NOTE ON WATER-BINDING EFFECT OF TWO DOUGH CONDITIONERS

H. DAOUST,[1] M.-A. CHABOT,[1] and R. WASIK[2]

Cereal Chem. 55(2): 255-258

More research is being carried out on the role of water within dough and bread systems as our awareness of its importance in these systems grows. Hlynka (1) and Larsen (2) introduced the concept of free and bound water in considering the relation between water and individual flour components. To these authors bound water was an integral part of the structure of dough, while free water was responsible for the fluidity or mobility of a dough.

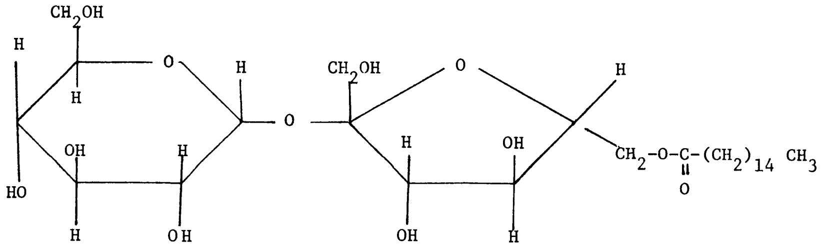
Differential scanning calorimetry (3), differential thermal analysis (4,5), nuclear magnetic resonance (6), and thermal gravimetric analysis (TGA) (7) have since been applied to the study of water in wheat, flour, dough, and bread. TGA is an analytical method which measures the change in weight of a substance as it is heated, cooled, or otherwise altered. The manner of weight change is characteristic of that substance. Each technique has its particular advantages and it is not the purpose of this paper to discuss each of them. To the authors' knowledge no one has reported any data from any of the above techniques on the effect of surfactant dough conditioners on the rate of evaporation of water from doughs when they are heated. Surface-active dough conditioners are used extensively in the baking industry to modify mixing properties and to improve the volume, texture, and keeping quality.

This note describes the effects of two surfactants, sucrose palmitate and succinylated monoglyceride (SMG), on the rate of water loss from flour-water doughs heated from 25° to 180°C, as examined by TGA.

MATERIALS AND METHODS

An unenriched bread flour, succinylated monoglyceride, and sucrose palmitate were obtained from the Ogilvie Flour Mills Co. Ltd., Montreal, Quebec. According to the supplier both surfactants are primarily dough strengtheners with limited antifirming properties. The proximate composition of the flour was: 7.55% moisture, 15.4% protein, 0.90% fat, and 0.48% ash. The molecular structure of the surfactants are:

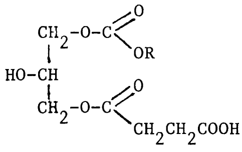
Sucrose Monopalmitate



[1]Department of Chemistry, University of Montreal, C.P. 6210, Succ. A., Montreal, Quebec H3C 3V1.
[2]Food Research Institute, Ottawa, Ontario K1A 0C6.

0009-0352/78/000029$03.00/0

Succinylated Monoglyceride



R = fatty acid chain

The proximate analysis was carried out according to AOAC (8) standard procedures.

All doughs were mixed at 63 rpm for 8 min in a Brabender Farinograph equipped with a 50 g bowl thermostated to 30 ± 1° C. All doughs were prepared at an absorption of 60% with distilled water. The surfactants were added to the flour prior to the addition of water to form a dough.

A Model RG Cahn electrobalance and a West programmer coupled to a Cahn furnace constituted the TGA apparatus. About 80 mg of dough was placed within the heating chamber of the electrobalance and heated at 5° C per min from ambient (25° C) to 180° C. In 20 min the sample temperature was approximately that inside a loaf of bread after 20 min in a regular oven at 200° C (9).

The temperature of the environment 1–2 mm from the sample was recorded with a cold junction (0° C) chromel-alumel thermocouple.

RESULTS AND DISCUSSION

The slopes of the desorption curves were calculated at 5° C intervals. The per cent weight loss per degree was then plotted against the temperature of the environment close to the sample. This produced a plot (Fig. 1) with two distinct regions, a plateau region at temperatures between 40° and 100° C and a peak region at temperatures above 100° C. The plateau region corresponds to a temperature span where the per cent rate of water loss is constant, the plateau height was measured at 70° C for all runs. The peak region corresponds to a temperature span where the percent rate of water loss is constant, the plateau water is further removed from the dough.

As can be seen from Fig. 1, the points above and under the thermograms represent the standard deviation calculated from four experimental runs. This deviation is small in the plateau region but quite large in the peak region. The error in the peak region is primarily attributable to:

1. Measurement of slopes. The slope, which is tan α, α being the angle between the curve and the horizontal axis, increases slowly when $0° \leqslant \alpha \leqslant 45°$ thus $0 \leqslant \tan \alpha \leqslant 1$ but increases rapidly when $45° < \alpha \leqslant 90°$, $1 < \tan \alpha \leqslant \infty$. Thus, for high desorption rates the error on slope measurement increases dramatically.
2. Sample temperature. The indicated temperatures are not sample temperatures but the temperature of the environment in contact with the sample, the environment temperature, and sample temperature are believed to be close to one another because the sample sizes are very small.
3. Sample geometry. It was difficult to control the amount of surface exposed to the environment because of the small amounts of sample used.
4. Heating rates. Reproducibility could have been marginally improved if programmer temperature control had been better than ± 0.5° C per min.

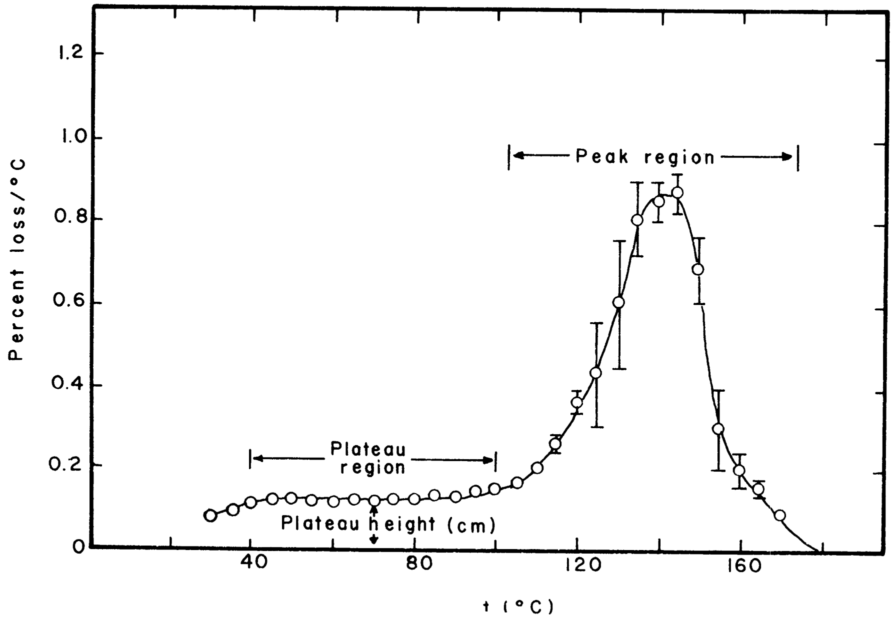


Fig. 1. Typical water desorption as a function of temperature graph from TGA of a dough with 0.5% sucrose palmitate.

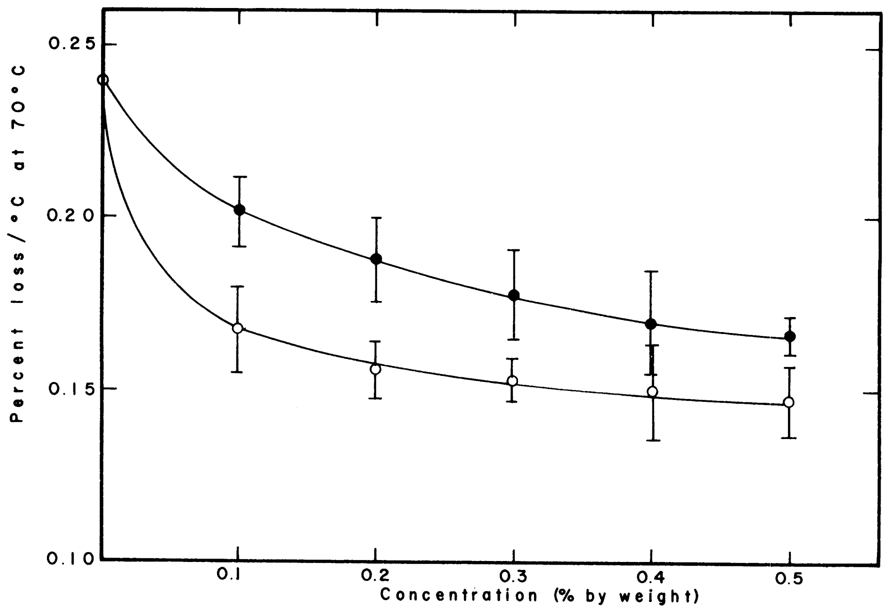


Fig. 2. Effect of surfactants on TGA of doughs. Closed circles: succinylated monoglyceride. Open circles: sucrose palmitate.

No statistically-significant data could be extracted from any analysis of the peak-region. No data about phenomena in this region will be presented.

The presence of either succinylated monoglyceride or sucrose palmitate in a simple water-flour dough significantly reduced the rate at which water was lost from the dough samples as measured by the lowering of the plateau height (Fig. 2). This lowering effect was greater for sucrose palmitate than for succinylated monoglyceride at the concentrations studied. Due to lack of a baking facility, comparative tests could not be carried out to evaluate either surfactant so it is not known which surfactant is better. The largest decrease in the rate of water loss occurred upon the first addition of the surfactant. Subsequently larger additions of either surfactant produced significant but smaller decreases in the rate of loss of water.

Mehrotra and Bushuk (5) have demonstrated that loaves baked at higher absorptions became stale less rapidly and suggested increasing the dough absorption as an inexpensive but effective means of improving both the yield and shelf life of baked products.

The retardation of the rate at which water is lost from a dough during baking by surfactants might, in part, account for the increased shelf life of products when surfactants are added to the formulation.

The mechanism through which surfactants in question might operate is purely speculative at this point. One hypothesis may be that the surfactant forms a moisture barrier over the hydrated dough components in a manner similar to that suggested by Herz (12) for fat. The surfactant might also increase the hydrophilicity of hydrophobic components, by complexing with them.

Literature Cited

1. HLYNKA, I. Dough mobility and absorption. Cereal Chem. 36: 378 (1959).
2. LARSEN, R. A. Hydration as a factor in bread flour quality. Cereal Chem. 41: 181 (1964).
3. WOOD, P. S., DANIELS, N. W. R., and GREENSHIELDS, R. N. The effect of water on lipid binding in doughs mixed to low work levels. J. Food Technol. 2: 183 (1972).
4. DUCKWORTH, R. B. Differential thermal analysis of frozen food systems. I. The determination of unfreezable water. J. Food Technol. 6: 317 (1971).
5. MEHROTRA, V. K., and BUSHUK, W. Studies of water binding by differential thermal analysis. I. Dough studies using the boiling code. Cereal Chem. 54: 311 (1977).
6. SHANBHAG, S., STEINBERG, M. P., and NELSON, A. I. Bound water defined and determined at constant temperature by wide-line nuclear magnetic resonance. Food Technol. 35: 612 (1970).
7. NEHER, M. B., PHEIL, R. W., and WATSON, C. A. Thermoanalytical study of moisture in grain. Cereal Chem. 50: 617 (1973).
8. ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. Official methods of analysis (12th ed.). The Association: Washington, D.C. (1975).
9. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. Wheat: Chemistry and technology (2nd ed.). The Association: St. Paul, Minn. (1971).
10. SOCIETY OF CHEMICAL INDUSTRY. Surface-active lipids in foods. S.C.I. Monograph No. 32. The Society: London, England (1968).
11. NEWBOULD, M. W. Crumb softeners and dough conditioners. Baker's Dig. 50(4): 37 (1976).
12. HERZ, K. O. Staling of bread—a review. Food Technol. 3: 1828 (1965).

[Received May 31, 1977. Accepted November 7, 1977]