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TECHNICAL REPORT

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DEVELOPMENT OF FLEXIBLY PACKAGED CAKES

by

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August 1972

UNITED STATES ARMY
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Natick, Massachusetts 01760

Food Laboratory

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Formulation changes of increasing sugar and shortening levels while lowering egg and moisture levels were responsible for improvements in texture and storage stability. With reformulation, however, sugar crystallization became noticeable. The use of crystallization inhibitors such as sorbitol and invert sugar were unacceptable primarily because of color problems. While the use of 0.2% gum arabic initially appeared to reduce the crystallization problem, subsequent storage studies showed no significant influence on general acceptance of the product, or change in crystallization.

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Fats			10			
Lowering (Reducing)			10			
Moisture			10			
Texture			9			
Storage Stability			9			
Acceptability			9			

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FOREWORD

To keep up with current military requirements, accelerated research in the field of food and packaging is essential. The need is urgent for an operational ration which provides individual meals such as the "Meal Ready-to-Eat, Individual" containing components which are ready to eat and highly acceptable when consumed under conditions precluding preparation. Among the components considered for such a meal are flexibly packaged, stable, dessert items. Therefore, these studies were conducted to develop flexibly packaged and heat processed cakes which offer acceptability, portability, stability and high caloric value.

This work was performed under Project No. 1J664713D548 Military Subsistence Systems.

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ABSTRACT

Attempts to improve flexibly packaged cake items in regard to texture, shelf-life and general acceptability have met with some degree of success.

Formulation changes of increasing sugar and shortening levels while lowering egg and moisture levels were responsible for improvements in texture and storage stability. With reformulation, however, sugar crystallization became noticeable. The use of crystallization inhibitors such as sorbitol and invert sugar were unacceptable primarily because of color problems. While the use of 0.2% gum arabic initially appeared to reduce the crystallization problem, subsequent storage studies showed no significant influence on general acceptance of the product, or change in crystallization.

INTRODUCTION

Feasibility of using flexible packages for heat processed foods has been reported in the literature (Hu et al 1955; Keller 1959; Mc Gregor 1959; Morgan et al 1961 and Tripp 1961).

Evaluation of flexibly packaged cakes produced under contract in accordance with initial work done by Mason, et al 1965 indicated that further development work was necessary. The primary areas needing improvement were acceptability, shelf life and texture.

Reformulation was considered to be the main approach to solving these problems. Also, different processing techniques were considered as a possible means of improving texture. From the condition of the production samples after prolonged storage it was evident that the old formulation had too much moisture. Also, for reformulation the basic premise was taken that since storage times were in excess of normal staling times of either amylose or amylopectin, the deterrent to staling would have to be to use a minimum of starchy components.

These investigations were limited to the development of improved formulations for various flavored cakes and to storage and acceptance studies of the newly formulated cakes.

MATERIALS AND METHODS

Materials

a. Packaging: The pouch material was a laminate of 0.5 mil polyester, 0.35 mil aluminum foil, 3.0 mil polyolefin. The inter layer of polyolefin was designed to withstand thermal processing up to 250°F.

b. Ingredients: A "high ratio" (sugar to flour) cake flour, Royal Patent* by Peavey Company was used in most of the trials. High stability shortening (100 Hour-Active Oxygen Method) is required to withstand the stringent storage - six months at 100°F. or two years at 70°F. A triple acting baking powder was used as the leavening agent.

c. Retort: A steam and air retort 5 ft. diameter by 8 ft. length was used in all of the studies.

Methods

Formula: In table 1A, the basic pound cake formula has a 145 percent ratio of sugar to flour. The fruit type cakes differ in that the sugar to flour ratio is 133 percent to compensate for the sugar content in the fruit. Table 1B is the old formula previously used by Mason, et al. Individual cake formulas are presented in Table 1C.

*Trade names and manufacturing names are used in this report for identification purposes only and such use does not constitute indorsement or approval of any particular product, process or manufacturer.

TABLE 1A

New Base Formulae for Flexibly Packaged Cakes

Ingredient	% (145% Ratio*)	% (133% Ratio*)
Sugar	41.20	39.50
Flour, Cake	28.10	29.80
Shortening, 100 Hour AOM	14.65	14.65
Whole Eggs	13.90	13.90
Baking Powder	1.30	1.30
Salt	0.85	0.85

TABLE 1B

Old Base Formula for Flexibly Packaged Cake

Ingredient	%
Whole Eggs	28.5
Flour, all purpose	25.0
Sugar	25.0
Shortening, 100 Hour AOM	12.5
Farina	4.7
Vanilla Extract	3.5
Baking Powder	0.4
Salt	0.4

*Ratio of sugar to flour

TABLE 1C

Flexibly Packaged Cake Formulae

	% Base (145% Ratio)	% Base (133% Ratio)	% Other Components
Pound Cake	95.76		0.06 lemon oil (2x) 4.18 water
Fruit Cake		49.216	13.32 pecans 14.95 raisins 9.97 cherries 8.34 pineapple 0.12 cinnamon 0.06 clove powder 0.06 mutmeg 4.18 water
Orange Nut		63.24	10.54 nuts 21.98 orange peel 0.06 orange oil (92x) 4.18 water
Date Nut	59.89		15.04 pecans 20.89 dates 4.18 water
Pineapple Nut		57.60	14.40 pecans 23.82 pineapple 4.18 water

TABLE 1C

Flexibly Packaged Cake Formulae (Cont'd)

	% Base (145% Ratio)	% Base (133% Ratio)	% Other Components
Cherry Nut		57.49	14.37 pecans 23.89 cherries .07 pure oil bitter almond 4.18 water
Maple Nut	76.65		19.03 pecans .14 nuts maple flavor 4.18 water
Chocolate Nut	68.34		13.67 pecans 13.58 chccolate drops .23 vanilla 4.18 water
Banana Nut	58.60		14.60 pecans 14.60 banana flakes 12.20 banana (ice cream form)
Dutch Apple	78.50		13.65 dehydrated apples 0.55 cinnamon 7.30 water
Raisin Nut	59.89		15.04 pecans 20.89 raisins 4.18 water
Spice Cake	63.366		12.79 rolled oats 9.85 raisins 9.85 brown sugar 0.186 cinnamon 0.142 vanilla 0.142 ground cloves 0.094 ground nutmeg 3.58 water

Preparation

a. All of the dry ingredients including any dry flavors were blended together in a Hobart mixer for 1 minute at low speed.

b. Shortening was added and blended for approximately 8 minutes or until it was mixed well with the dry ingredients.

c. Beaten whole eggs and water were added and mixed at low speed for 1 minute, then high speed until there was no appearance of small shortening lumps (about 5 minutes). It was not necessary to warm eggs to room temperature since the product did not change when cold eggs were used. Vanilla and other liquid flavors were added to the water.

d. Fruits and nuts were blended in at low speed, then mixed at high speed until distribution was uniform.

Pouching

$4\frac{1}{2}$ x $5\frac{1}{2}$ inch pouches were filled according to the type of cake with the amount of batter as shown in table II. Product contamination in the final seal area was carefully avoided to reduce the problem of leakers. The pouches were sealed with a heat sealer set at 425°F.

TABLE II

Batter Weight of Different Cakes per Pouch

Product	oz.
(1) Pound Cake	3.25
(2) Fruit Cake	3.75
(3) Orange Nut	3.75
(4) Date Nut	3.75
(5) Pineapple Nut	3.75
(6) Cherry Nut	3.75
(7) Maple Nut	3.50
(8) Chocolate Nut	3.50
(9) Banana Nut	3.50
(10) Dutch Apple	3.50
(11) Raisin Nut	3.75
(12) Spice Cake (Oatmeal)	3.50

Processing

Tests were conducted to determine what package orientation for processing was most desirable. Samples were placed between vertical or horizontal plates with 3/4 or 1 inch spaces. Results showed that product processed in a 3/4 inch vertical space produced the desired shape, size, and texture cake with absence of bubbles and channels on the upper surface usually caused by trapped air or liberated gas. The gas pockets or channels are not noticeable on the top edge of the product when packages are placed vertically. Subsequently, pouches were placed between vertical plates 3/4 inches apart. Processing was carried out at 250°F. for 15 minutes at 25 pounds of pressure in a steam/air retort. An overriding air pressure of 10 pounds per square inch was maintained above the steam pressure to prevent pouch rupture due to internal pouch pressure.

Acceptance Test

Acceptance evaluations were made using randomly selected consumer panels by the Acceptance Laboratory Group using a hedonic scale ranging from 9 (like extremely) to 1 (dislike extremely) (Peryam 1957).

RESULTS AND DISCUSSION

As reported in earlier studies (Mason, et al 1956), the major obstacle to producing an acceptable product was found to be texture. Since a grainy, hard, dark product developed during extensive storage, it was felt more work was needed on the formulation. The grainy texture came from the farina, and during storage the grainy texture became more pronounced. Preliminary studies showed that with a combination of a low moisture level (12 - 20%), and a high shortening level (14%) a soft, moist, open texture could be produced in pound cake.

In earlier trials, a "high ratio" flour was used which enabled the use of higher sugar and shortening levels. Since the higher shortening level had an apparent moistening effect, less water was needed. With a lower moisture level, 12 - 20%, the end product was not spongy or gummy but open and soft. Although "high ratio" flour would produce an acceptable product at a higher moisture level, 25% and above, cakes were more acceptable at the lower moisture level. Table III shows the maximum percent moisture for each cake item after processing.

Another important factor was the reduction of the whole egg content from 28.5% to 13.3%. A much lighter color was produced and the brittleness of the former cakes was not evident. Also, less off-flavors and odors were noted. The baking powder was increased from a .44% to 1.25% in the pound cake. As a result, the cake in the pouch was soft and open grained after retorting. Flavoring agents were added to enhance the flavors of many of the fruits and to mask any off-flavors that may develop during storage.

TABLE III

Maximum Moisture in Cakes

		Percent
1.	Pound Cake	18
2.	Fruit Cake	18
3.	Cherry nut	17
4.	Pineapple nut	17
5.	Raisin nut	16.5
6.	Orange nut	17
7.	Date nut	17
8.	Maple nut	15
9.	Chocolate nut	12
10.	Dutch Apple	20.0
11.	Banana Nut	17
12.	Spice Cake (oatmeal)	17

Not only was a soft, more moist product produced by the above changes, but the caloric density was increased in the pound cake from 372 cal/100 gm. to 394 cal/100 gr., which is essential for the military ration. However the decreased moisture introduced the problem of crystallization of dissolved ingredients. To prevent crystallization, sorbitol, invert sugar, gum arabic, and emulsifiers were tried at various levels. The sorbitol was tested at 2.1%, 4.2%, and 8.4% of the base. After three months at 70°F. and 100°F. all samples had an undesirable dark color. Invert sugar used at 5.% of the sucrose level, produced a dark product after processing. In initial tests gum arabic at a 0.2% level of the cake batter appeared to be helpful in controlling sugar crystallization. From these initial results a more extensive storage study was performed to evaluate the addition of gum arabic plus a combination of emulsifiers, Span 60, Twee 60, Atmul 80, and Atmul 84. Table IV gives the results of the effect of added gum arabic and emulsifiers on acceptance panel ratings. From this data the general conclusion was that the addition of gum arabic and/or emulsifiers did not have a significant effect on overall acceptance ratings. Anticipated prevention of crystallization as a result of the above ingredients did not materialize.

TABLE IV

Effect of Gum Arabic and Emulsifiers on Acceptability of Cakes During Storage (100°F.)

NGA - no additive

E+GA - emulsifiers + gum arabic added

GA - gum arabic added

E - emulsifiers added

Raisin nut	NGA	E+GA	GA	E	Main Withdrawal effect
			Acceptance Panel Ratings		
Initial	7.3*	7.4**	6.9**	7.1**	7.2**
3 mo.	6.2	5.9	5.9	6.2	6.1
6 mo.	5.6	6.0	5.9	5.6	5.8
12 mo.	5.9	6.3	6.1	---	
Main Treatment effect	6.4	6.5	6.2	6.3	

*Significantly preferred to 6 mo.

**Significantly preferred to 3 mo. and 6 mo.

TABLE IV (Cont'd)

Effect of Gum Arabic and Emulsifiers on Acceptability on Cakes During Storage (100°F.)

Chocolate nut	NGA	E+GA	GA	E	Main withdrawal effect
			Acceptance Panel Ratings		
Initial	6.8	6.8	6.8	6.6	6.8*
3 mo.	6.4	6.6	6.2	6.9	6.5
6 mo.	6.7	6.6	6.5	6.1	6.5
12 mo.	5.8	5.7	5.5	5.7	5.7
Main treatment effect	6.5	6.4	6.3	6.4	

*Significantly preferred to 12 mo.

Pound Cake	NGA	E+GA	GA	E	Main withdrawal effect
			Acceptance Panel Ratings		
Initial	6.5	7.1	6.7	7.0	6.8*
3 mo.	6.0	5.7	6.2	5.8	5.9
6 mo.	6.2	6.2	6.2	6.2	6.2
12 mo.	6.0	6.1	6.2	5.6	6.0
Main treatment effect	6.3	6.2	6.3	6.3	

*Significantly preferred to 3 mo.

TABLE IV (Cont'd)

Effect of Gum Arabic and Emulsifiers on Acceptability on Cakes During Storage (100°F.)

Fruit Cake	NGA	E+GA	GA	E	Main withdrawal effect
			Acceptance Panel Ratings		
Initial	6.5	6.7	6.9+++	7.0++	6.8
3 mo.	6.8+	7.3+++	6.8+++	7.1+++	7.0*
6 mo.	6.6	6.6	5.9	6.3	6.4
12 mo.	6.1	6.4	6.0	6.4	6.2
Main treatment effect	6.5	6.7**	6.4	6.7**	

** Significantly preferred to GA

* Significantly preferred to 12 mo.

+++ Significantly preferred to 6 and 12 mo.

++ Significantly preferred to 6 mo.

+ Significantly preferred to 12 mo.

TABLE IV (Cont'd)

Effect of Gum Arabic and Emulsifiers on Acceptability on Cakes During Storage (100°F.)

Orange nut	NGA	E+GA	GA	E	Main withdrawal effect
		Acceptance Panel Ratings			
Initial	6.5	6.7	6.8	7.0	6.8
3 mo.	6.1	6.2	6.3	6.2	6.2
6 mo.	6.5	6.6	6.6	5.9	6.4
12 mo.	---	---	---	---	---
Main treatment effect	6.4	6.5	6.6	6.4	

The new formulations for seven types of flexibly packaged cakes were evaluated over a 24 month storage period at 40°F, 70°F, and 100°F. The acceptance panel ratings from this study are shown in Table V. Two flavors, pineapple nut and cherry nut, maintained high acceptance ratings (approximately 7.0 - like moderately) throughout the study. The maple nut and spice flavors had slightly lower ratings (approximately 6.0 - like slightly) and three flavors, banana nut, dutch apple and date nut were unacceptable after storage. These formulations will have to be modified in order to improve their overall quality. Comparison of the new formulation with the old is shown for date nut cake in Table VI. The procedure for batter makeup differed considerably from the procedure described by Mason, et. al. (1965). It was found that better aeration was obtained by the new procedure. Also, it was found that the temperature of the eggs was not critical since various temperatures did not change the product. Another advantage of the new procedure is that less time is involved in preparing the batter.

TABLE V

Acceptability of Flexibly Packaged Cakes During Storage
(New Formulations)

	Storage temp. °F.	Initial	3 mo.	6 mo.	1^ mo.	24 mo.
		Acceptance Panel Ratings				
Pineapple	40	6.8	7.1	6.8	6.7	7.1
Nut	70	7.1	6.8	6.8	7.1	7.1
	100	6.8	6.6	6.8	6.9	---
Cherry	40	6.7	7.1	7.2	7.2*	7.2
Nut	70	6.9	7.3	7.4	7.2*	6.9
	100	6.9	7.2	7.0	6.7	---
Banana	40	6.2	5.8	5.7	5.9*	5.8
Nut	70	6.3	6.1	6.1	5.7*	6.2
	100	5.9	5.7	5.7	4.6	---
Maple	40	6.7	6.6	6.6	6.6	6.3
Nut	70	6.4	6.4	6.8	6.6	6.0
	100	6.5	6.7	6.7	6.4	---
Dutch	40	6.5	6.9*	6.5	5.9	---
Apple	70	6.7	---	---	---	---
	100	6.4	6.3	6.3	5.3	---

*Significantly preferred to 100°F. sample

TABLE V (Cont'd)

	Storage temp. °F.	Initial	3 mo.	6 mo.	12 mo.	24 mo.
			Acceptance Panel Ratings			
Spice	40	6.4	6.6	6.7	6.5	6.7
	70	6.9	6.5	6.6	6.5	6.5
	100	6.5	6.6	6.4	6.1	---

TABLE VI

Comparison of Formulations for Datenut Cakes

Datenut	40	6.6	6.8**	6.8**	6.6**	6.6
	70	6.9	7.0**	6.4*	6.5**	6.0
	100	7.0	6.6*	5.7	5.6	---
Datenut	40	6.3	6.2*	5.8	6.1*	6.0
	70	6.5	5.5	5.4	4.9	5.5
	100	6.5	4.9	4.9	4.4	---

* Significantly preferred to "initial" 100°F. Sample

**Significantly preferred to "initial" 70°F. and 100°F. Samples

Contamination of the seal area was less of a factor with the new formulation since the batter was thicker and stayed in the bottom of the pouch when placed there. It was not necessary to seal the pouches under a vacuum.

A two phase thermal process was investigated again using the new formulation. It was theorized that a precook would set the proteins; therefore, a less dense product would be produced at the high pressure during sterilization. The precook process involved cooking at 212°F. under 4 pounds air pressure for 30 minutes; the 4 pounds of pressure prevents distortion of the pouch. A softer, more open texture product was produced by using a precook. Also, the absence of a grease film on the surface of the product was another advantage. However, without the precook, less time was required in processing and a lighter color product was produced. The grease film on the surface, due to the high pressure at the early stage of processing, tends to disappear during storage.

A steam/air retort was used throughout the study. The atmospheric pressure control device was not used since better control was obtained by manually controlling the retort pressure. The retort pressure was held between 25-27 pounds and the temperature was held at 250°F. After cooking for 15 minutes, the air purge lasted for 6 minutes - to clear all of the steam out of the retort before applying the cooling water. During cooling with water, it was found that a pressure drop of about 1½ to 2 pounds per minute was most desirable. Water cooling required approximately 10 minutes or until the temperature of the retort was 150°F. with a pressure of approximately 5 pounds.

SUMMARY

Cakes cooked in hermetically sealed packages differ from those cooked under normal atmospheric conditions since there is no loss of moisture and volatile material. The batter moisture content must be reduced to compensate for this. In addition, cooking under pressure forms a steam atmosphere inside the package which seems to produce better starch hydration. A batter with a moisture content equal to that of an atmospherically baked cake produces a rubbery textured cake when baked in an hermetically sealed package. Thus with effective starch hydration the moisture content must be reduced further to produce an acceptable cake in an hermetically sealed package. A batter moisture content of from 12 to 20% was found to be the optimum range for hermetically sealed cakes. Batters with less than 12% moisture fail to rise. 14% shortening (actual percent) was found to be optimum. The sugar level was 145% of the flour, and the eggs were 13.3 actual percent. In the fruit type cakes the sugar was reduced to 133% of the flour to compensate for the fruit sugar. The high sucrose content in the non-fruit type cakes in conjunction with a low moisture content caused crystallization in most cakes in which this batter was used. The use of invert sugar and sorbitol to prevent crystallization produced a darkening effect. A combination of gum arabic and emulsifiers while appearing to control initial sugar crystallization did not significantly increase the acceptance rating over a 12 month storage period.

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