[Reprinted from FOOD TECHNOLOGY, 1958, Vol. XII, No. 11, Pages 625–629]

Modern Baking Concepts for Troop Feeding: Development of the Instant Bread Mix[a]

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(Manuscript received May 13, 1958)

A BREAD-TYPE FOOD is an indispensable item in every Army ration. In the United States, and in many overseas posts during peacetime, bread is procured from commercial bakeries in the area. In wartime, especially in forward areas, this mode of supply is not feasible. The soldier must either be supplied preserved bakery products such as crackers or canned bread, or fresh bread from an Army bakery located near the point of consumption.

PRESERVED BAKERY PRODUCTS—SOME LIMITATIONS

Crackers are a stable, easily transported bread substitute, but they are not desirable for constant consumption because their acceptability declines rapidly. A morale problem may eventually be the result. This is unfortunate because crackers possess many desirable characteristics from the ration standpoint. In addition to being extremely resistant to both texture and flavor staling, they are economical, easy to dispense, and fairly simple to package. They are now used in certain operational rations in spite of their drawbacks, but it would be more desirable to use bread if it were possible.

Canned bread is the second alternative. More acceptable as a constant diet than are crackers, canned bread is less desirable than fresh for a number of reasons. Although it remains edible after many months of storage at elevated temperatures, its hedonic rating declines constantly throughout this period. Table 1 compares the hedonic ratings on a 9-point scale of canned bread samples stored at 100° F. for varying periods. There is little doubt that much of the bread stored for 9 months, or even less, would be discarded by the intended consumer.

Canned bread also presents logistical problems. One problem is weight. The container, in itself, represents about one-third to one-half of the gross weight. About 35% of the net weight is due to water, as opposed to the 12 to 14% usually found in flour. Another problem is the disposal of the empty cans. If the cans were to be left on the ground in battle areas, they might very well provide the enemy with valuable information as to the strength and disposition of our forces. The alternative, burying the cans, is a time-consuming practice and may be impossible when enemy action is imminent. Some of the logistical difficulty might be overcome by packaging the bread in hermetically sealed plastic envelopes. Such envelopes, as a matter of fact, are under study and experimental work has been active.

Dehydrated bread has also been considered as a possible means of supplying bread to the soldier. Bread can be reduced very readily to less than 5% moisture without much permanent damage to any of its inherent physical properties. Unfortunately, no method of rapid rehydration has been devised, or even visualized, which could be applied during military operations in the field. Dehydrated bread is no longer receiving serious emphasis.

To summarize, it can be said that preserved bakery products are probably indispensable for certain applications but are undesirable for general use. It would be far more desirable to bake bread near the points of consumption. Bread ingredients are much more stable than the product itself, they contain less moisture, and they require less expensive packaging.

THE PRESENT SITUATION IN FIELD BAKING

Two types of installations, one mobile and the other portable, are available at present for baking near forward areas. The mobile field bakery is manned by 3 operating platoons and a headquarters unit. Nearly 250 men are involved. About 50 vehicles are required for transporting this installation. The specialized equipment alone weighs nearly 50 tons. Partly as a result of its large size, the mobile field bakery is fairly efficient and is capable of supplying bread to 100,000 men. However, it has disadvantages. Only 3 units each of certain specialized equipment are present. If a trailer transporting one of these pieces of equipment is lost through enemy action or by accident, the capacity of the bakery is immediately reduced by one-third. In addition, the coordinated transportation and erection required are very difficult to achieve in wartime.

For defense in atomic warfare, the Army may be envisioned as units of about 2,000 men, completely mechanized, highly dispersed, and moving rapidly

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists held in Chicago, Illinois, 25–29 May 1958.

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TABLE 1

Effect of the time of storage at 100° F. on the acceptability of canned bread

Storage time at 100° F.	Hedonic rating[1]
Months	
0	6.06
3	5.64
6	5.28
9	5.04
12	4.94

[1] 5.0 means neither *like* nor *dislike*.

over long distances. These units would be completely separated, in a physical sense, from command headquarters. The impracticability of transporting a perishable, light weight, and fragile foodstuff to 50 units (100,000 men) from a central bakery every day seems self-evident.

The second alternative for supplying fresh bread is to bake it within the basic unit. At present, no efficient unit exists for accomplishing this alternative. It is true that a so-called portable bakery is described in the field manuals. For use under the new concept, the portable bakery, which involves much manual handling of the doughs, cannot be regarded as adequate. Persons who have operated this equipment indicate that even under the best of conditions less than 250 pounds of dough per day per operator can be made. Under the less favorable conditions of nuclear combat, the output can be expected to drop sharply. In any case, it can be easily imagined what kind of product would be supplied by this equipment.

Although the *ideal* bakery for the Army of the future does not exist, the recent development of continuous bread making processes suggests a possible approximation of one. It should be borne in mind, however, that any process embodying the fermentation steps necessary in the conventional bread making procedure has certain inherent disadvantages for field use. For example, the dough must be maintained at controlled temperatures for varying periods—which means that fairly large space will be occupied by an insulated room with controlled heating equipment. If the fermentation steps could be eliminated, a bakery for supplying 2,000 men with bread could conceivably be designed around a continuous mixing and dough forming apparatus and one or more ovens.

This is where chemical leavening systems come into the picture. The QMFCI project to develop an instant bread mix based on chemical leavening systems was begun, in fact, to provide a basis for the design of such a bakery. This paper reports the experimentation that resulted in the development of an instant bread mix capable of meeting the requirements of continuous bread making, under combat conditions of the future, in a field bakery.

MATERIALS AND METHODS

The flour used was a good commercial grade of hard wheat flour, bakers' patent, analyzing 12.06% protein, 0.48% ash, and 12.94% moisture. In some cases, the same flour, dehydrated to 6.0% moisture, was used. No damage to baking properties resulting from the dehydration could be observed. The yeast was compressed bakers' yeast, never more than 7 days old. Nonfat dry milk was the high heat type produced for bakery use. Shortening was 100-hour vegetable shortening. The leavening acid was 95% glucone-delta-lactone coated with 5% calcium stearate.

From the nutritional standpoint, it was considered desirable, though not essential, to retain the formulation of standard Army bread, so far as possible. Bread baked by conventional methods for comparison purposes had the formula shown in Table 2.

Conventional bread was prepared by suspending the yeast in a portion of the water and placing it in the McDuffee mixing bowl with all the remaining ingredients and the rest of the water. The dough was mixed for one minute at slow speed and 7 minutes at second speed of a three-speed mixer. The loaves were scaled at 20½ ounces into individual fermentation jars and allowed to ferment 2 hours. The doughs were then punched and given a 20-minute rest period at 85° F. before molding. The loaves were proofed for 60 minutes at 100° F. and 95% R.H. after molding and then were baked for 30 minutes at 425° F. in a gas fired reel oven.

TABLE 2

Standard Army bread formula

Ingredient	Per cent of flour weight
Flour	100.0
Sucrose	5.5
Nonfat dry milk	6.0
Salt	1.0
Shortening	5.0
Compressed yeast	2.5
Water	65.0

TABLE 3

Instant bread mix formulation

Ingredient	Per cent of flour weight	Grams
Flour	100.0	700.0
Sucrose	5.5	38.5
Nonfat dry milk	6.0	42.0
Salt	1.0	7.0
Shortening	5.0	35.0
Soda	3.5	24.5
Delta-lactone of Gluconic acid	9.0	63.0
Lyophilized flavor broth	4.0	28.0
	134.0	938.0

Flavor broth	
Di basic sodium phosphate (0.1M)	1,000 ml.
Sucrose	100 g.
Nonfat dry milk	50 g.
Compressed yeast	50 g.

In papers presented elsewhere, the development of a chemically leavened bread *(3)* flavored with cell-free fermentation broths *(2)* was described. Formulas in use at the beginning of the series of experiments described in the present paper are shown in Table 3. The cell-free broth was prepared by fermenting sucrose in the presence of nonfat dry milk solids dissolved in 0.1M dibasic sodium phosphate with *Saccharomyces cerevisiae*. The quantities of each component of the broth are also shown in Table 3. The quantities of auxiliary ingredients in the chemically-leavened formula were selected by analogy with Army bread formulas. Method of mixing for the chemically-leavened bread was also the same as for the conventional bread.

Volume determinations were made by the usual rape-seed displacement method. The pH was determined electrometrically 10 minutes after mixing 10 g. of crustless crumb in 100 g. of distilled water.

RESULTS AND DISCUSSION

Development of a flavor for use with the chemically-leavened bread including the results of experiments aimed toward improving the flavoring constituent has been previously reported *(3)*. The formula for the broth preparation has already been shown. The technique of preparation may be summarized as follows: the broth was fermented at about 100° F. for 4 hours and then centrifuged to remove the yeast. During fermentation, the pH of the medium dropped from 7.6 to about 6.1. Effort to improve the flavor has continued. In one experiment, an apparatus was set up to ferment the broth at a constant pH. An automatic titrating device was used to add quantities of 5 *N*. sodium hydroxide solution continuously in quan-

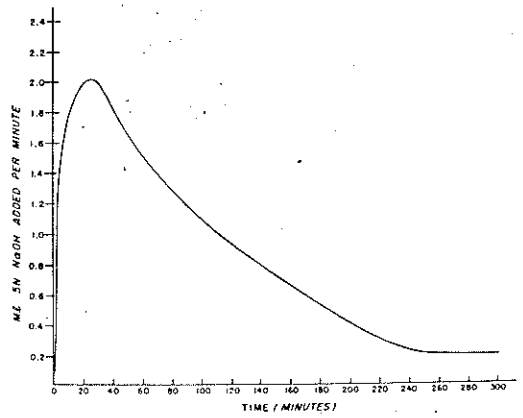

Figure 1. Rate of addition of sodium hydroxide required to maintain a constant pH of 7.4 during the period of fermentation.

tities sufficient to maintain a constant pH of 7.4. Since the rate of addition of sodium hydroxide parallels the rate of fermentation, the curve in Figure 1 also illustrates the rate of fermentation. The broth was centrifuged in the normal manner. Half was treated with ion exchange resins to remove the additional sodium. These broths were used as flavoring agents for the chemically-leavened bread. An evaluation of the bread showed the broth fermenting at constant pH, both with and without ion exchange treatment, had less of the desirable taste characteristics than did the control broth. It was concluded that the products of the metabolism of yeast at pH 7.4 are less desirable for a bread flavor than those at uncontrolled pH from 7.6 to 6.1.

A second experiment was conducted to increase the solids content of the broth and thus to facilitate drying. Four broths were prepared: a control with the composition shown earlier, one with two times the amount of dry materials, one with three times, and one with four times as much dry materials. The compositions of the broths are illustrated in Table 4. These were fermented, centrifuged, and used in the usual manner. With the exception of the control, each was used at two levels of concentration in the chemically-leavened mix. The results shown in Table 5 indicate that the broth having 3 times the initial concentration of the original formulation—300 g. sugar, 150 g. nonfat dry milk, and 150 g. compressed yeast—furnished the loaf of preferred flavor. Table 5 also indicates that when the higher concentration broths were diluted, they gave the same preference as the lowest concentration broth. The change in pH with increasing fermentation time for each of the broths is shown in Figure 2.

It is very desirable to have a dry flavor incorporated in a complete mix. Several methods of drying the centrifuged broth were tried. Lyophilization of the broth gave the best results. Broths dried at 28-in. vacuum at room temperature possessed slightly less flavoring capacity than did lyophilized broth. Spray drying gave about the same results as vacuum drying.

TABLE 4

Effect of broth ingredient composition on bread flavor

Broth	0.1M. Na_2HPO_4	Sucrose	Nonfat dry milk	Compressed yeast
	ml.	*grams*	*grams*	*grams*
1 x	1000	100	50	50
2 x	1000	200	100	100
3 x	1000	300	150	150
4 x	1000	400	200	200

TABLE 5

Acceptability of chemically-leavened bread

Broth	Dilution	Hedonic rating	Dilution	Hedonic rating
1 x	0	6.2	0	6.2
2 x	0	6.8	1/2	6.5
3 x	0	7.2	1/3	6.5
4 x	0	5.5	1/4	6.2

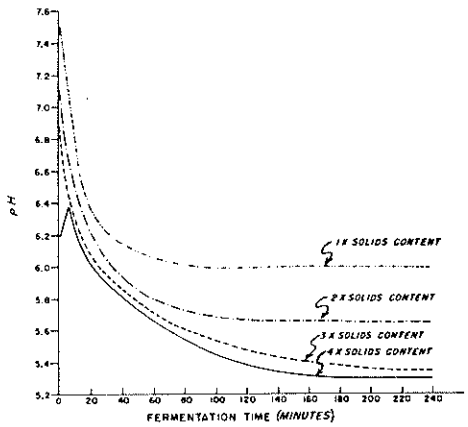

Figure 2. Effect of fermentation time on pH by broths containing various concentrations of solids.

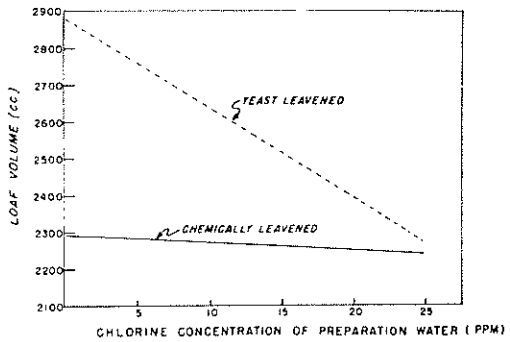

Figure 3. Effect of chlorine concentration on water used in preparing yeast leavened and chemically leavened bread.

Although the artificially flavored, chemically-leavened bread performs satisfactorily in laboratory tests, it is necessary to know how it will react to some of the untoward influences encountered during field use. Water available in the field is usually purified with chlorine. The concentration of this chemical may vary considerably for one reason or another. The effect of varying concentrations of chlorine in the preparation water of yeast-leavened bread and of chemically-leavened bread on their volumes is shown in Figure 3. These results show that chemically-leavened bread doughs are much more resistant to the effect of excess chlorine in the water than yeast-leavened bread doughs. This is most desirable for a

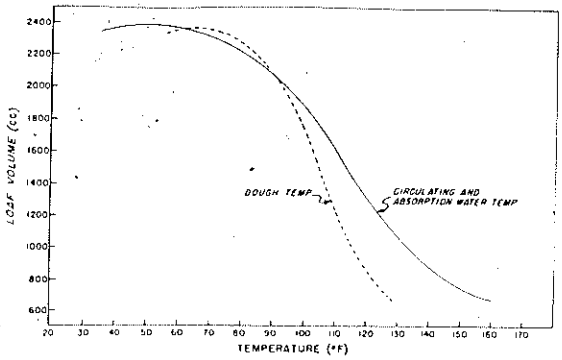

Figure 4. Effect of temperature on loaf volume.

product destined for field use. Odor and flavor of the chlorine becomes detectable, however, at the higher concentrations used here.

Temperature of the water is another variable not always subject to precise control in the field. Figure 4 gives the loaf volume results of an experiment in which the water used to prepare chemically-leavened bread was varied over a wide range. It is clear that the mix can be prepared with water having any temperature likely to be encountered. The loaf volumes show an appreciable decline at 90° F. and above.

Since the measurement of water and mix at the bakery will, if manually done, be subject to the usual human vagaries and, if mechanically performed, be affected by uncertainties of adjustment, it was considered to be of interest to find the response of the mix to changes in the proportion of water to mix. Loaf volumes of the resulting loaves are shown in Table 6. Again we see a rather astonishing flexibility; the loaves retain good volume even though the water-to-mix proportion is varied over a wide range.

TABLE 6

Effect of variation of absorption water on loaf volume

	Per cent absorption water based on flour weight				
	45%	50%	55%	60%	65%
Loaf volume (cc.)	2080	2375	2275	2065	1950

A variety of baked goods is desirable for troop feeding, and it would be unsound logistically to have to supply ingredients for other yeast-leavened goods when bread ingredients are eliminated through use of a complete mix. Therefore, the versatility of the instant bread mix was tested by preparing several varieties of products from it.

Figure 5 shows the products of instant bread mix. The white bread had the formulation shown in Table 3. The hot rolls had the same formulation and weighed about one and one-half ounces each. The wheat bread used the basic mix with the addition of 100 g. wheat base *(1)*. The sesame egg twist had 2½ egg yolk solids based on the flour in the basic mix. It was braided, washed with milk and dipped in sesame seeds before baking. The streussel coffee cake was made with 2½% additional egg yolk solids and then covered with a

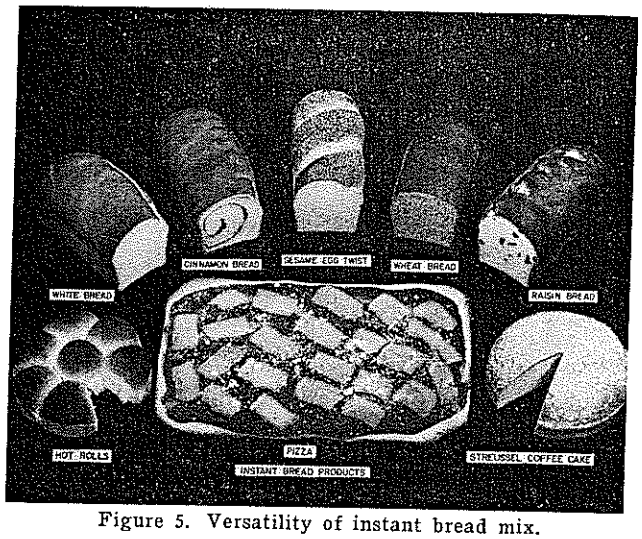

Figure 5. Versatility of instant bread mix.

streussel topping. The cinnamon bread also had the extra 2½% egg yolk solids. It was rolled out, washed with egg yolk, and lightly sprinkled with a cinnamon-sugar mixture and then rolled. The pizza, using the basic mix, was partially baked on one side, turned over, and covered with the sauce and cheese. It was baked until the cheese melted. The preparation of the raisin bread caused some difficulty. Bleached raisins did not perform satisfactorily. Even when the raisins were soaked for 4 hours prior to use, they still caused decreased volume in the bread when incorporated either at the beginning or the end of the mixing period. The water in which the raisins were soaked caused a similar volume reduction. Use of 30% unbleached raisins on a flour weight basis in the pictured loaf caused only a slight volume decrease. The raisins were incorporated at the end of mixing.

The field bakery utilizing this chemically-leavened bread mix is visualized as consisting of a continuous mixer which will also form the dough pieces into loaves. It will require just 3 men to operate, on overlapping 10-hour shifts for a total of 18 hours per day to supply 8 ounces of bread and 4 ounces of cake per day to each of 2,000 men. The entire unit could be transported on one 2½-ton truck.

SUMMARY

An instant bread mix developed by the Quartermaster Food and Container Institute has been shown to be versatile, capable of being prepared under a wide range of conditions, and to have good sensory characteristics. It could be used in a small simplified field bakery designed around a continuous mixer. This new bakery should eliminate, without any loss in baking efficiency, many difficulties which presently attend the preparation in the field of baked goods for small diversified combat units.

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