EFFECTS OF ABSORPTION AND TEMPERATURE UPON FLOUR-WATER FARINOGRAMS[1]

E. G. BAYFIELD[2] AND C. D. STONE[2]

ABSTRACT

By the use of the farinograph, studies with flour-water doughs over a range of temperatures between 81.5° and 121°F. (27.5° and 49.4°C.) indicate that, at constant absorption, consistency softens with increase in temperature. With consistency held constant, the absorption decreases as the temperature increases. As the farinograph has been standardized at 30°C., the customary interpretation of farinograms may not be valid when the curves are obtained at temperatures other than normal.

High-temperature dough fermentation systems (100°–104°F. or 37.8°–40°C.) may have considerable advantage over the present (80°–90°F. or 26.7°–32.2°C.) conventional systems. Published information concerning the newer breadmaking processes gives evidence of a tendency toward higher temperatures than those presently used in commercial production. The object of this study was to find what effect

[1] Manuscript received March 2, 1959. Contribution from the Department of Baking Science & Management, Florida State University, Tallahassee, Florida.
[2] Professor and Assistant Professor, Department of Baking Science and Management.

variations in absorption and temperature have on flour-water farinograms.

Numerous earlier workers have contributed to the development of methods for interpreting farinograms of doughs obtained under ordinary temperatures. Swanson (5) discusses the effects of absorption and temperature on flour-water doughs up to 35°C. Markley and Bailey (4) found that a curvilinear relation existed between absorption and time to bring a dough to the point of minimum mobility. When plotting the logarithm of time required to reach the point of minimum mobility against the flour concentration in the dough, they found that this curvilinear relation could be straightened. Stone and Bayfield[3] found that fermenting yeast doughs exhibited the same trends of temperature effect as were observed with flour-water doughs; dough consistency varied inversely with the temperature, other factors being constant. With the use of a constant absorption, bread baked from doughs fermented at 100°F. (37.8°C.) was comparable or superior to bread baked from doughs fermented at 86°F. (30°C.).

Materials and Methods

A nonbromated, nondiastatted, bleached flour, milled from hard red winter wheat was used. Its analysis was approximately 11.40% protein and 0.43% ash. Distilled water was used, and the flour absorption was 57.2% (14% M.B.) when determined in the farinograph at 86°F. (30°C.) with the peak development at 500 Brabender units.

Farinograms (1) were obtained varying the temperature by increments of 7°F. (3.88°C.) between 86° and 121°F. (30° and 49.4°C.). An interval of 4.5°F. (2.57°C.), from 86° down to 81.5°F. (30° to 27.5°C.), was recorded; this was the lowest temperature that could be maintained with the available water cooling system. The highest temperature was 121°F. (49.4°C.) as this approached the upper limit of yeast activity. White (6) has shown that 100° to 104°F. (37.8° to 40°C.) is the maximum temperature range to obtain optimum fermentation. The flour and water were both preconditioned to the temperatures at which the farinograms were recorded before the water was titrated into the flour in the mixing bowl of the farinograph. Constant flour weight was used throughout; water and temperature were the variables in the experiments.

Fifteen-minute farinograms were obtained over the range of temperatures described above, with constant absorption as one variation and "500 consistency" curve peaks the other. The 500 consistency

[3] Stone, C. D. and Bayfield, E. G. A comparative study of several factors influencing the course of fermentation under three systems of bread production. Presented at the 44th annual meeting, Washington, D. C. (1959).

farinograms required recording a number of curves before the exact consistency desired was obtained.

Results

Figures 1 to 4 and Table I record the results of the farinograph studies. When the temperature was increased from 81.5° to 121° F.

TABLE I
MEASUREMENTS TAKEN FROM FARINOGRAMS RECORDED OVER A RANGE OF TEMPERATURES

TEMPERATURE	CONSTANT ABSORPTION (57.25%)				CONSTANT CONSISTENCY (500 B.U.[a]) VARIABLE ABSORPTION			
	Peak Time	Mixing Time (minutes)			Peak Time	Water[b] Used	Mixing Time (minutes)	
		Peak	7	15			7	15
°F	*minutes*	*Bu*	*Bu*	*Bu*	*minutes*	*%*	*Bu*	*Bu*
81.5	7	555	555	478	8	59.40	500	440
86.0	7	500	500	445	7	57.25	500	440
93.0	3	455	438	395	2½	55.50	480	425
100.0	2½	412	375	338	2	54.50	445	398
107.0	2	390	325	290	1⅞	53.80	400	358
114.0	1¾	375	285	258	1¾	52.80	375	332
121.0	1⅔	362	265	232	1⅔	52.40	355	318

[a] B.u. — Brabender units.
[b] Percent absorption based on the flour as 100% (14% M.B.).

(27.5° to 49.4°C.), with constant absorption, there was a decrease in height of the curve of 193 Brabender units. The results for the higher temperatures illustrated in Fig. 1 show considerable similarity to curves obtained from certain weak flours or with results of various enzymes on wheat flours at normal temperatures, as shown by Gray (2) and Johnson and Miller (3). They are also in agreement with the discussion by Swanson (5).

When titrations were adjusted to give a peak value of 500 consistency, there was a decrease in absorption, based on flour as 100%, of 7% between the temperatures of 81.5° and 121°F. (27.5° and 49.4°C.). With the use of constant absorption, the farinogram height decreased as the temperature was increased.

When the data in Table I were graphed (Fig. 2), the absorption-temperature curves (measured for 500 consistency) and the consistency-temperature curves (measured at their peaks with constant absorption) were curvilinear. When the curve peaks were measured at 7-minute mixing time with constant absorption and varied temperature, the curves were less curvilinear in nature and became almost a straight

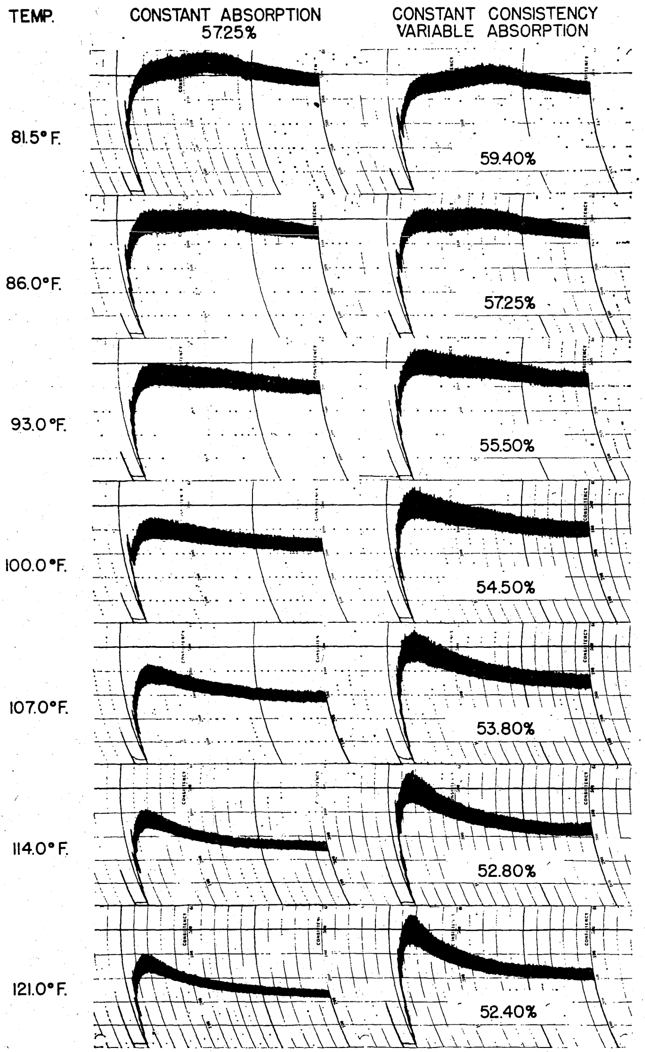

Fig. 1. Effects of varying temperature and absorption upon farinograms.

line between 86° and 107°F. (30° and 41.7°C.).

When these data were plotted on semilogarithmic paper (Fig. 3), the peaks of the constant-consistency and constant-absorption curves approximated a straight line. A logarithmic relation is suggested between flour absorption, mixing time, and dough temperature when one of these three factors is held constant. This is in accord with the work of Markley and Bailey (4) and extends the logarithmic relation

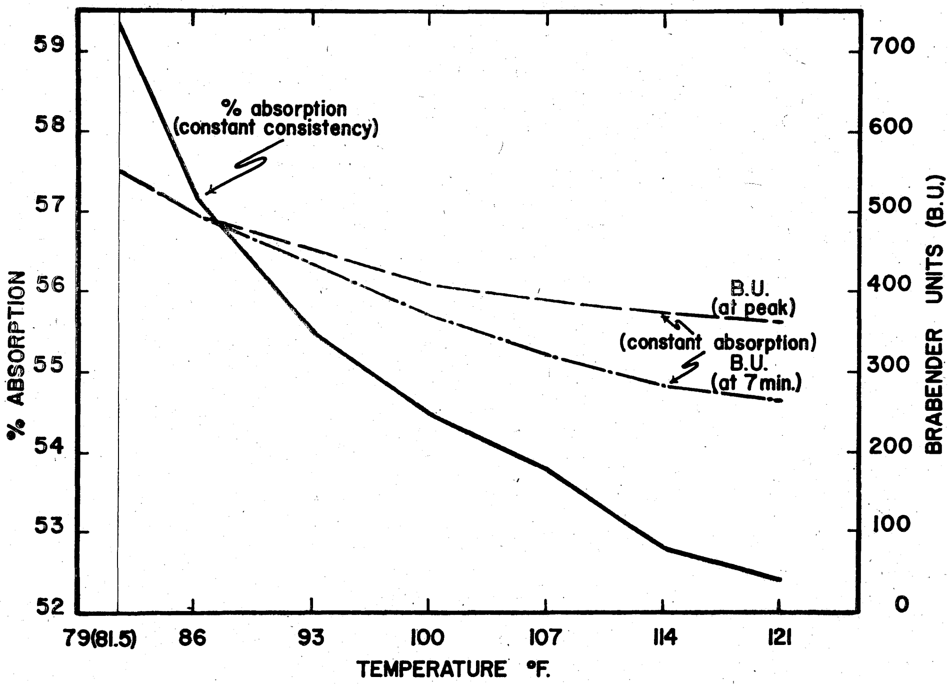

Fig. 2. Effect of temperature upon dough absorption.

over a range of temperatures.

The 7-minute curves were of an inverted curvilinear nature. Measurements at 15 minutes were roughly parallel to the 7-minute curves, but were lower in height (Table I and Fig. 4).

Discussion

This study shows the effects of absorption and temperature upon farinograph flour-water doughs and points out that the farinogram, as now interpreted, does not show correct flour absorption or mixing characteristics when the dough is mixed at higher or lower temperatures than normal.

One may conclude that dough consistency varies inversely with the temperature and, with this particular flour, in a semilogarithmic relationship between the temperatures of 81.5° and 121°F. (27.5° and 49.4°C.). The higher the temperature at which a dough is mixed, the less its absorption at constant consistency, or the softer it becomes at constant absorption.

Studies by Stone and Bayfield (see footnote 3) show that slackness in yeasted doughs of commercial consistency, due to increased tem-

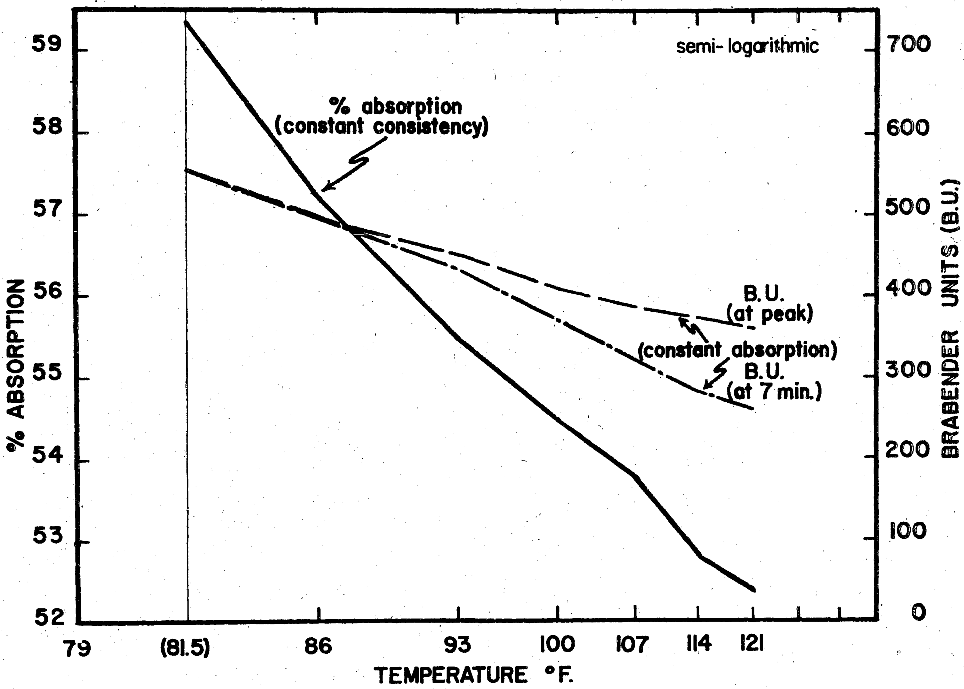

Fig. 3. Effect of temperature upon dough absorption (temperature axis semi-logarithmic).

perature, does not indicate a longer mixing requirement for properly mixed doughs (in terms of finished bread). They found that doughs mixed in the higher temperature range appeared to be too slack, but did not produce baked bread containing excess moisture and did not have excessive moisture loss during proofing and baking.

Data in Table I show the mixing time required to reach the farinogram peaks. Mixing time to the curve peak decreased slowly between 81.5° and 86°F. (27.5° and 30°C.); then it decreased abruptly between 86° and 93°F. (30° and 33.9°C.) and decreased much more slowly at higher temperatures. This indicates that the farinogram peaks as interpreted at 86°F. (30°C.) are not a measure of the same factors as the peaks at the higher temperatures (Fig. 4).

Farinogram interpretations such as optimum mixing time, obtained from normal temperature curves, are not satisfactory at higher or lower temperatures. In Figs. 1 and 4, it appears that the farinogram peaks sink into the curves, rather than shifting to the left (reaching the peak sooner), with increased temperature. This is probably due to decrease in the viscosity of the water films lessening the adhesion tensions

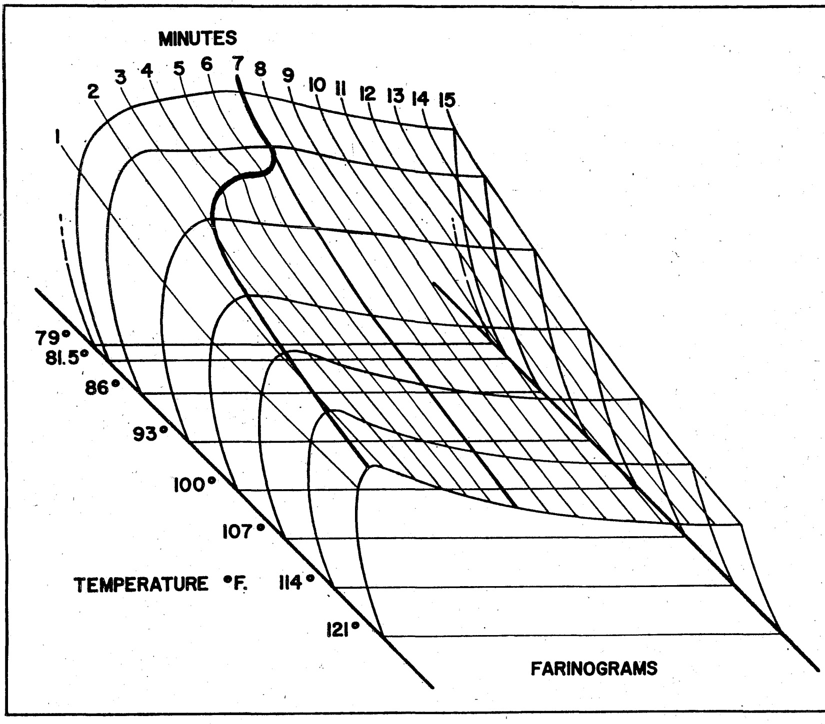

Fig. 4. Three-dimensional interpretation of farinogram curves (constant absorption).

of the dough (5). The new peaks formed to the left at higher temperatures represent other factors involved in the initial mixing of the dough ingredients. These factors are present in all of the doughs but are partially obscured by the farinogram peaks at normal temperatures.

New farinogram interpretations need to be developed for doughs at temperatures other than those previously considered as normal. This is especially important in the area of higher temperature conditioning and processing of doughs used by the more recent developments in continuous bread production.

Acknowledgment

The authors are indebted to the Pillsbury Company, Minneapolis, Minnesota for the provision of certain supplies.

Literature Cited

1. American Association of Cereal Chemists. Cereal laboratory methods (6th ed.). The Association: St. Paul, Minnesota (1957).
2. Gray, P. P. Fungal enzymes in the bakery fact and fancy. Wallerstein Labs. Communs. **16** (No. 54): 215–227 (1953).
3. Johnson, J. A., and Miller, B. S. The relationship between dough consistency and proteolytic activity. Cereal Chem. **30**: 471–479 (1953).