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# Comparative Efficiencies of Bread Crumb Softeners at Varied Bread Storage Temperatures

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## ABSTRACT

A series of commercial surfactants was evaluated in white pan bread for their crumb antifirming effects during storage at 10, 20, 30, 40 and 50 C. These agents produced softer breads at all temperatures as compared to bread without surfactants. Although breads kept at 40 and 50 C remained softer than at room temperature (25 C), storage at elevated temperatures is not advised due to possible organoleptic and microbial deteriorations. At temperatures below 25 C, faster firming generally occurred, but was much less in the presence of surfactants. This observation suggests that a surfactant system might be found to retard firming at those conditions.

## INTRODUCTION

Many concurrent changes take place in bread during storage; all are part of a complex phenomenon—generally called "staling." Specificially, as bread ages, we observe crumb firming, detect an increasing degree of crumb-texture harshness, loss of crust crispness, and also disappearance of fresh bread flavor concurrent with emergence of stale bread flavor (1). Although all these factors contribute to reduction of freshness and thus to a decrease of consumer acceptability of the product, the changes in firmness are given a preeminent importance in evaluation of staleness because they are readily detectable by the consumer; they are also correlated with organoleptic deterioration of organoleptic properties of breads during early stages of storage (2).

It is generally accepted that retrogradation of starch polymers is responsible for firmness characteristics of breads —amylose for the firmness of freshly baked bread and amylopectin for the progressive firming during bread storage (3). Retrogradation is essentially a crystallization process, involving transformation of amorphous starch into an ordered crystalline state. As expected for this type of reaction, it proceeds at a rate with a negative temperature coefficient. This was shown by Cornford et al. (2) for bread. Complexation of amylose with surfactants also lowers the swelling power of starch granules, making more water available for the gluten phase. This effect may indirectly influence moisture distribution between starch and gluten phases in bread (3,4) and reduce the crumb firming rate. The practical consequences of this trend are that breads firm more quickly as the storage temperature decreases; consequently, it is advisable to keep breads at room temperature rather than in a refrigerator.

To maintain bread softness for a longer period of time, the baking industry generally uses various surfactants that are permitted by FDA Standards of Indentity (5). The antifirming characteristics of these agents are attributed to their abilities to form insoluble helical complexes with amylose, to interact to a limited extent with amylopectin, and also to strengthen doughs by complexation with proteins (6-9). The effectiveness of surfactants varies in these interactions, as was shown by various investigators.

In basic research studies, effects of bread storage temperature on bread firming rates have been determined in the absence of surfactants. Practical evaluation of surfactants in bakery foods were usually limited to room temperature, since breads are generally kept at that temperature in plants, supermarkets and homes.

In the present study, we examined and compared the softening effectiveness of surfactants over the temperature range of 10-50 C to provide information for predicting firmness changes at various temperatures, and also, to determine if any of the selected surfactants might aid in maintaining bread softness in the refrigerator (an effect which would be advantageous since flavor and microbial deteriorations would also be retarded).

## MATERIALS AND METHODS

### Baking Procedure

One-pound loaves were prepared according to a straight dough formula shown in Table I. The flour used was of baker's patent grade (11.2% protein [N × 5.7], and 0.50% ash on 14% mb), commercially milled from a blend of hard red winter and spring wheats. The doughs were mixed in a Hobart A-120 mixer, equipped with bowl and hook, fermented for 1.5 hr at 85 F and 85% R.H., divided into 500-g pieces, given a 10-min rest time, mechanically molded and proofed at 100 F to a uniform height (1 in. above pan) and baked at 425 F for 20 min.

### Surfactants

All materials were obtained from commercial sources and their chemical composition and characteristics are given in Table II. They were added at 0.5% (flour basis) level along with other dry ingredients, except for the SMG and Myverol 18-07 which, because of their hardness, had been melted into shortening before use in a bread dough.

### Measurements

Bread volume was measured by rapeseed displacement 1 hr after baking. Breads were then wrapped in moisture-proof polyethylene bags, sealed and stored at 10, 25, 40 and 50 C for 1, 3 and 6 days for firmness determinations.

Bread firmness (g force at 0.5 mm compression) was estimated using a Baker Compresimeter (10) using 2-cm-thick slices. Each loaf provided nine slices, and two determinations were made per slice.

All chemical determinations were made according to official AACC procedures (10).

**TABLE I**

**Bread Formula**

| Ingredient | % |
|---|---|
| Flour[a] | 100 |
| Water | as required |
| Compressed yeast | 2.5 |
| Yeast food | 0.5 |
| Sucrose | 6.0 |
| Nonfat dry milk solids | 2.0 |
| Shortening | 3.0 |
| Calcium propionate | 0.3 |
| Emulsifier | 0.5 |

[a]Flour composition (14% mb): protein (N × 5.7) = 11.17%; ash = 0.50%, crude fat = 1.01%.

## RESULTS AND DISCUSSION

### Bread Volume

Specific volumes of breads ranged from 4.74 cc/g for the bread baked with Centrolene A (hydroxylated lecithin) to 6.29 cm/g for that baked with SMG (succinylated monoglycerides). The loaf volume of control bread (without any added surfactants) was 4.90 cc/g. Since some of the crumb softening agents evaluated also act as dough strengtheners, differences in bread volumes alone (Table III) are expected to increase the crumb softness value simply by the volume effect.

### Bread Firmness: Time and Temperature Effects

Bread firmness data during 6-day storage at 10, 25, 40 and 50 C, reported in Table III, indicate considerable differences in effectiveness of the tested softening agents. All of them, however, possessed softening properties as evident from comparison with control bread (without surfactant). After a 1-day storage at 10 C, the crumb firmness values ranged from 3.3 to 8.9 vs 14.1 for the control; at 25 C from 2.8 to 5.2 vs 8.2 for the control; at 40 C from 2.4 to 4.1 vs 6.4 for the control; and at 50 C from 2.1 to 3.6 vs 5.3 for the control. Similar trends were observed throughout the entire storage period; the higher the storage temperature, the greater the softness of bread (both with and without surfactants).

### Effectiveness of Individual Surfactants

As discussed above, all surfactants tested enhance bread softness at all storage temperatures. However, their effectiveness depends on the type used. It is generally accepted that complexation with amylose is the underlying cause of the antifirming action of surfactants. However, this type of reaction is not limited to starch only; proteins also undergo a similar reaction which causes dough strengthening with concurrent loaf volume increase. Since breads of larger volumes tend to be softer than the more compact loaves, and vice versa, firmness values of breads of approximately equal volumes were plotted vs storage temperatures in Figures

**TABLE II**

**Composition of Crumb Softeners**

| Trade name | Form | Chemical composition | Supplier | HLB number |
|---|---|---|---|---|
| Atmul 500 | Soft Plastic | Mono- and diglycerides (54-58% mono) | Atlas Chem. Industries Wilmington, DE | 3.5 |
| Centrolene A | Liquid | Hydroxylated lecithin | Central Soya, Chicago, IL | – |
| Durem 207 | Dry beads | Mono- and diglycerides (52-56% mono) | Durkee Industrial Food Group Cleveland, OH | 3.3 |
| Durfax EOM | Soft plastic | Polysorbate 60 (ethoxylated mono- and diglycerides) | Durkee Industrial Food Group Cleveland, OH | 13.1 |
| Durfax 60 | Soft plastic | Polyoxyethylene (20) sorbitan monostearate/polysorbate 60 | Durkee Industrial Food Group Cleveland, OH | 14.9 |
| Emplex | Dry powder | Sodium stearoyl-2-lactylate | Patco Products, Kansas City, MO | 21.0 |
| Myverol PO6 | Dry beads | Distilled propylene glycol mono- and diesters | Eastman Chem. Products Kingsport, TN | 1.8 |
| Myverol 18-07 | Dry beads | Mono- and diglycerides (90% mono) | Eastman Chem. Products Kingsport, TN | 3.3 |
| SMG | Dry beads | Succinylated monoglycerides | Eastman Chem. Products Kingsport, TN | 5.3 |
| Tandem 8 | Soft plastic | Monoglycerides 31%, polysorbate 60, 40% | Atlas Chem. Industries Wilmington, DE | 8.1 |
| Verv | Dry powder | Calcium stearoyl-2-lactylate | Patco Products, Kansas City, MO | – |

**TABLE III**

**Specific volume and Firmness Values of Breads Stored at 10, 25, 40 and 50 C**

| | | Bread firmness (g force)[a] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Storage (days) | | | | | | | | | | | |
| | Bread sp vol | at 10 C | | | at 25 C | | | at 40 C | | | at 50 C | | |
| Crumb softener | (cc/g) | 1 | 3 | 6 | 1 | 3 | 6 | 1 | 3 | 6 | 1 | 3 | 6 |
| Atmul 500 | 5.11[b] | 6.0 | 8.0 | 9.5 | 3.4 | 4.7 | 7.7 | 3.0 | 3.7 | 6.6 | 2.8 | 3.3 | 4.0 |
| Centrolene A | 4.74[b] | 8.9 | 9.7 | 12.2 | 5.2 | 9.2 | 10.5 | 4.1 | 6.6 | 8.4 | 3.6 | 5.7 | 7.9 |
| Durem 207 | 5.41 | 5.3 | 5.3 | 7.2 | 4.1 | 5.3 | 8.1 | 2.8 | 4.7 | 4.8 | 2.6 | 3.3 | 4.1 |
| Durfax EOM | 5.62 | 3.8 | 5.6 | 5.6 | 2.8 | 3.8 | 5.3 | 3.3 | 3.4 | 4.5 | 2.2 | 2.9 | 5.3 |
| Durfax 60 | 5.84 | 3.8 | 5.4 | 6.4 | 3.0 | 5.1 | 5.7 | 2.7 | 3.6 | 4.9 | 2.4 | 3.4 | 4.7 |
| Emplex | 5.45 | 5.4 | 6.1 | 7.1 | 3.7 | 4.7 | 6.9 | 3.3 | 4.5 | 5.7 | 3.3 | 4.2 | 5.3 |
| Myverol 18-07 | 5.53 | 5.6 | 5.9 | 6.7 | 3.3 | 5.2 | 5.7 | 3.0 | 4.0 | 5.3 | 2.3 | 3.4 | 4.5 |
| Myverol PO6 | 5.53 | 3.3 | 3.9 | 4.4 | 2.4 | 4.3 | 5.6 | 2.4 | 2.7 | 4.5 | 2.1 | 3.5 | 5.0 |
| Myverol SMG (V) | 5.06[b] | 5.3 | 4.7 | 5.8 | 4.1 | 4.3 | 6.7 | 3.5 | 5.0 | 5.9 | 2.6 | 4.1 | 5.7 |
| SMG | 6.29[b] | 4.1 | 7.2 | 8.4 | 2.8 | 4.3 | 5.9 | 2.3 | 3.9 | 5.1 | 2.6 | 3.2 | 4.7 |
| Tandem 8 | 5.54 | 4.9 | 5.3 | 7.8 | 4.1 | 5.4 | 7.7 | 3.2 | 4.7 | 6.1 | 2.9 | 3.7 | 4.1 |
| Verv | 5.45 | 7.1 | 11.1 | 13.5 | 5.1 | 6.2 | 9.7 | 3.7 | 4.5 | 5.9 | 3.2 | 4.7 | 5.6 |
| Control (without surfactant) | 4.90 | 14.1 | 26.1 | >32.0 | 8.2 | 14.8 | 19.7 | 6.4 | 7.3 | 16.0 | 5.3 | 7.6 | 15.9 |
| Avg. | 5.45 | | | | | | | | | | | | |
| SD | 0.25 | | | | | | | | | | | | |

[a]Data are averages of 10 determinations.

[b]Not included in computation of average loaf volume and SD.

1A and 2A for storage periods of 1 and 6 days, respectively. This presentation permits a direct visualization of the softening effects. The same effects of surfactants for breads that deviated in loaf-volume from the average by more than ± 1 SD are evident from Figures 1B (1 day storage) and 2B (6 days storage), respectively.

Of the surfactants tested, Myverol PO6, Durfax EOM, Durfax 60 and Myverol SMG(V) were the most effective at 10 and 25 C. At 40 and 50 C, effectiveness of all the agents, except for Centrolene, was similar. In general, surfactants which were found most effective after 1 day were also best after prolonged storage (6 days).

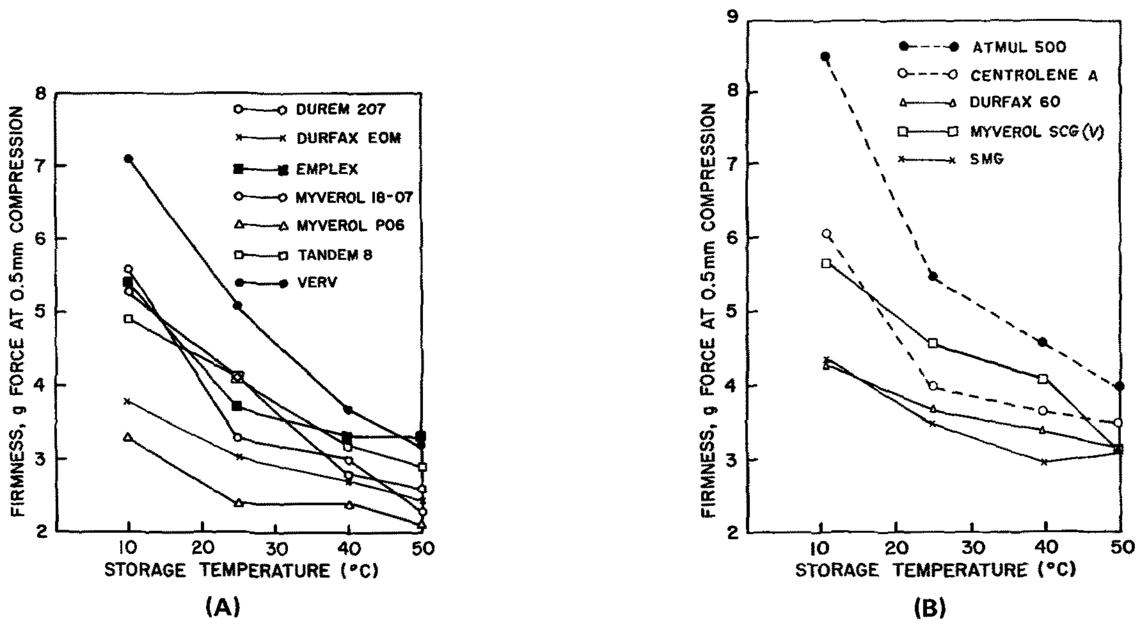


**FIG. 1. (A) Effects of surfactants on crumb firmness (1 day storage) at varied storage temperatures of breads of approximately equal specific volume (average specific volume ± 1 SD, 5.45 cc/g ± 0.25). (B) Effects of surfactants on crumb firmness (1 day storage) at varied storage temperatures of breads deviating in specific volume more than 1 SD from average. (Broken lines for specific volumes below average; solid lines above average.)**

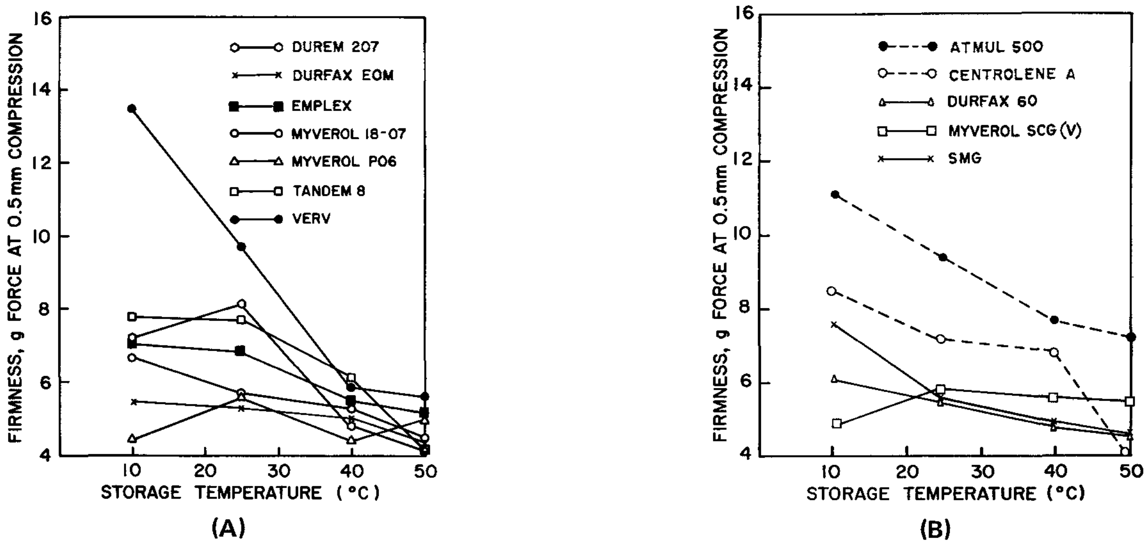


**FIG. 2. (A) Effects of surfactants on crumb firmness (6 days storage) at varied storage temperatures of breads of approximately equal specific volume (average specific volume ± SD, 5.45 cc/g ± 0.25). (B) Effects of surfactants on crumb firmness (6 days storage) at varied storage temperatures of breads deviating in specific volume more than 1 SD from average. (Broken lines for specific volume below average; solid line above average.)**

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