SOME ASPECTS OF THE BREAD STALING PROBLEM[1]

Contribution from the Department of Cereal Technology

Importance of Bread Staling

The United States Food Administration estimated in 1917 that the return of stale bread caused an annual loss of more than 600,000 barrels of flour, equivalent to 2,700,000 bushels of wheat. Pirrie (1940) and Schoch and French (1945) reported that as much as 3.0% to 4.7% of the total bread production was lost annually due to staling. Other reports (1946) indicated that despite starvation in numerous parts of the world many day old loaves are continually being discarded in the United States. In 1942 the annual wastage was estimated to be equivalent to 250,710,000 loaves, or approximately 5,756,097 bushels of wheat. In time of war the problem becomes more acute because the desirability of bread in field rations has been repeatedly emphasized (Geddes and Bice, 1946).

A secondary aspect of bread staling is the social side; bakers are required to perform undesirable night work so the consumer may purchase fresh bread each day. Katz (1928) started bread staling studies to eliminate night work in bakeries in Holland.

It is apparent from these facts that bread staling is a serious problem, and means of preventing it are of marked importance to the American economy. This problem also affects wheat growers because bread tends to become stale in the home, while many other foods may be kept fresh for considerable lengths of time in refrigerators or containers. This may lead to increased public preference for other foods with resultant decrease in the demand for bread.

Changes Occurring During Staling

During staling the compressibility of the crumb decreases as well as the ability to imbibe water. Crumb opacity and the amount of water-soluble starch also decline. X-ray analysis has indicated a change from a V-pattern to a B-pattern superimposed upon a V-pattern as staling progresses. Starch of stale bread is more resistant to enzyme attack than starch of fresh bread. Changes in bread crumbliness likewise occur during staling. Probably staling essentially consists of a transfer of moisture from the starch to the gluten component. There is no relation between loss of moisture from the loaf as a whole and staling.

These characteristic changes during staling form the basis of laboratory methods to measure the staling rate of bread. It is probable that the determination of crumb firmness has the most practical value since it yields data related to the consumer's concept of bread staling. It does not reveal as much information regarding the biochemical basis of staling as some of the alternative methods. Dif-

[1]This report resulted from a preliminary study made under Purnell Project 147, "An Investigation of the Effect of Durum Wheat Flour and Potato Constituents on the Staling Rate and Quality of Bread."

ferences in crumb compressibility induced by a constant force have little meaning, particularly if the reciprocal of the strain values are not used in interpretation.

Prevention of Staling

Many investigations have been made on the inhibition of the staling rate of bread, and a large number of substances have been studied. These include milk solids, sugar, flour protein content, chemical compounds, etc. Studies have also been conducted on bread production procedures such as absorption, fermentation, mixing time, etc. The data from these investigations have tended to be non-comparable, or are highly conflicting because of lack of uniformity in methods of evaluating staleness. Commercial products made from shortenings, as polyoxyethylene stearate, for example, prevent staling as far as the increase in crumb firmness is concerned, but have been classified by some chemists as softening rather than staleness retarding agents. A number of agricultural products, including potato and durum wheat flour, have been thought to slightly inhibit the staling rate, but no data have been published regarding the effect of durum wheat flour on staling.

Storing bread at temperatures above but near the freezing point accelerates the staling rate. Frozen bread will remain fresh (when thawed) for a maximum of 345 days when stored in tin cans and held at -22°C. (1941). Heating tends to refreshen bread, probably due to redistribution of the moisture between the starch and gluten components.

Methods Employed in Measuring Staling

The macaroni tenderness tester described by Binnington, Johannson and Geddes (1939) was employed for ascertaining changes in the firmness of bread crumb. Preliminary work indicated that care was necessary in selecting the size and thickness of the slice utilized. Care was taken that the square sections selected did not contain holes and were free from hard lumps. The squares were free of crust and were taken at random throughout the loaf. The balance of the loaf was shredded in the Waring Blender and used for moisture, mixograph, and hydration tests. Following preliminary tests, it was decided to compress the bread to a definite degree, ⅘ of the original thickness, and determine the time in seconds and the weight of mercury in grams required to attain this compression.

The hydration, or amount of water imbibed by the bread, at different ages was determined using shredded crumb suspension in distilled water. The suspension was centrifuged and the central portion of the swollen residual crumb removed for moisture assay by drying overnight in an electric oven at 105°C. This method was employed for the determination of the swelling power of starch by Harris and Jesperson (1946).

An apparatus was constructed to measure the staling rate by determining the turbidity of crumb-water extracts through measurement, by means of a photo-electric cell and galvanometer, of the amount of light reflected from the crumb particles suspended in the water extract. The more highly hydrated particles would scatter more light, and this afforded a means of determining the hydration. The data secured resembled those obtained from the measurement of the actual hydration, but were less consistent. These data are therefore omitted in this report.

Mixograms, or mixing curves, were obtained on the shredded crumb when mixing with distilled water employing three proportions of water, 118%, 123% and 128%, based on weight of dry crumb. The samples were mixed until a definite curve was formed rather than for a specified length of time.

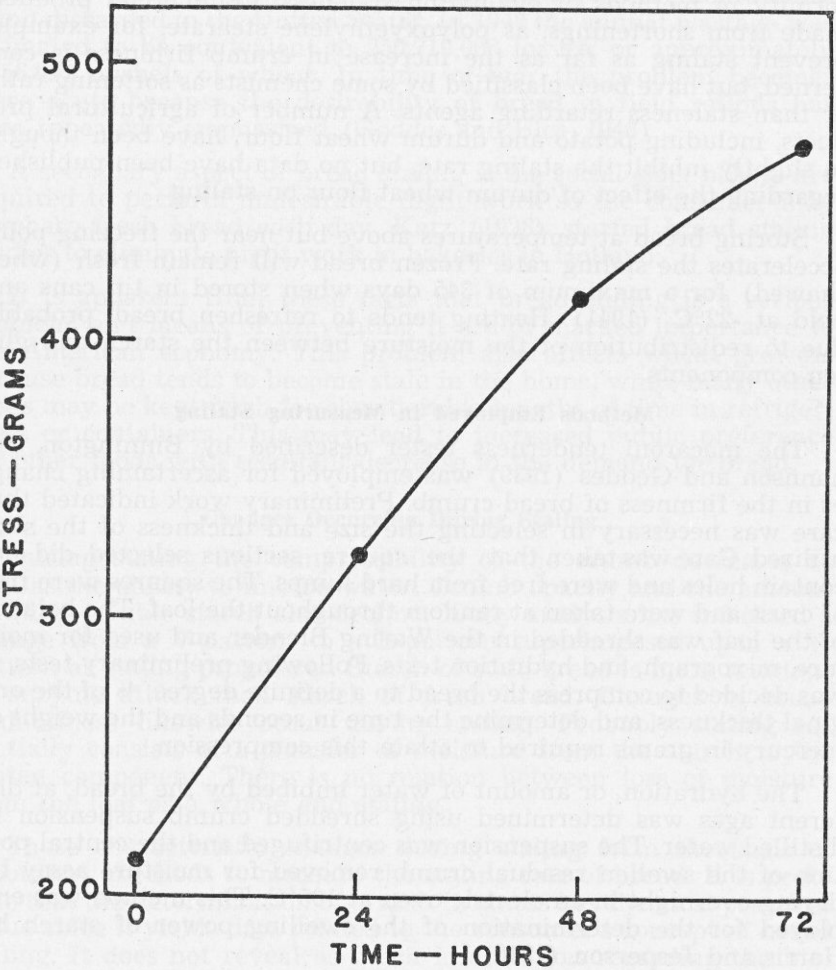

Fig. 1. Relation between age of bread and stress in grams of mercury required to produce a depression of 4/5 of the original 1/2 inch thick bread slice 1 1/2 inches square.

Results and Discussion

The data obtained with the macaroni tenderness tester are represented in Fig. 1. It is evident that the weight of mercury required to secure a uniform depression of the slice of bread increases with the age of the bread. This relationship is caused by the greater resistance of the older bread to compression, and is closely correlated with the consumer's concept of staling. If the bread remained fresh, the relation between weight of mercury employed and age of bread should yield approximately a straight, horizontal line. Bread to which an anti-staling agent has been added should tend to produce the same result, because the bread would remain soft and unchanged with age. This method suffers from marked experimental variability occasioned by the difficulty of securing duplicate slices of bread of uniform texture and crumb structure. These factors have a definite influence on the results obtained with the tenderness tester.

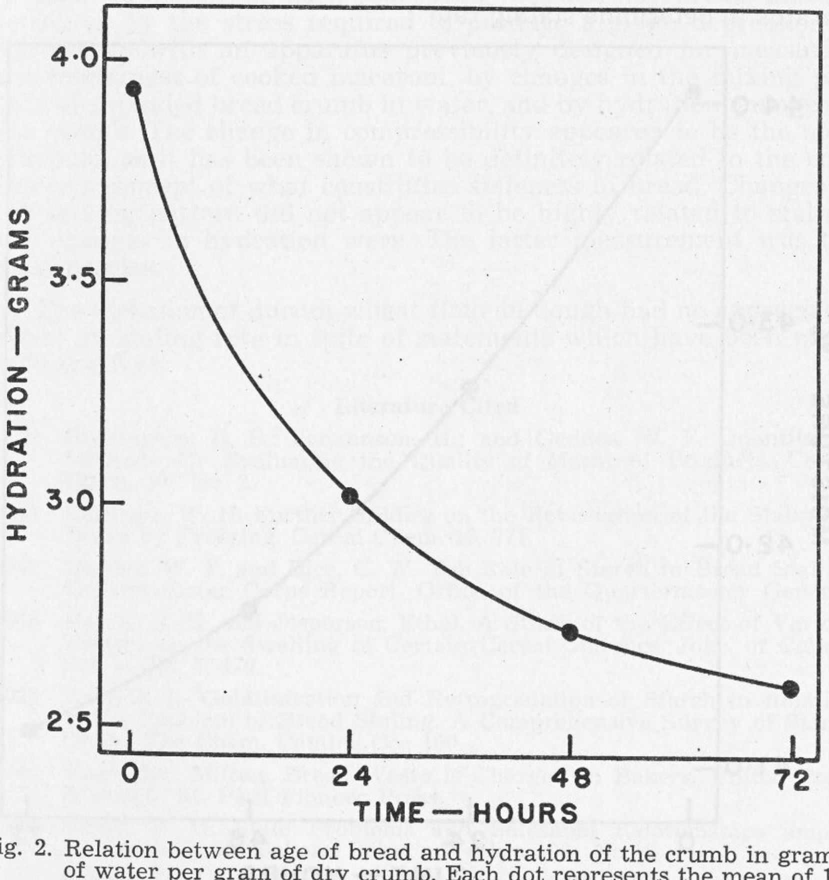

Fig. 2. Relation between age of bread and hydration of the crumb in grams of water per gram of dry crumb. Each dot represents the mean of 12 tests.

Fig. 2 provides information on the proportion of water imbibed by the bread crumb at different periods after baking. The hydration decreases consistently with age of the bread, in the same way as the resistance to compression increases. This method of determining staling was less subject to error than the resistance procedure first described, since the crumb structure had no influence on the results.

For the mixograph tests differences among the samples of bread were found, but these did not appear to be consistent and were not highly related to age of the bread. A number of difficulties in this method soon became apparent; often the bread-water mixture refused to form a satisfactory dough, and the mixing blades would merely pass through the mixture without mixing action. Clumps of the crumb would often form and cause erratic variations in the mixograph pattern; and in some samples, particularly after aging, prolonged mixing was required before a dough would form. There was some relation between staleness and mixogram patterns, but this was too slight to permit the use of this apparatus to determine staling rate.

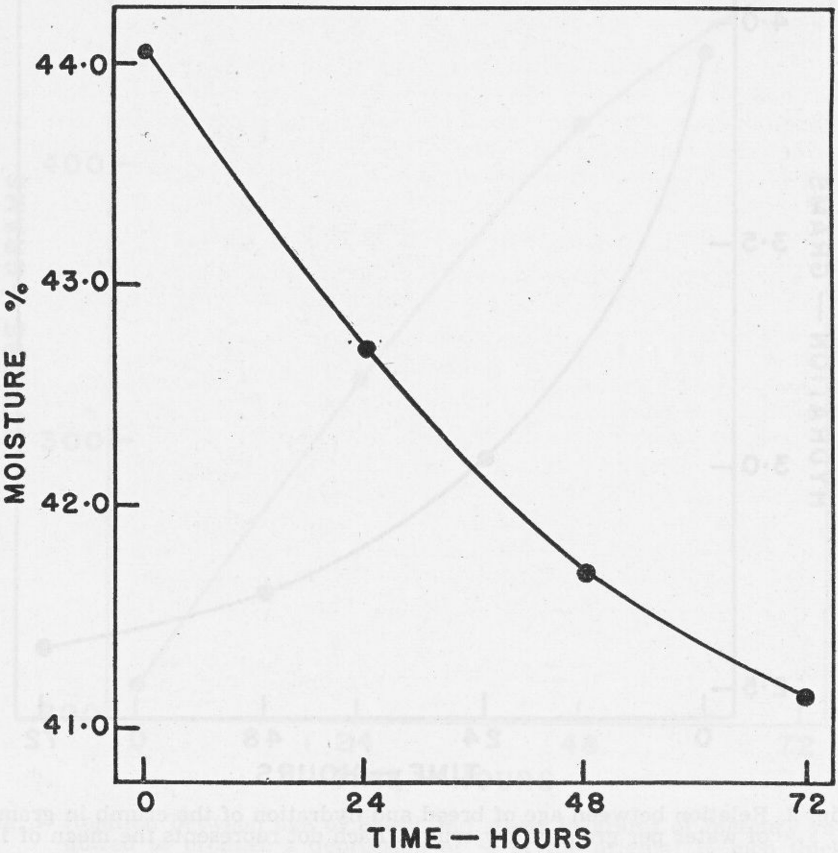

Fig. 3. Changes in moisture content of the crumb of loaves of bread with time.

These objective tests showed that the addition of durum wheat flour to the doughs had no appreciable effect on the staling rate. Examination of the loaves using accepted quality judging methods confirmed the conclusion derived from these tests.

Fig. 3 shows representative data for moisture loss from the bread crumb during the staling period. The loaves were wrapped in double sheets of waxed paper and sealed. They were then placed in tin cans and sealed with scotch tape to prevent moisture loss as far as possible. Storage was under laboratory conditions.

It is proposed to investigate the effect of uncooked and cooked potato flour on bread staling rate, employing the crumb firmness and hydration tests described. The baking quality of the resultant loaves will also be rated.

Summary

Rate of staling of hard red spring wheat flour bread was determined by the stress required to produce a given depression of the crumb with an apparatus previously designed for measuring the tenderness of cooked macaroni, by changes in the mixing pattern of shredded bread crumb in water, and by hydration changes of the crumb. The change in compressibility appeared to be the most practical, as it has been shown to be definitely related to the consumer's concept of what constitutes staleness in bread. Changes in the mixing pattern did not appear to be highly related to staling, but changes in hydration were. The latter measurement was the most precise.

The inclusion of durum wheat flour in dough had no appreciable effect on staling rate in spite of statements which have been made to that effect.

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