtering Cage and a portion of oil was expressed. Resulting pressed peanut butter contained approximately 37% oil. To assist in the firming of the loaves approximately 15% of a higher temperature softening point fat (Wecobee SS supplied by Drew Food Products) was combined with the pressed peanut butter. Additional ingredients of powdered sugar and salt were included, the combination was thoroughly mixed with slight heating and then cast into loaf form. Upon cooling, the resulting peanut butter loaf was free of excess surface oil, satisfactorily dry to the touch and suitable for slicing such as with a cheese type wire cutter.

The formulation and method of preparation of the sliceable peanut butter is contained in the Appendix. Product so prepared was used for compressed sandwich evaluation and storage testing which are described in later sections of the report.

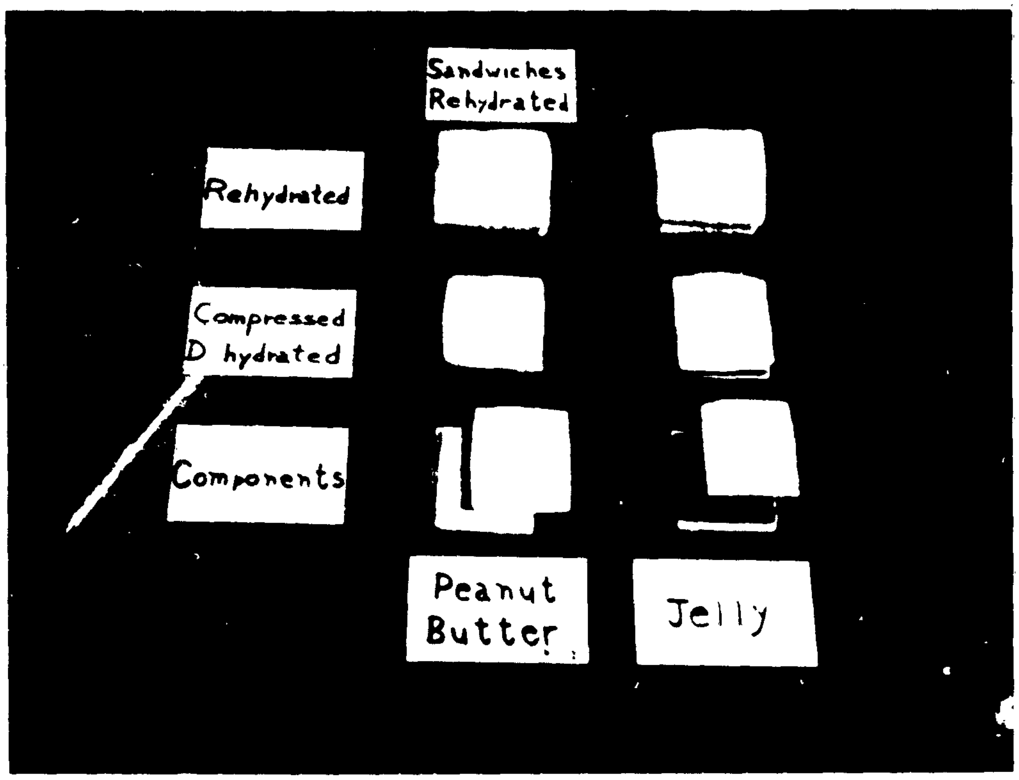
## XII. Compressed Sandwiches

Compressed sandwich prototypes were made by placing the sliced sandwich fillings prepared as described in Section XI, between compressed bread slices made by the Phase II (-28°F.) Process. Performance of the compressed bread sandwiches with respect to rehydration characteristics was checked by dipping the entire sandwich in water. It was generally found that the presence of either the jelly or peanut butter did not seriously limit rehydration of the compressed bread cover. An adjustment was required, however, with respect to the time of immersion in water. While a 6 second immersion was adequate for compressed bread, it was found that a period of 7 to 10 seconds immersion is required to assure that an adequate quantity of moisture is absorbed by the assembled sandwich form.

Typical compressed jelly and peanut butter sandwiches in both dehydrated and rehydrated forms are shown in Picture VII.

Picture VII

Typical Compressed Jelly and Peanut Butter Sandwiches




XIII. Storage Study of Compressed Sandwiches

A series of sandwiches were prepared and packaged for a storage evaluation program. Samples packaged included:

Phase II (-28°F.) Process bread and basic jelly filling
Phase II (-28°F.) Process bread and basic peanut butter filling
Phase II (0°F.) Process bread and basic jelly filling
Phase II (0°F.) Process bread and basic peanut butter filling

Compressed sandwiches for storage testing were prepared utilizing bread made by both the Phase II (-28°F.) and Phase II (0°F.) processes. As indicated previously, slight differences were noted in the rehydration quality of compressed bread made by these processes. Rather than select one or the other processed bread for this storage test both were included so as to determine if one or the other is better suited for compressed sandwich use.

The sandwiches were packed under 20 inches of vacuum in cellophane/polyethylene/foil/polyethylene pouches. The packaged samples were placed in conditioned storage rooms at 70°F. and 100°F. Additional samples are being cycled three times a week between 0°F. and 70°F.

The decision to package the sandwiches under twenty inches of vacuum was based on the results of a preliminary storage test of sandwiches prepared with Phase II (-28°F.) Process bread and the basic jelly and peanut butter fillings. This work showed that when these sandwiches were stored at 100°F. for four days they plasticized and hydrated poorly when packed under 29 inches of vacuum, whereas, they hydrated properly when packed at 21 inches or lower.

Prior to placing the samples in storage representative units were examined bacteriologically. Results which are as follows indicated the sandwiches to be in excellent condition.

| | Phase II (-28°F.) Process Bread & Jelly | Phase II (-28°F.) Process Bread & Peanut Butter | Phase II (0°F.) Process Bread & Jelly | Phase II (0°F.) Process Bread & Peanut Butter |
|---|---|---|---|---|
| Standard Plate Count | 30 | 20 | 10 | 70 |
| Thermophils | <10 | <10 | <10 | <10 |
| Coliforms | <10 | <10 | <10 | <10 |
| Mold | <10 | <10 | <10 | <10 |
| Yeast | 10 | <10 | 20 | 10 |
| Staphylococci | none detected | none detected | none detected | none detected |
| Streptococci | none detected | none detected | none detected | none detected |
| Fecal Enterococci | none detected | none detected | none detected | none detected |
| Co-perfringens | none detected | none detected | none detected | none detected |

The storage samples have been evaluated on a monthly basis for a period of four months with a sufficient number of units retained for evaluation over a period of several additional months. Results obtained indicated that there was no difference in the performance of the Phase II (-28°F.) and the Phase II (0°F.) compressed breads for sandwich use. Accordingly, data shown in Tables VIII and IX pertaining to an evaluation of their rehydration characteristics applies to both processed compressed breads.

## TABLE VIII

### Storage Evaluation of Compressed Peanut Butter Sandwiches

### Rehydration Evaluation *

| Months of Storage | 70°F. Storage | 100°F. Storage | Cycle 0°F. - 70°F. Storage |
|---|---|---|---|
| Zero Time | The bread fully expanded to 12MM and was slightly wet. The filling separated into several pieces. | The bread fully expanded to 12MM and was slightly wet. The filling separated into several pieces. | The bread fully expanded to 12M and was slightly wet. The filli separated into several pieces. |
| 1 | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. |
| 2 | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. |
| 3 | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. |
| 4 | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. | The bread fully expanded to 12MM and was dry and resilient. The filling separated into several pieces. A slight amount of oil was evident on the rehydrated sandwich. |

* Dip in water for 7 seconds - let equilibrate at room temperature for 10 minutes.

TABLE IX

Storage Evaluation of Compressed Jelly Sandwiches

Rehydration Evaluation *

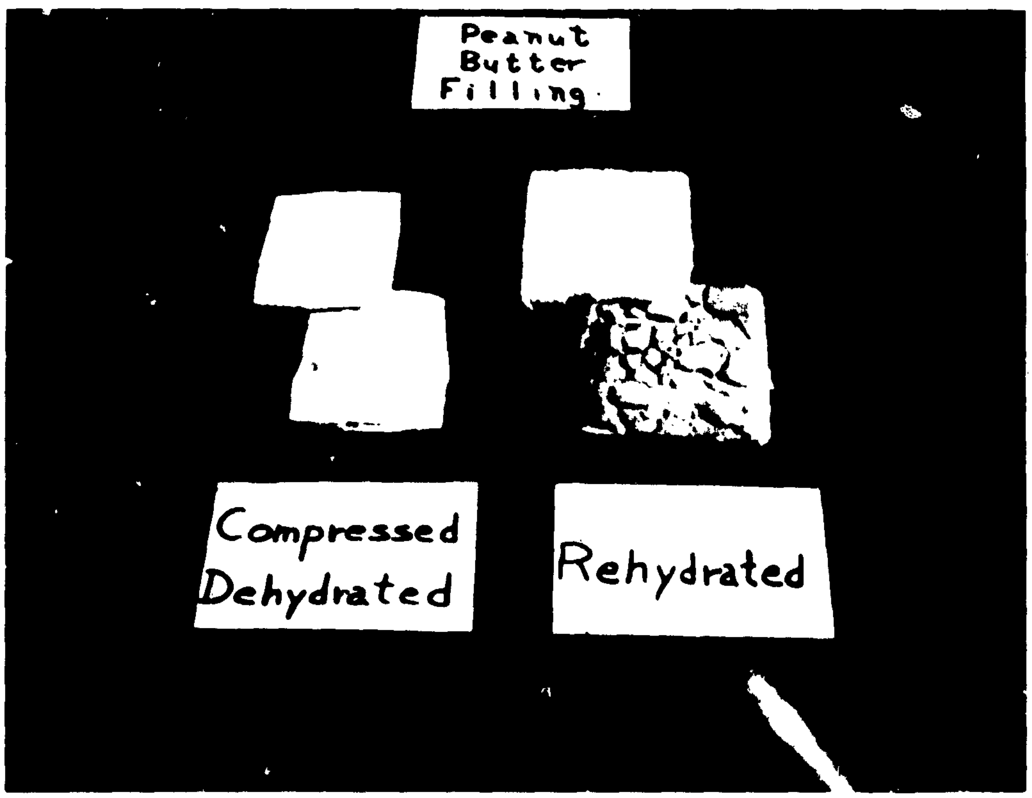
| Months of Storage | 70°F. Storage | 100°F. Storage | Cycle 0°F. - 70°F. Storage |
|---|---|---|---|
| Zero Time | The bread fully expanded to 12MM and was slightly wet. | The bread fully expanded to 12MM and was slightly wet. | The bread fully expanded to 12MM and was slightly wet. |
| 1 | The bread expanded to 9MM and was slightly wet. The bread in contact with the jelly was dry. | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. | The bread expanded to 10-11MM and was slightly wet. |
| 2 | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. |
| 3 | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. |
| 4 | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. | The sandwich was mottled prior to hydration. The bread did not expand and was very wet. |

* Dip in water for 7 seconds - let equilibrate at room temperature for 10 minutes.

As can be seen from Table VIII the peanut butter sandwiches perform well and, although a slight amount of oil is observed on the bread, it does not interfere with the hydration. This test also shows that on hydration the peanut butter slice separated into several pieces. It is believed that this cracking is due to the bread expanding on hydration while the peanut butter remains firm and does not expand. The cracking of the peanut butter slice after sandwich rehydration is shown in Picture VIII.

Picture VIII

Typical Cracking of Peanut Butter Slice on Sandwich Rehydration




Data in Table IX shows that the jelly sandwiches do not perform well After one month storage at 100°F. and at the two month interval under the other storage conditions, it was noted that the sandwiches had expanded slightly and, in addition, the bread was mottled by absorbed moisture or syrup. It is believed that under these storage conditions moisture may migrate to the bread from the jelly or a sugar inversion may occur in which a syrup is formed which is in turn absorbed by the compressed bread cover. Under storage in a vacuum pouch, plasticization of the bread occurs which limits bread expansion upon rehydration.

In an attempt to overcome moisture or syrup migration to the compressed bread a Modified Jelly Loaf was made. Preparation of this jelly was mentioned in Section XIA and its formula and preparation is described in the Appendix. Generally, the modified loaf contains an increased level of agar-agar to yield a firmer loaf and, in addition, is chilled to minimize sugar inversion.

A supplementary storage study was initiated in which the modified jelly was used to prepare compressed sandwiches for placement at 100°F. This study gave the same results on hydration as reported in the above test using the basic jelly loaf. This indicated that increasing the strength of the gel system does not prevent the bread from being mottled during storage with subsequent plasticization of the bread cover. It is theorized that packaging under less than 20 inches of vacuum may limit the transfer of jelly constituents which cause mottling to the bread cover. A study of this type, however, was not made during the contract period.

XIV. Compressed Dehydrated Cake

An additional objective of this contract was to develop two cake products which can be stored for extended periods in a collapsed state and be readily expanded to yield organoleptically acceptable products. As is generally known there is a wide range of cake structures. These range from highly foamed types such as angel food to compact types such as pound cakes. The various cake structures are obtained by formulation variation such as no shortening in angel food to fairly high shortening in pound cake. In addition, recipe preparation will impart differences in cake structure.

Initial research effort done with respect to compressed dehydrated cake was to select cake types for experimental use. It was decided not to use commercially available ready to eat cakes. This decision was prompted by the fact that there would be a wide variation in cake quality, shape, freshness, etc. which might cloud research results. Accordingly, it was decided to use commercially available cake mixes and bake cakes in the laboratory as required for experimental work. Toward this end the following cake mixes were selected.

| Cake Type | Brand of Cake Mix |
|---|---|
| White Cake | Swans Down |
| Yellow Cake | Swans Down |
| Angel Food Cake | Swans Down |
| Devil's Food Cake | Swans Down |
| Pound Cake | Betty Crocker |
| Sponge Cake | Pillsbury |

Using these packaged mixes, cakes were baked, sliced, subjected to compression tests, freeze dried and then subjected to rehydration tests. This work was aimed toward selecting the two cake structures having the best chance of meeting the desired compression and rehydration requirements. Work which was done is described in the following sections of this report.

A. Expansion Properties of Frozen Compressed Cakes

Swans Down's White, Yellow, Devil's Food and Angel Food cakes, Pillsbury's Golden Sponge cake and Betty Crocker Pound cake were mixed as directed by the manufacturer and baked in a loaf form. Baking in loaf form was selected in order to have cakes of uniform dimension and shape so as to permit easier slicing.

Twelve millimeter thick slices of the above cakes were wrapped in aluminum foil, conditioned overnight at 25°F., compressed to 4MM and frozen between plates charged with dry ice. The frozen slices were then allowed to thaw at room temperature with the results as indicated below:

| | |
|---|---|
| Sponge Cake | - Full expansion to 12MM |
| Angel Food Cake | - Full expansion to 12MM |
| Devil's Food Cake | - Center and upper one inch plasticized while the remainder fully expanded |
| Pound Cake | - Uniform expansion to 10-11MM |
| Yellow Cake | - Plasticized in center and full expansion around edges |
| White Cake | - Plasticized in center and full expansion around edges |

It is shown by the above data that the foam type cakes, Sponge and Angel Food fully expanded while the other cakes expanded in certain areas, primarily along the bottom and side edges. A comparison of the above processed cakes and the freshly baked cakes showed that the areas which fully expanded were the drier edge portions and the areas which plasticized were the wetter center and upper portions. On the assumption that these wetter areas were due to incomplete baking, caused by baking all the cakes in the loaf form, the Devil's Food, White and Yellow cakes were baked in shallow eight inch circular pans as recommended by the manufacturer. These cakes were sliced 12MM thick, compressed to 4MM and frozen between plates charged with dry ice. The frozen slices were then allowed to thaw at room temperature with the results tabulated below:

| | |
|---|---|
| Devil's Food Cake | - Full expansion to 12MM |
| White Cake | - Uniform expansion to approximately 9MM |
| Yellow Cake | - Moderate expansion to about 8MM |

It can be seen from a comparison of the two sets of data that baking the cake in the circular pans resulted in better expansion of the frozen compressed form than when they were baked in loaf form. This is probably due to a more uniform baking and thereby drier texture of the flatter circular ... the above data it was decided that future baking would be done in pans as recommended by the manufacturer, that is, White, Yellow and Devil's Food cakes in 8-inch circular pans, the Sponge and Angel Food cakes in 10-inch tube pans and the Pound cake in a 9" x 5" x 2-3/4" loaf pan. The method of preparation of the six cake types selected are reported in the Appendix.

Evaluation of the expansion characteristics of the frozen compressed cake structures indicated that no permanent structural deformation was caused due to compression. Best results were obtained with Sponge cake, Angel Food cake, Devil's Food cake, and Pound cake. As the next step it was decided to subject the various cake types to the entire process in which the compressed form is freeze dried. Studies with the freeze dried compressed cakes would then be directed toward an evaluation of the rehydration and expansion characteristics of the cake structure. This work is described in the following sections of this report.

B. Rehydration of Compressed-Dehydrated Cakes

The six cake types were baked as reported in the Appendix and processed as follows:

Twelve millimeter thick slices of the cakes were autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil and conditioned overnight at 25°F. The conditioned slices were then compressed to 4MM and frozen between plates charged with dry ice and freeze dried. Other slices were processed as above, but omitting the autoclaving step.

When the compressed dehydrated cake slices were rehydrated by dipping them in water for 6 seconds and allowing them to equilibrate at room temperature for 10 minutes it was found that the Sponge cake fully hydrated and expanded to a very soggy texture. The slice which was not autoclaved being more fully hydrated and soggier than the autoclaved slice. The other cake slices only hydrated on the surface with the water never penetrating into the center of the slice.

To determine if this inability of the water to penetrate the center of the slice was due to the rehydration technique or to a permanent deformation of the cake structure, occurring during the dehydration process, two slower, but more thorough techniques were employed. These techniques allowed for the slow application of moisture while the cake slices were hydrating and expanding to their fullest.

The two hydration techniques examined were:

1. Over a period of one hour water was applied to selected areas of the slice to allow it to rehydrate and expand to its fullest.

2. The slice was exposed to 90°F./85% relative humidity conditions for 80 hours to allow the slice to rehydrate slowly.

The results of the two rehydration techniques are reported in Table X and shown in Pictures IX, X and XI.

## TABLE X

### Rehydration of Compressed-Dehydrated Cakes

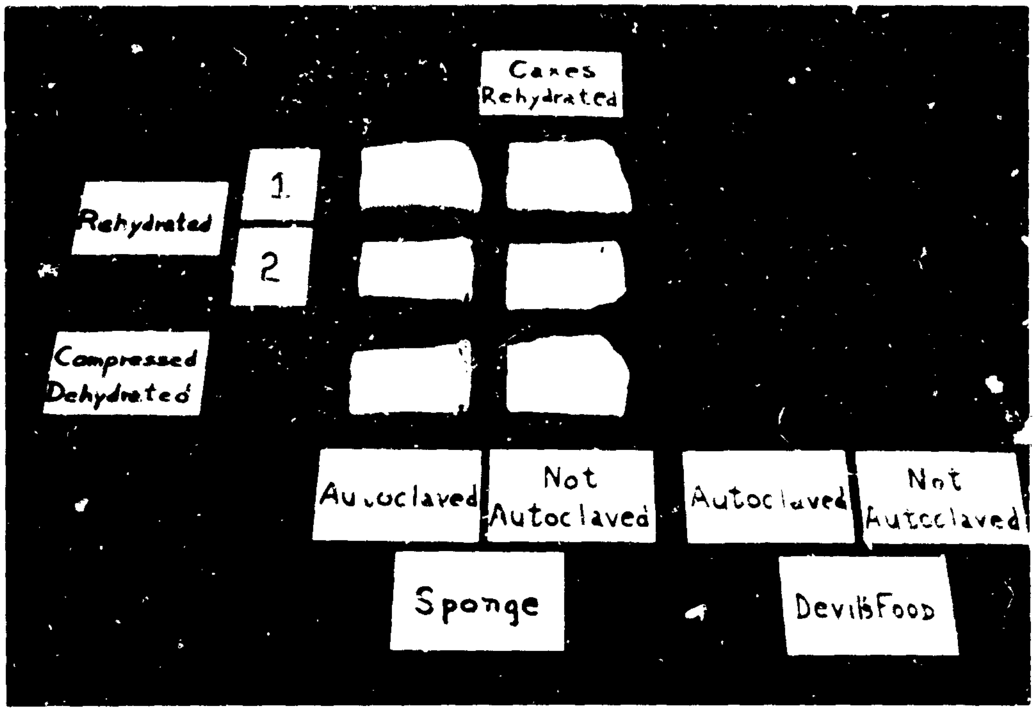
| Cake | Process | Hydration - Method 1[a] | Hydration - Method 2[b] |
|---|---|---|---|
| Sponge | Autoclaved | Moderate expansion to 8MM | Slight expansion to 5-6MM |
| | Not autoclaved | Full expansion | Moderate expansion to 6-8MM |
| Devil's Food | Autoclaved | Full expansion | Full expansion |
| | Not autoclaved | Full expansion | Edges expanded - center plasticized |
| Pound | Autoclaved | Full expansion | Full expansion |
| | Not autoclaved | Full expansion | Full expansion except for the edges |
| White | Autoclaved | Edges expanded - center plasticized | Edges expanded - center plasticized |
| | Not autoclaved | Edges expanded - center plasticized | Edges expanded - center plasticized |
| Yellow | Autoclaved | Edges expanded - center plasticized | Edges expanded - center plasticized |
| | Not autoclaved | Edges expanded - center plasticized | Edges expanded - center plasticized |
| Angel Food | Autoclaved | No expansion | No expansion |
| | Not autoclaved | Slight expansion to 5-6MM | Slight expansion to 5-6MM |

a. Selected application of water - in general all the slices were soggy on rehydration.

b. High humidity conditioning - in general all the slices were dry on rehydration.

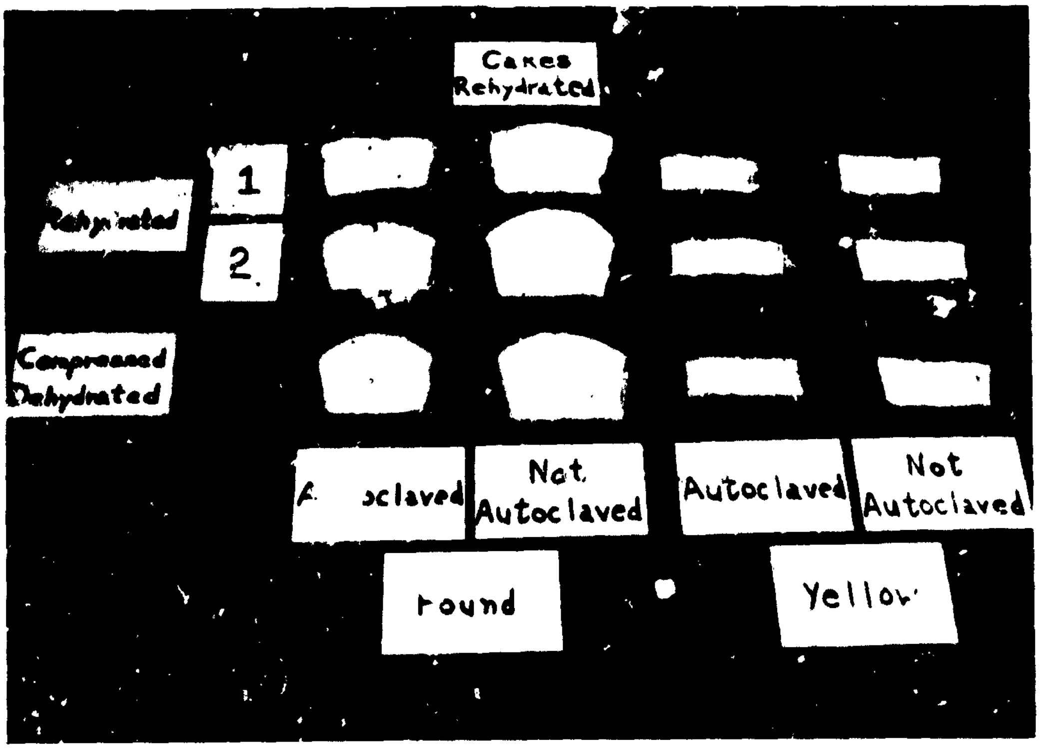
Picture IX

Forced Rehydration of Sponge and Devil's Food Cakes



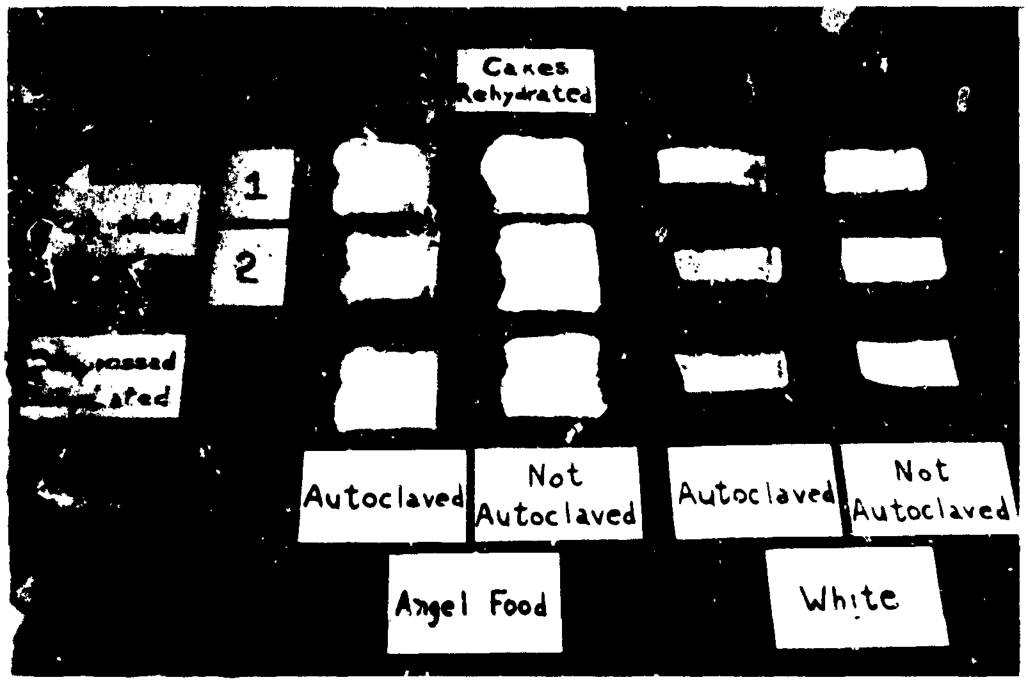

Picture X

Forced Rehydration of Pound and Yellow Cakes



Picture XI

Forced Rehydration of Angel Food and White Cakes




In these pictures the number 1 refers to rehydration method 1, that is, the selected application of water and the number 2 refers to rehydration method 2, that is, exposure to high humidity conditions. The remaining portions of the pictures are self-explanatory. A close examination of these pictures reveals that the White and Yellow cakes darken on autoclaving making them unacceptable from an appearence point of view.

The above data and pictures also show that the compressed-dehydrated Sponge, Devil's Food and Pound cakes have the ability to expand to their original dimensions on rehydration whereas the Angel Food, White and Yellow cakes do not. Based on the above data, it was decided to limit further investigation to the Sponge and Devil's Food cakes.

C. <u>Effect of Processing Variables on Sponge Cake</u>

The earlier work indicated that on rehydration a compressed-dehydrated Sponge cake slice which was not autoclaved expanded more fully and was slightly wetter than one which was autoclaved. To establish if conditions could be obtained which would result in a fully hydrated relatively dry slice the effect of processing variables such as autoclaving time, compression thickness, the moisture level of the compressed-dehydrated slice and the length of dip time were examined.

Twelve millimeter thick slices were autoclaved at 10 psig for 0, 5 and 10 minutes, wrapped in aluminum foil and conditioned overnight at 25°F. Samples of the various autoclaved and conditioned slices were compressed and frozen to 2, and 4MM between plates charged with dry ice and freeze dried for 6½ hours to a final moisture of 6.2%. These slices were dipped in 72°F. water for 3 seconds, equilibrated at room temperature for 10 minutes and evaluated as reported in Table XI which follows.

TABLE XI

Effect of Autoclaving and Compression on Sponge Cake

| Autoclaving Time (Minutes) | Compression Thickness (MM) | Evaluation * |
|---|---|---|
| 0 | 2 | Full expansion around edges and partial expansion in the center which was not fully hydrated. |
| | 3 | Full expansion around edges and partial expansion in the center which was not fully hydrated. |
| | 4 | Full expansion to 12MM and hydrated to a slightly soggy texture. |
| 5 | 2 | No expansion |
| | 3 | No expansion |
| | 4 | Moderate expansion to 7-11MM and hydrated to a slightly soggy texture. |
| 10 | 2 | No expansion |
| | 3 | No expansion |
| | 4 | Moderate expansion to 7-11MM and hydrated to a slightly soggy texture. |

* Dipped in 72°F. water for 3 seconds and equilibrated at room temperature for 10 minutes.

This work showed that when sponge cake slices are compressed to 4MM without being autoclaved they fully expand and are slightly soggy while the samples which were autoclaved did not fully expand and were also slightly soggy. It would appear, therefore, that autoclaving is not beneficial. This work also showed that compression to 2 and 3MM resulted in no expansion regardless of the time of autoclaving.

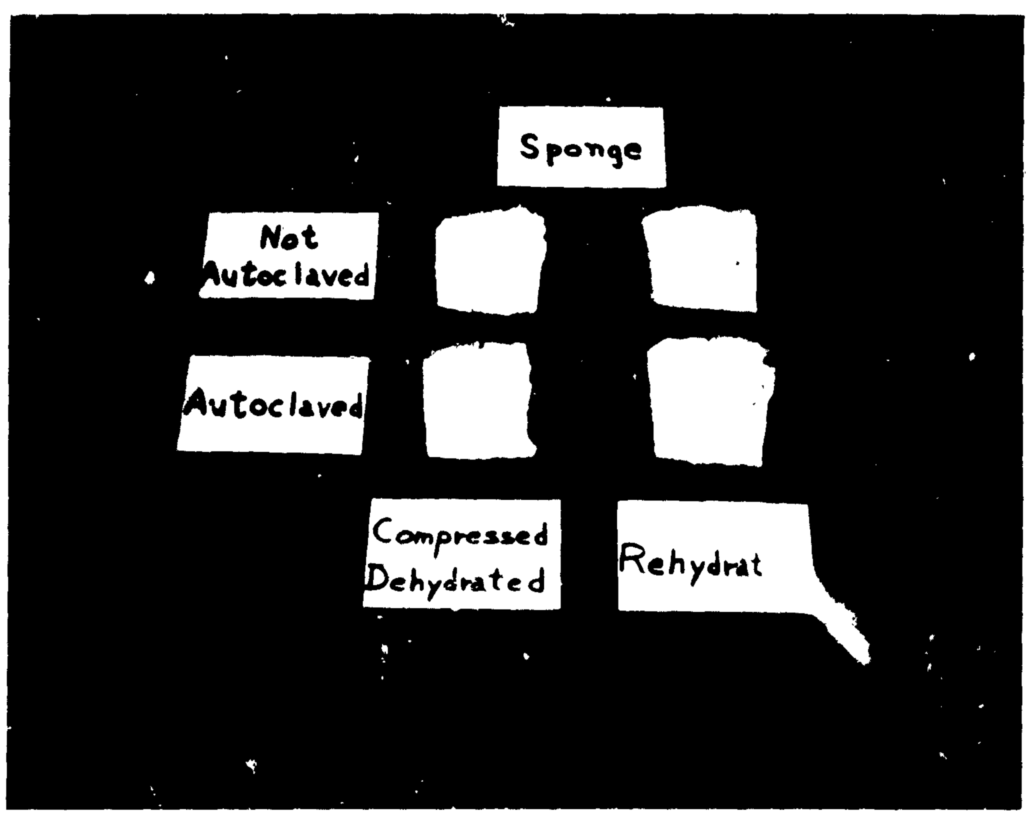
The effect of moisture content of the compressed Sponge cake slices prior to rehydration was also examined. Cake slices were stored under varying relative humidity conditions so that their moisture levels became stabilized at 1.5%, 6.2% and 9.0%. Rehydration experiments indicated no significant improvement with respect to rehydration tolerance or eating quality.

Length of dip time was also explored as a means of limiting water pickup. Dip times of 1 and 2 seconds were compared to the prior selected 3 second dip with no significant improvement noted.

Both the non-autoclaved and the 10 minute autoclaved samples of Sponge cake which were compressed to 4MM appeared to rehydrate satisfactorily as shown in Picture XII. Further studies to determine how the rehydrated slices compare to the fresh unprocessed cake with respect to final moisture and texture were made. In addition, packaged compressed sponge cake slices were made for storage evaluation.

Picture XII

Processed and Rehydrated Sponge Cake



D. Effect of Processing Variables on Devil's Food Cake

The earlier work, reported in Section XIVB, indicated that Devil's Food cake would be explored further in order to obtain a second cake type (in addition to Sponge cake) which can be compressed, dehydrated and subsequently rehydrated to an acceptable texture.

The work reported in this section details these explorations. The effect of autoclaving and compression thickness on the Devil's Food cake are reported below:

Twelve millimeter thick slices were autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil and conditioned overnight at 25°F. Samples of the conditioned slices were compressed and frozen to 4, 5 and 6MM between plates charged with dry ice and freeze dried for 6½ hours to a final moisture of 6.0 to 6.5%. Other slices were processed as above, but omitting the autoclaving.

When the cake slices were dipped in 72°F. water for 3 seconds, it was found that insufficient water for complete hydration and expansion was absorbed by the 4 and 5MM samples. Subsequently the 5MM sample was dipped for 5 seconds and the 4MM sample was dipped for 10 seconds. The results of this is tabulated below:

| | | |
|---|---|---|
| 4MM | Autoclaved | no hydration or expansion |
| | Non-autoclaved | no hydration or expansion |
| 5MM | Autoclaved | lower 3/4 of the slice fully hydrated and expanded |
| | Non-autoclaved | fully hydrated but not expanded |
| 6MM | Autoclaved | lower 3/4 of the slice fully hydrated and expanded |
| | Non-autoclaved | fully hydrated but not expanded |

An examination of the above processed cake slices and the freshly baked cake showed that the area which fully expanded was the drier bottom area and the area which did not fully expand was the wet upper portion and the crust. To eliminate the wet area, the baking time was increased from 45 to 55 minutes and the upper crust was removed.

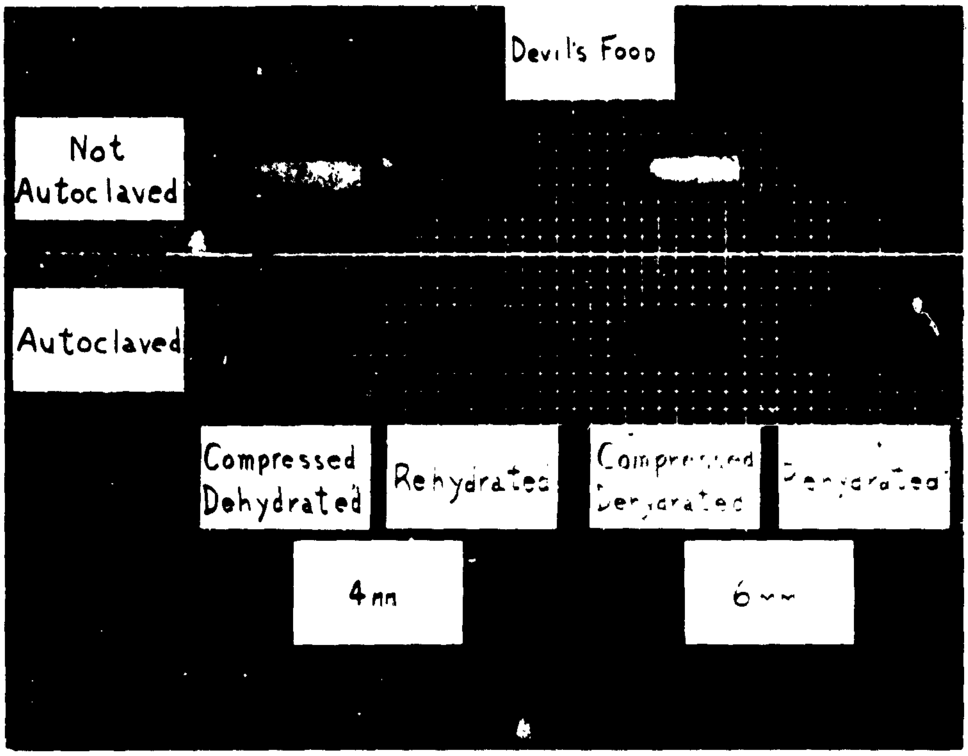
Using Devil's Food cake baked for 55 minutes, the above experiment was repeated and the results are tabulated as follows:

| | | | |
|---|---|---|---|
| 4MM | - Autoclaved | - | Expanded and hydrated only around the edges of the slice |
| | Non-autoclaved | - | Expanded and hydrated only around the edges of the slice |
| 5MM | - Autoclaved | - | Partial expansion and full hydration |
| | Non-autoclaved | - | Partial expansion and full hydration to a wet texture. |
| 6MM | - Autoclaved | - | Fully expanded to 10-12MM and fully hydrated to a slightly wet texture |
| | Non-autoclaved | - | Fully expanded to 10-12MM and fully hydrated to a wet texture |

An examination of the data indicated that the sample which was baked for 55 minutes, autoclaved at 10 psig for 10 minutes, compressed to 6MM and freeze dried, resulted in a product which when dipped in water for 3 seconds fully hydrated and expanded. Rehydration and expansion characteristics of the 4MM and 6MM samples are shown in Pictures XIII and XIV. The 6MM sample was evaluated further to determine how the rehydrated slices compare to the fresh unprocessed cake from which they were made. In addition, compressed Devil's Food cake slices were made and packaged for storage evaluation.

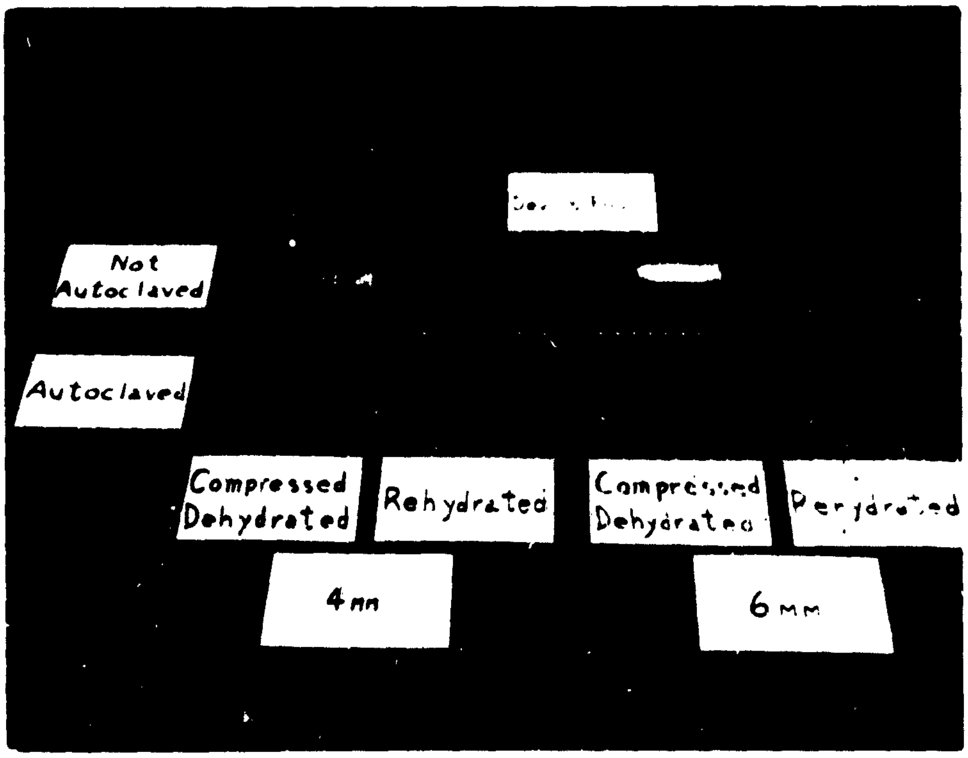
Picture XIII

Top View




Picture XIV

Angle View



E. Hydration of Compressed-Dehydrated Sponge and Devil's Food Cake Slices

In Section XIVC it was noted that both autoclaved and non-autoclaved Sponge cake slices which were compressed to 4MM prior to dehydration had acceptable texture on rehydration. It was also shown in Section XIVD that Devil's Food cake slices which were autoclaved and compressed to 6MM prior to dehydration had acceptable texture on rehydration. Work was done and is reported here to show how the rehydrated and expanded form of these two cake types compare to the fresh cakes from which they were processed in appearance and final moisture content.

This information was obtained as follows:

1. The autoclaved compressed Sponge and Devil's Food cake slices were dipped in 72°F. water for 3 seconds, and placed on an elevated wire mesh screen to stand for 10 minutes turning the slices over after 5 minutes. The slices were then -

a. Evaluated for appearance and texture.

b. Dried to determine their moisture content by placing the entire slices in a vacuum oven at 158°F. for 18 hours.

2. The non-autoclaved Sponge cake slices were dipped in 72°F. water for 2 seconds and evaluated as above.

3. The fresh Sponge and Devil's Food cake slices were also analyzed for moisture content.

The results of this experiment are reported in Table XII.

TABLE XII

Evaluation of Sponge Cake and Devil's Food Cake Samples

| Sample | As Is Thickness (MM) | As Is Moisture (%) | Dip Time (Seconds) | Final Thickness (MM) | Final Moisture (%) | Evaluation |
|---|---|---|---|---|---|---|
| Sponge Cake Control | 12 | 29.4 | 0 | 12 | 29.4 | Normal soft even sponge-like texture. |
| Sponge Cake Non-autoclaved | 4 | 7.0 | 2 | 11 - 12 | 35.3 | Fully hydrated and almost fully expanded to the normal soft even sponge-like texture. |
| Sponge Cake Autoclaved for 10 minutes at 10 psig | 4 | 7.5 | 3 | 7 - 11 | 33.2 | Similar to above, but not as fully or uniformly expanded. |
| Devil's Food Cake Control | 12 | 36.1 | 0 | 12 | 36.1 | Normal uniform texture. |
| Devil's Food Cake Autoclaved for 10 minutes at 10 psig | 6 | 6.6 | 3 | 12 | 46.9 | Fully hydrated and almost fully expanded to a slightly moist texture. |

As can be seen from the data in Table XII all experimental samples have relatively good texture on hydration and contain slightly more moisture than the controls. The Sponge cake which was not autoclaved is more fully expanded and more moist than the autoclaved sample. The Devil's Food cake sample had the largest increase in water uptake when compared to its control. However, it should be noted that this particular control was a very thoroughly baked sample (55 minutes baking instead of 45 minutes) and, therefore, its moisture content was less than would be normally expected.

F. Storage Study of Compressed-Dehydrated Sponge and Devil's Food Cake Slices

Sponge cake and Devil's Food cake slices were processed to the dry compressed form as described below:

Twelve millimeter thick slices were autoclaved at 10 psig for 10 minutes, wrapped in aluminum foil and conditioned overnight at 25°F. The conditioned slices were compressed between plates charged with dry ice and freeze dried.

Additional Sponge cake slices were processed as above, but omitting the autoclaving procedure. Sponge cake slices were compressed to 4MM and the Devil's Food cake to 6MM. Samples were vacuum packed in pouches consisting of cellophane/polyethylene/0.00035 foil/polyethylene (130C-7P-35F-30P). The packaged samples were placed in conditioned storage rooms maintained at 70°F. and 100°F. and cycled three times a week between 0°F. and 70°F. Representative samples were examined bacteriologically prior to initiating the storage test. Results which are reported below indicate the cakes to be in excellent bacteriological condition prior to placement in storage.

| | Autoclaved Sponge Cake | Non-Autoclaved Sponge Cake | Autoclaved Devil's Food Cake |
|---|---|---|---|
| Standard Plate Count | 10 | 10 | <10 |
| Thermophils | <10 | <10 | <10 |
| Coliforms | <10 | <10 | <10 |
| Mold | <10 | <10 | <10 |
| Yeast | <10 | <10 | <10 |
| Staphyococci | none detected | none detected | none detected |
| Streptococci | none detected | none detected | none detected |
| Fecal Enterococci | none detected | none detected | none detected |
| Salmonella | none detected | none detected | - |

The samples are scheduled to be evaluated on a monthly basis for a period of six months. Table XIII summarizes the zero time and one and two month evaluation of the Sponge cake slices. The Devil's Food cake slices have not been in storage long enough to permit an evaluation.

TABLE XIII

Storage Evaluation of Sponge Cake Slices

Rehydration Evaluation *

| Months of Storage | Sample | 70°F. Storage | 100°F. Storage | Cycle 0°F. - 70°F. Storage |
|---|---|---|---|---|
| 0 Control | Autoclaved | Fully hydrated and expanded to 11-12MM to a very good texture. | Fully hydrated and expanded to 11-12MM to a very good texture. | Fully hydrated and expanded to 11-12MM to a very good texture |
| | Non-autoclaved | Fully hydrated and expanded to 10-11MM to a very good texture. | Fully hydrated and expanded to 10-11MM to a very good texture. | Fully hydrated and expanded to 10-11MM to a very good texture. |
| 1 | Autoclaved | Almost fully hydrated and expanded to 8-9MM to a very dry crumb. | Not fully hydrated or expanded - center was dry and hard. | Not fully hydrated or expanded - center was dry and hard. |
| | Non-autoclaved | Fully hydrated and expanded to 8-10MM to a slightly wet, but good textured crumb. | Fully hydrated and expanded to 8-10MM to a slightly wet, but good textured crumb. | Fully hydrated and expanded to 8-10MM to a slightly wet but good textured crumb. |
| 2 | Autoclaved | Center was hard and dry. Edges were hydrated and expanded to 8-10MM. | Center was hard and dry. Edges were hydrated and expanded to 8-10MM. | Center was hard and dry. Edges were hydrated and expanded to 8-10MM. |
| | Non-autoclaved | Fully hydrated and expanded to 8-10MM to a slightly wet, but good textured crumb. | Fully hydrated and expanded to 8-10MM to a slightly wet, but good textured crumb. | Fully hydrated and expanded to 8-10MM to a slightly wet but good textured crumb. |

* Dip in water for 3 seconds - let equilibrate at room temperature for 10 minutes.

Data in Table XIII shows, within the limits of this study, the non-autoclaved compressed-dehydrated Sponge cake slices to store better than the autoclaved samples, having greater tolerance to the temperature conditions to which they were exposed. The non-autoclaved Sponge cake slices were fully hydrated and expanded to approximately 10MM after being in storage for two months whereas the autoclaved slices were not fully hydrated or expanded after only one month in storage. This storage study will be continued with the results obtained on the Sponge and Devil's Food cake slices being reported when the study is completed.

## XV. Compressed-Dehydrated Waffles

An additional objective of this contract was to develop a compressed-dehydrated waffle which can be stored for extended periods and be readily expanded to yield an organoleptically acceptable waffle.

For this work we selected a commercially available waffle mix manufactured by the Quaker Oats Company under the Aunt Jemima Pancake label. The waffles were made according to the manufacturer's suggested recipe and cooked on a teflon coated electric waffle iron. The particulars of this preparation are reported in the Appendix.

### A. Effect of Processing Variables on Waffles

To determine the effect of autoclaving and compression thickness the following was done:

Waffles which are 14-15MM at their thickest point were autoclaved for 10 minutes at 10 psig, wrapped in aluminum foil and conditioned overnight at 25°F. Samples of the conditioned slices were compressed and frozen to 4, 5 and 6MM between plates charged with dry ice and freeze dried for 6½ hours. Other slices were processed as above, but omitting the autoclaving. The dried samples were then conditioned overnight at 70°F./50% R.H. to 7-8% moisture.

On rehydrating the waffles by dipping them for 6 seconds in 72°F. water the following results were obtained:

| | | |
|---|---|---|
| 4MM | Non-autoclaved | not fully hydrated or expanded |
| | Autoclaved | not fully hydrated or expanded |
| 5 & 6MM | Non-autoclaved | fully hydrated and expanded to a relatively good texture |
| | Autoclaved | not fully hydrated or expanded |

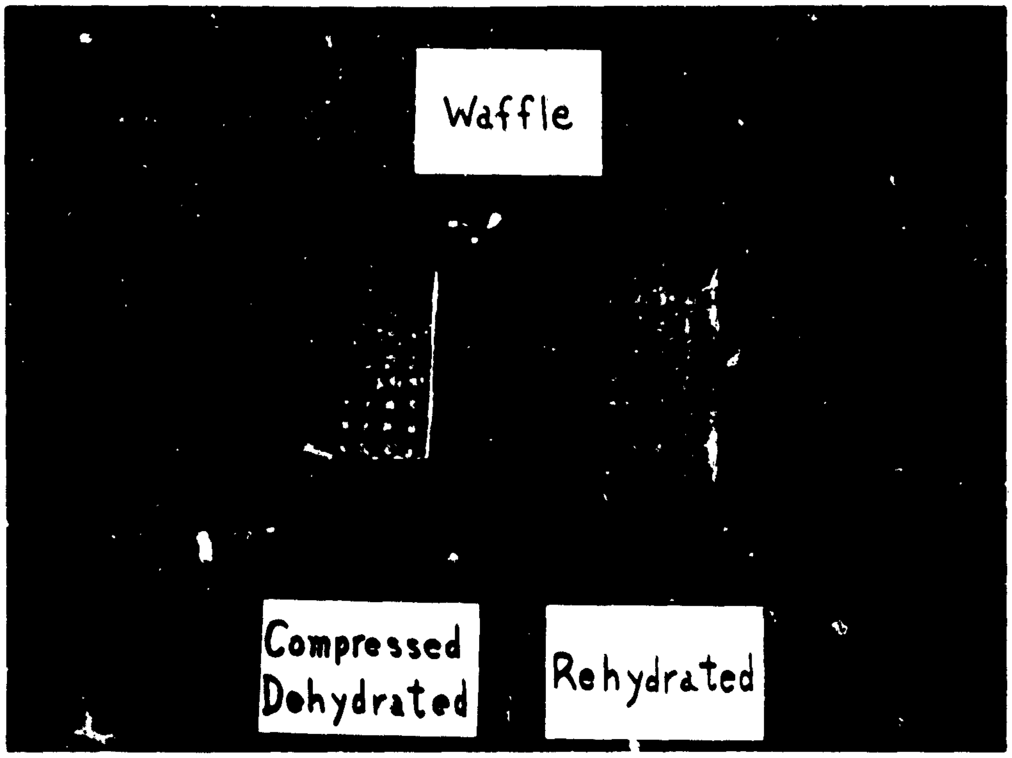
Increasing the length of dip time of the autoclaved waffles to 10 seconds had little effect on their rehydration properties.

It can be seen from this data that autoclaving waffles results in products which are only poorly rehydrated when compared to the non-autoclaved counterpart.

The non-autoclaved waffle, which was compressed to 5MM, hydrated satisfactorily and is shown in Pictures XV and XVI. Further work was done to determine how the rehydrated and expanded waffle form compared to the fresh unprocessed waffle with respect to final moisture and texture. In addition, compressed dehydrated waffles were made and packaged for storage evaluation.

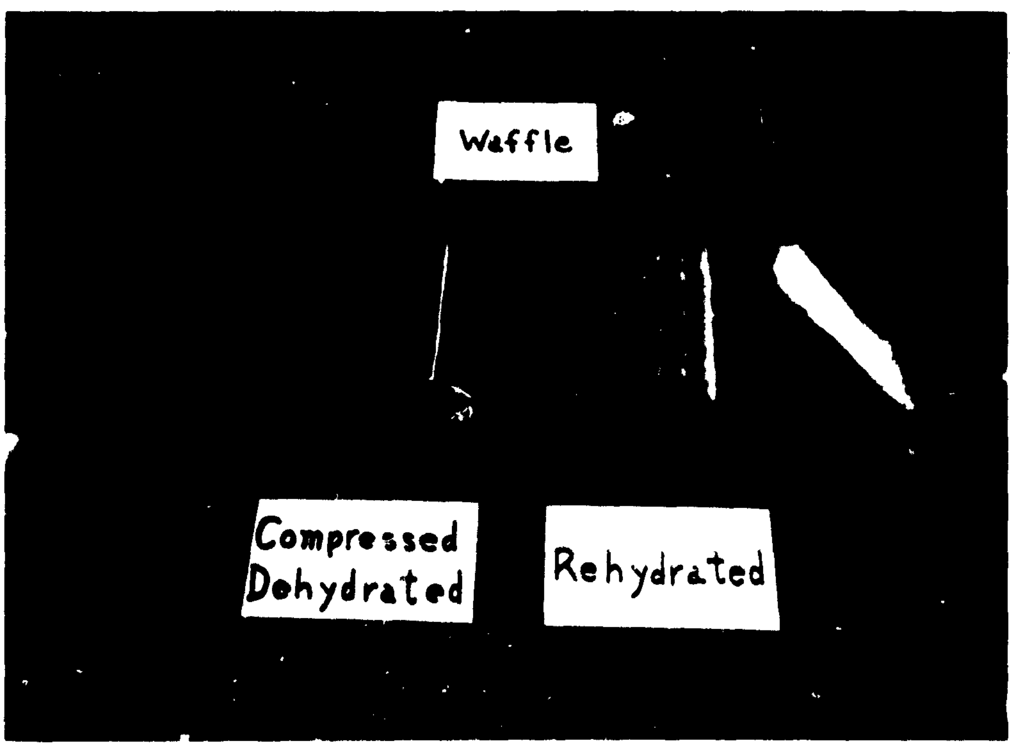
Picture XV

Top View




Picture XVI

Angle View



B. Rehydration of Compressed-Dehydrated Waffles

The non-autoclaved waffles which were conditioned overnight at 25°F., compressed to 5MM between plates charged with dry ice and freeze dried and equilibrated to 7-8% moisture were evaluated for total moisture content after rehydration.

The slices were dipped in 72°F. water for 6 seconds and placed on an elevated wire mesh screen to stand for 10 minutes, turning the waffles over after 5 minutes. The waffles were then dried to determine their moisture content by placing the entire waffle in a vacuum oven at 158°F. for 18 hours. The fresh waffles were also analyzed for moisture content in the same way.

The results of this work showed that the rehydrated waffles had a moisture content of 48.5% as compared to a moisture content of 44.8% for the fresh waffles.

C. Storage Study of Compressed-Dehydrated Waffles

The waffles, as processed in Section B above, were packed under 20 inches of vacuum in cellophane/polyethylene/foil/polyethylene (130C-7P-35F-30P). The packaged samples were placed in conditioned storage rooms at 70°F. and 100°F. Additional samples are being cycled three times a week between 0°F. and 70°F.

Prior to placing the samples in storage, representative units were examined bacteriologically. Results which are as follows indicated the waffles to be in excellent condition.

| | |
|---|---|
| Standard Plate Count | 70 |
| Thermophils | 30 |
| Coliforms | <10 |
| Mold | <10 |
| Yeast | <10 |
| Staphylococci | none detected |
| Streptococci | none detected |
| Fecal Enterococci | none detected |

The samples are scheduled to be evaluated on a monthly basis for a period of six months. Since the storage test was only recently started, no indications of possible change due to storage are as yet available.

## CONCLUSIONS

Freeze compression was found to be a very effective method of compressing baked porous products at their full moisture content as normally prepared without altering their characteristic texture and structure.

Freeze compression coupled with freeze drying was found to be an effective method of preventing compressed baked porous products from expanding during dehydration. Furthermore, resulting freeze dried structures were found to retain the compressed form when their moisture content was reduced to approximately 10% or less.

The freeze compression-freeze drying process was successfully applied to crustless commercial white bread slices, Sponge cake, Devil's Food cake and waffles. Final compressed thickness in the dehydrated form ranged from 1/3 the original slice thickness for bread to about 1/2 the original slice thickness for Devil's Food cake.

The compressed-dehydrated forms were found to rehydrate and expand by dipping for a short time in water. Upon standing for about five minutes to permit moisture equilibration the various rehydrated and expanded structures were found to resemble their fresh counterparts with respect to appearance, flavor, texture and moisture content.

Attempts to apply the freeze compression-freeze drying process to commercial white bread slices containing the normal crust area proved unsuccessful. Although a satisfactory compressed-dehydrated form was made, it was found that while the crumb area rehydrated and expanded normally, the crust area remained hard and only partially hydrated. This is a recognized deficiency and will require further investigation to determine means of improving rehydration of the crust area.

Compressed crustless bread slices were subjected to difference testing by both triangle test and single stimulus testing procedures. Generally it was found that the experimental bread rated well with respect to appearance and flavor. Texture differences were noted, however, with the experimental bread being identified as being wetter and heavier to the touch. No data is available with respect to acceptance. It is believed that acceptance data should be obtained for compressed bread under some form of field use.

A formulation and technique was identified to prepare jelly and peanut butter sandwich fillings in a loaf form. The loaf can be sliced in a manner similar to processed cheese and provides a filling for compressed sandwich use.

Prepared compressed jelly and peanut butter sandwiches were made by placing the sliced sandwich fillings between compressed crustless bread slices. Satisfactory rehydration and expansion is obtained by dipping the entire sandwich in water.

Storage testing of the various compressed prototypes was conducted at 70°F., under cycling conditions of 0°F. to 70°F. and at 100°F. Compressed bread stored very well for six months at 70°F. and under the cycling conditions. Deterioration was noted at 100°F. Compressed peanut butter sandwiches have shown satisfactory storage properties to date of four months at all conditions. Compressed jelly sandwiches failed after one month at 100°F. and two months at the 70°F. and cycling conditions. Compressed Sponge cake slices have shown no deterioration after two months under all conditions. Compressed Devil's Food cake and compressed waffles are in storage and awaiting a scheduled evaluation.

## PLANS

This is the final report for Phase II of work done on the Compressed Bread Contract and no additional exploratory research is scheduled. Prototype samples which were processed by the defined Phase II freeze compression-freeze drying process and presently in storage will be evaluated by the Corporate Research Department of General Foods Corporation to the end of a six month storage test period.

# APPENDIX

The following is included in the Appendix of this report:

A. Standard Bread Formula
B. Method of Preparation of Standard Bread
C. Phase I Process
D. Method of Rehydration - Phase I Process
E. Picture XVII Compression-Freezing Plates for Carver Press
F. Picture XVIII Compression-Freezing Plates Mounted on Carver Press
G. Basic Jelly Formula
H. Preparation of Basic Jelly Loaf
I. Modified Jelly Formula
J. Preparation of Modified Jelly Loaf
K. Basic Peanut Butter Formula
L. Preparation of Basic Peanut Butter Loaf
M. Picture XIX Typical Jelly and Peanut Butter Loaves
N. Preparation of White Cake - Swans Down
O. Preparation of Yellow Cake - Swans Down and Devil's Food Cake - Swans Down
P. Preparation of Modified Devil's Food Cake - Swans Down
Q. Preparation of Angel Food Cake - Swans Down
R. Preparation of Golden Pound Cake - Betty Crocker
S. Preparation of Golden Sponge Cake - Pillsbury
T. Preparation of Waffles - Aunt Jemima Pancake

## STANDARD BREAD FORMULA

| Ingredients | Composition Grams/Batch | Per Cent |
|---|---|---|
| **Part I** | | |
| Water (110°F.) | 295.0 | 18.44 |
| Dry Yeast, active | 15.0 | 0.94 |
| **Part II** | | |
| Water (80°F.) | 273.0 | 17.06 |
| Sucrose | 40.0 | 2.50 |
| Milk Solids, non-fat | 34.0 | 2.12 |
| Carrageenan, Sea Kem, Type 7 | 4.2 | 0.26 |
| **Part III** | | |
| Flour Mixture* | 428.0 | 26.75 |
| **Part IV** | | |
| Flour Mixture* | 425.0 | 26.56 |
| Lard | 50.0 | 3.12 |
| Salt | 21.0 | 1.31 |
| Emulsifier** | 15.0 | 0.94 |
| | 1600.2 grams | 100.00% |

*Consists of 74 per cent Bakers Flour milled from selected Northwestern Bakery type wheat and 26 per cent raw edible wheat starch. Specifications for the flour are 0.47 - 0.51 ash, 14.8 - 15.1 protein, moisture 14%.

**All vegetable emulsifier for yeast raised baked goods. Mono and diglycerides of edible fats or oils.

## METHOD OF PREPARATION OF STANDARD BREAD

Bread Baking

1. Prepare flour mixture by blending flour and starch.

2. Part 1 - Dissolve yeast in water at 110°F. by blending at low speed in Hobart mixer for five minutes using McDuffy Bowl.

3. Part II - Dissolve carrageenan in water at 80°F. by blending at medium speed in Mixmaster for five minutes. Add sugar and milk solids and blend for additional five minutes.

4. Add Part II to Part I and blend for one minute at low speed.

5. Part III - Add flour mixture and blend for five minutes at low speed.

6. Part IV - Add flour mixture, lard salt and emulsifier and blend for five minutes at low speed.

7. Place dough in glass bowl and ferment for 30 minutes at 85°F.

8. Divide dough in half, roll dough out with rolling pin into flat sheets approximately 18" long x 8" wide, pat with hands to remove excess air.

9. Form loaf by rolling into jelly roll shape - place in greased 4" x 4" x 13" pullman pan.

10. Proof for one hour at 85°F.

11. Bake with cover for 50 minutes at 350°F.

12. Cool - slice 12MM thick.

## PHASE I - PROCESS

### Autoclaving - Dehydration - Compression

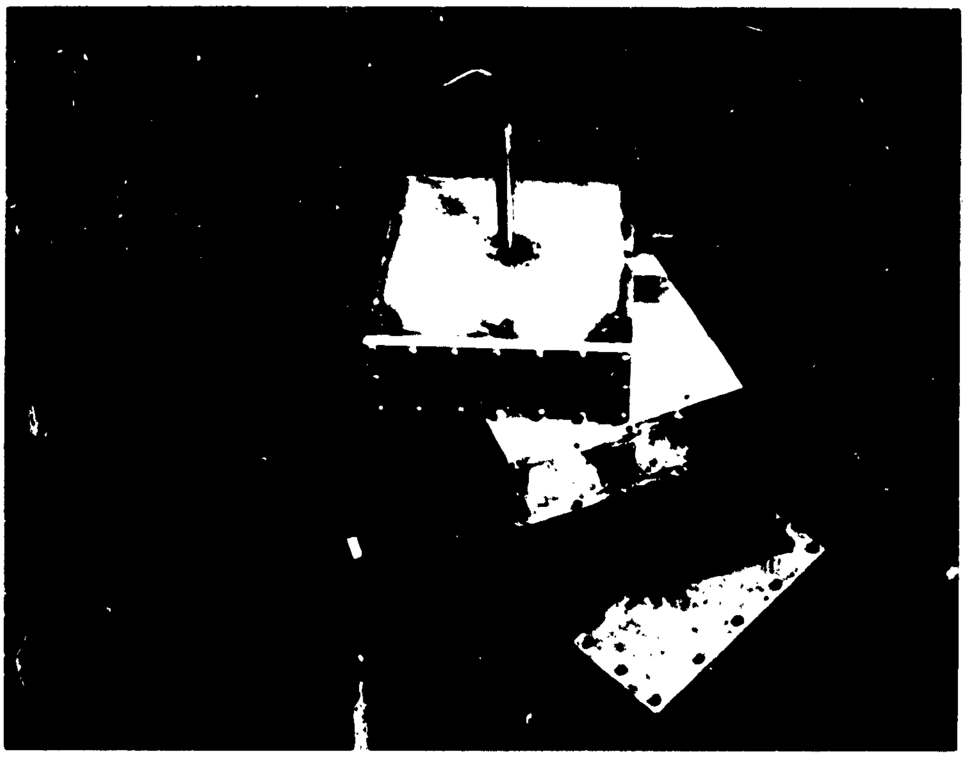
1. Autoclave bread slices (uncovered) for 10 minutes at 10 psig (238°F.) in a standard autoclave or sterilizer.
2. Dry breads to 13 - 15% moisture by placing in a forced air dryer maintained at 125°F. for 45 minutes.
3. Equilibrate bread slices in sealed jars for at least three hours.
4. Compress to 4MM in press - hold compressed for 30 seconds.
5. Dry to 8 - 10% moisture in forced air dryer maintained at 125°F. for 15 - 20 minutes.
6. Package in foil/poly/foil pouch or other good moisture protection pouch.

### METHOD OF REHYDRATION

1. Place dried compressed bread slice in excess water - hold submerged in water for 3 seconds.
2. Shake bread slice to remove excess surface water.
3. Place on paper towel - let rehydrate for a minimum of ten minutes.

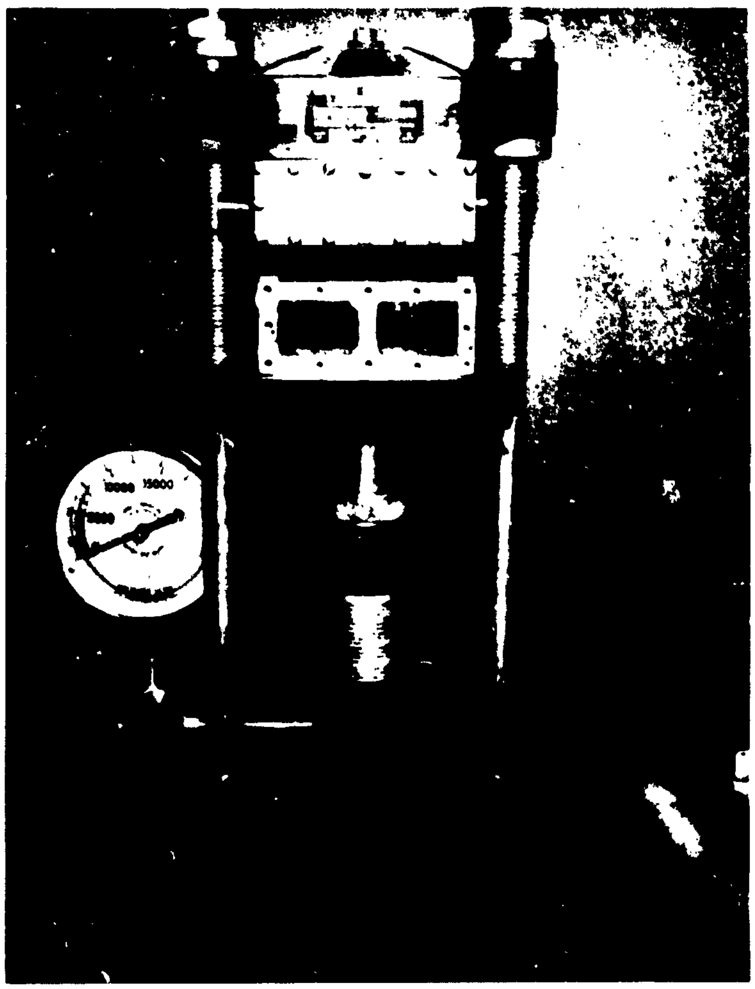
Picture XVII

Compression-Freezing Plates for Carver Press



Picture XVIII

Compression-Freezing Plates Mounted on Carver Press



## BASIC JELLY FORMULA

| Ingredients | Composition Grams/Batch | Percent |
|---|---|---|
| **Part I** | | |
| Water | 200.00 | 34.15 |
| Dextrose - Cerelose 2041 | 87.58 | 14.93 |
| Agar-Agar* | 5.25 | 0.90 |
| Tri-sodium citrate | 0.92 | 0.16 |
| Salt | 0.62 | 0.11 |
| Color - Jell-O Color CG-3 | 0.16 | 0.03 |
| Flavor** | 0.15 | 0.03 |
| **Part II** | | |
| Sugar | 266.0 | 45.42 |
| **Part III** | | |
| Water | 20.00 | 3.41 |
| Citric Acid | 5.00 | 0.85 |
| | 585.68 | 99.99 |

***Penick and Co. No. 1 Powdered WCB-673**

****Permaseal Imitation Grape Flavor F-3033 Givaudan Flavors, Inc.**

## PREPARATION OF BASIC JELLY LOAF

1. Part I - Dry blend the dextrose, agar-agar, tri-sodium citrate, salt, color and flavor.

2. Add the above to the water in a double boiler and heat to 188-190°F., maintaining this temperature for 5 minutes.

3. Add Part II to the above and bring back to 188-190°F., maintaining this temperature for 5 minutes and remove from the heat.

4. Part III - Dissolve the citric acid in the water and blend into cooked jelly mixture.

5. Cast into a loaf mold and cool at room temperature.

6. Slice to 4MM using a cheese slicer.

## MODIFIED JELLY FORMULA

| Ingredients | Composition Grams/Batch | Composition Per Cent |
|---|---|---|
| **Part I** | | |
| Water | 200.00 | 34.05 |
| Dextrose - Cerelose 2041 | 87.58 | 14.91 |
| Agar-Agar* | 7.00 | 1.19 |
| Tri-sodium citrate | 0.92 | 0.16 |
| Salt | 0.62 | 0.11 |
| Color - Jell-O Color CG-3 | 0.16 | 0.03 |
| Flavor** | 0.15 | 0.03 |
| **Part II** | | |
| Sugar | 266.00 | 45.28 |
| **Part III** | | |
| Water | 20.00 | 3.40 |
| Citric Acid | 5.00 | 0.85 |
| | 587.43 | 100.01 |

*Penick and Co. No. 1 Powdered WCB-673

**Permaseal Imitation Grape Flavor F-3033 Givaudan Flavors Inc.

PREPARATION OF MODIFIED JELLY LOAF

Preparation is the same as for the Basic Jelly Loaf but the loaf mold is cooled in an ice bath.

## BASIC PEANUT BUTTER FORMULA

| Ingredients | Composition Grams/Batch | Per Cent |
|---|---|---|
| **Part I** | | |
| Milled Peanut @ 37% oil | 850.0 | 80.19 |
| Frosting Sugar | 50.0 | 4.72 |
| Salt | 10.0 | 0.94 |
| **Part II** | | |
| Wecobee Fat - SS | 150.0 | 14.15 |
| | 1060.0 | 100.00 |

PREPARATION OF BASIC PEANUT BUTTER LOAF

1. Place milled peanuts in a steam jacketed Hobart bowl with the frosting sugar and salt. Mix with a paddle and heat mixture by passing stream through the jacketed bowl.

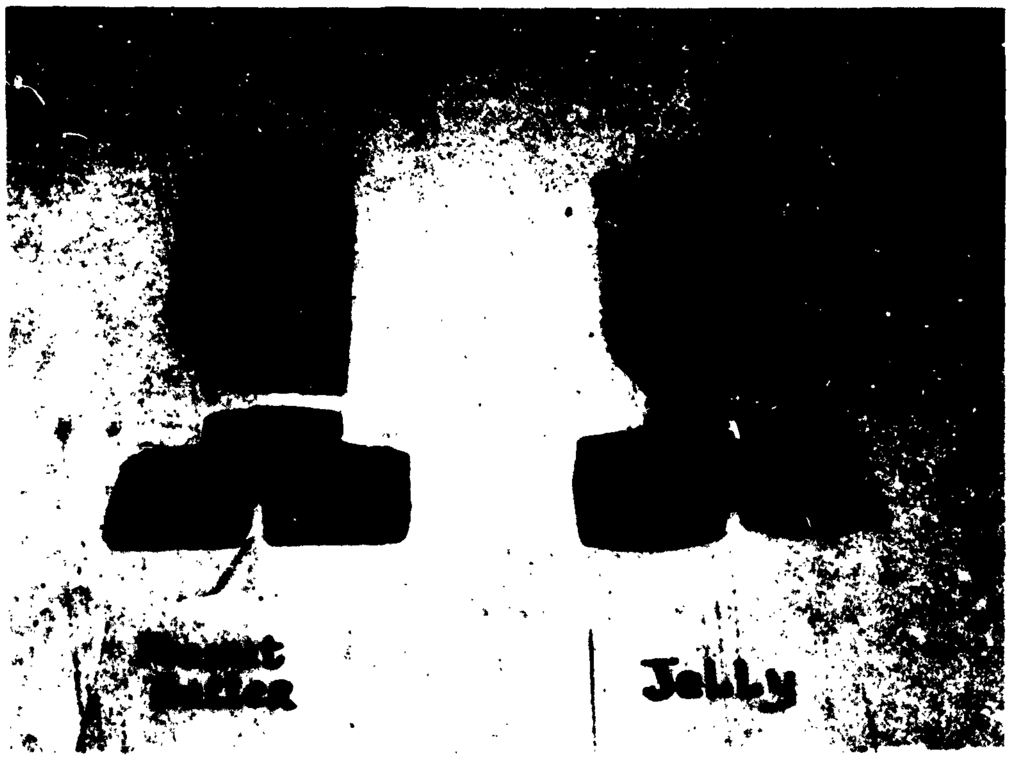
2. Melt the Wecobee Fat, add to the above and mix well at speed #1.

3. Cast into mold and cool at room temperature.

4. Cool slightly, in the refrigerator, to firm up the loaf, and slice to 4MM using a cheese slicer.

Picture XIX

Typical Jelly and Peanut Butter Loaves



PREPARATION OF WHITE CAKE - SWANS DOWN

1. To the cake mix in the large bowl add 1-1/4 cups of water and 2 unbeaten egg whites.

2. Using a Sunbeam Mixmaster blend at speed #1 for 30 seconds to moisten. Beat at speed #3 for 3 minutes.

3. Turn into two 8-inch circular pans fitted with pan liners.

4. Bake for 35 minutes in an oven preheated at 350°F.

5. Cool in pans for 10 minutes, then remove and cool on cake rack.

PREPARATION OF
YELLOW CAKE - SWANS DOWN
DEVIL'S FOOD CAKE - SWANS DOWN

1. To the cake mix in the large bowl add $1\frac{1}{4}$ cups of water and 2 unbeaten eggs.

2. Using a Sunbeam Mixmaster blend at speed #1 for 30 seconds to moisten. Beat at speed #3 for 3 minutes.

3. Turn into two 8-inch circular pans fitted with pan liners.

4. Bake for 45 minutes in an oven preheated at 350°F.

5. Cool in pans for 10 minutes, then remove and cool on cake racks.

PREPARATION OF
MODIFIED DEVIL'S FOOD CAKE - SWANS DOWN

Preparation is the same as for the Devil's Food cake as reported above, except the cakes are baked for 55 minutes in an oven preheated at 350°F.

## PREPARATION OF ANGEL FOOD CAKE - SWANS DOWN

1. To the contents of package 1 in the large bowl add 1-1/3 cups of water.

2. Using a Sunbeam Mixmaster blend at speed #1 for 1 minute to moisten. Beat at high speed for 3 minutes to form peaks.

3. While mixing at speed #1 add package 2 to the above over a period of 1 minute.

4. Blend at speed #3 for 1-1/2 minutes.

5. Turn into an ungreased 10-inch tube pan.

6. Bake for 45 minutes in an oven preheated to 375°F.

7. Cool upside down in pan, placing tube of pan over a narrow long-necked flask so air can circulate all around cake.

## PREPARATION OF GOLDEN POUND CAKE - BETTY CROCKER

1. To the cake mix in the small bowl add 1/2 cup of water and 2 unbeaten eggs.
2. Using a Sunbeam Mixmaster blend at speed #1 for 30 seconds to moisten. Beat at speed #3 for 3 minutes.
3. Turn into a well greased and floured 9" x 5" x 2-3/4" pan.
4. Bake for 60 minutes in an oven preheated at 350°F.
5. Cool in pans for 10 minutes, then remove and cool on cake rack.

## PREPARATION OF GOLDEN SPONGE CAKE - PILLSBURY

**Part I**

1. To the contents of package 1 in the large bowl add 1 cup of water.

2. Using a Sunbeam Mixmaster blend at speed #3 for 2 minutes. Beat at high speed for 5 minutes.

**Part II**

3. To the contents of package 2 in the small bowl add 1/3 cup of water and 2 unbeaten eggs.

4. Using a Sunbeam Mixmaster blend at speed #1 for 1 minute to moisten. Beat at high speed for 2 minutes.

5. Pour Part II over Part I and gently fold together until evenly blended.

6. Turn into an ungreased 10-inch tube pan and cut through batter to remove air bubbles.

7. Bake for 50 minutes on the lowest rack in an oven preheated to 350°F.

8. Cool upside down in pan, placing tube of pan over a narrow long-necked flask so air can circulate all around cake.

## PREPARATION OF WAFFLES - AUNT JEMIMA PANCAKE

1. To one cup of milk, one egg and three tablespoons of Mazola Oil in a small bowl is added one cup of the mix.

2. Beat by hand with a wooden spoon until the batter is relatively smooth. A somewhat lumpy batter is acceptable.

3. Three-quarters of a cup of the batter is baked on a General Electric Automatic Waffle Grill Baker, supplied with a teflon coated grill, for three minutes at the low setting.

4. Each waffle is divided into four sections and approximately $\frac{1}{2}$-inch is trimmed from the top and bottom of each waffle. The trimming is necessary so that the waffle could fit on the compression plates being used.

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13 ABSTRACT

This final report describes a process by which full moisture baked goods can be freeze-compressed and freeze-dried. The compressed dry form is immersed in water to rehydrate and expand to resemble the fresh counterpart. Successful application was made to sliced white bread, sponge cake, devil's food cake and waffles. Sliceable jelly and peanut butter were formulated which were combined with the prior processed compressed bread to make complete compressed sandwiches. Difference testing of compressed bread indicated similarity to a control bread with respect to appearance and flavor with texture of the experimental classified as being slightly moist. Storage testing of the various compressed prototypes was conducted at 70°F., under cycling conditions of 0°F. to 70°F. No appreciable change was noted at the 70°F. and cycling storage conditions for periods up to six months. Deterioration did occur at 100°F. which requires further investigation.

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| 14. KEY WORDS | LINK A ROLE | LINK A WT | LINK B ROLE | LINK B WT | LINK C ROLE | LINK C WT |
|---|---|---|---|---|---|---|
| Compression | 8 | | | | | |
| Freezing | 8 | | | | | |
| Dehydration | 8 | | | | | |
| Storage | 8 | | | | | |
| Rehydration | 8 | | | | | |
| Bread | 1,2 | | 9 | | | |
| Sandwiches | 1,2 | | 9 | | | |
| Cake | 1,2 | | 9 | | | |
| Waffles | 1,2 | | 9 | | | |
| Storage stability | | | 8 | | | |
| Dehydrated | | | 0 | | | |
| Frozen | | | 0 | | | |
| Compressed | | | 0 | | | |

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