Effects of Proof Temperature on the Quality of Pan Bread

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ABSTRACT

A variety pan bread formula was used in examining the effects of proof temperature with relatively constant proof duration. Proof temperatures varied from 24 to 52°C, and enough yeast was added to keep proof times constant. Internal temperatures of dough were monitored before and during baking. The effect on finished loaf volume and internal grain and texture was also examined. A sponge-and-dough baking process was used for a 1-lb finished weight product. Great care should be exercised in determining proof and dough temperatures before baking to produce optimum bread in commercial practice.

Final proofing is an important part of the bread-making process. A dough piece is put through sheeting, curling, and degassing stages of the molding process. During the last fermentation, or final proof, the dough is allowed time to relax, and the yeast produces CO_2 that is trapped within the dough. This additional CO_2 results in light, airy products.

Proofing conditions of time, temperature, and humidity vary for different products and processes. In pan breads, Dubois and Vetter (1987) found that proofing times ranged from 41-65 min, with 55 min being most typical. Freilich (1949) studied proof time of 0-150 min and found optimum conditions to be 45-60 min. Loaf volume increased with additional time, but crumb grain was unacceptably open.

Pyler (1973) found proof temperatures reported within the practical range of 33-54°C (90-130°F), with most bakeries holding temperatures of 41-43°C (105-110°F) for pan breads. Typical proof temperature, according to Dubois and Vetter (1987), is 115°F. They also noted that typical proof temperature used in 1987 was higher than that used a few years before. Temperatures as high as 120°F have been used but present the danger of inhibiting yeast action (Kamman 1970).

Freilich (1949) studied the effect on loaf volume of proofing to a constant height at various temperatures. The final volumes had a relatively narrow range, but proof times varied from 270 min at 13°C (56°F) to 36 min at 57°C (135°F). However, optimum bread was produced in the range of 30-46°C (86-115°F). Kamman (1970) also found 63 min to be optimum proof time, but the range was much narrower. Underproofed product was produced in 48 min and overproofed product in 72 min.

Relative humidity is also a major consideration. Pyler (1973) reported the typical range is 75-90% rh; lower humidity produces a dry, crusty surface of the proofed product, and higher humidity (>90%) may cause moisture condensation on the product, resulting in surface discoloration or spotting.

Our intention was to proof identical wheat doughs made in a sponge-and-dough baking process and to expose them to various temperatures during the final proofing phase. To keep the time of proof constant, additional yeast was added to the doughs that were proofed at lower temperatures and less yeast was added to doughs proofed at higher temperatures. This commercially acceptable proof, with a constant proof time and height, would allow evaluation of the effect of proof temperature.

MATERIALS AND METHODS

The flour used in this study was a straight-grade, unbleached, enriched, white flour containing 12.5% protein (5.7 × N), 13.8% moisture, and 0.48% ash. The test wheat bread formula replaced 15% of the flour with wheat bran. Spring wheat bran was supplied by North Dakota Mill and Elevator (Grand Forks, ND). Protein, moisture, and ash were determined by AACC-approved methods 46-11A, 44-15A, and 8-01 (AACC 1983).

The bread-making method used was a 70/30 sponge-and-dough process as formulated in Table I. All sponges were set at 24°C (75°F) and fermented for 3 hr at 30°C (86°F) and 80% rh. Average temperature of the sponge after fermentation was 27-28°C (80-82°F). This formulation was tripled to produce a dough containing 255 g of flour and 45 g of bran per test dough (300 g of flour, less 15% bran on a replacement basis).

The sponge was mixed for 1 min in a 100-200 g mixer (National Mfg. Co., Lincoln, NE) with an optional larger bowl (325 g). The dough ingredients were added to the fermented sponge and mixed to optimum (2.5 ± 0.25 min). Dough temperatures were 80 ± 2°F. Doughs were allowed to rest for 10 min, scaled to 540 g, rested for an additional 10 min, and molded using a straight-

TABLE I
Sponge-and-Dough Baking Formula

Ingredients	Baker's Percentage	Weight (g)
Sponge		
Flour	55	165
Water	50	150
Wheat bran	15	45
Yeast (compressed)	2.5	7.5
Vital wheat gluten	2	6
Dough		
Flour	30	90
Water	15	45
Sucrose	10	30
Vegetable shortening	3	9
Salt	2	6
Yeast	Variable	Variable
Ascorbic acid	100 ppm	100 ppm

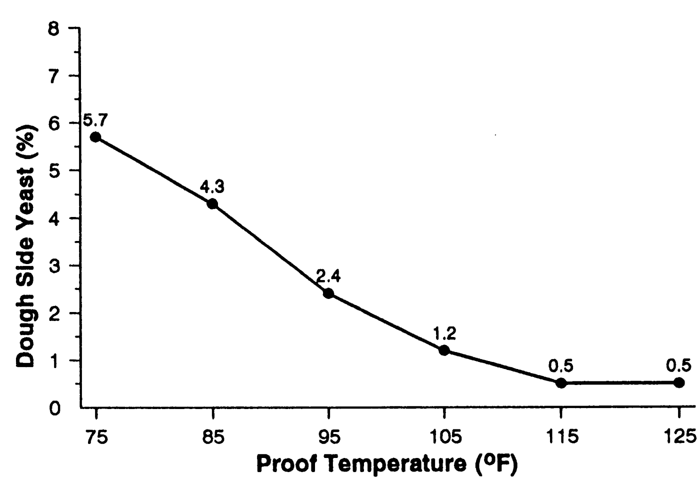

Fig. 1. Dough-side yeast amount (%) required to proof doughs in 50-55 min at 75, 85, 95, 105, 115, and 125°F.

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grain experimental molder (Rol-Sheeter, model 8, Acme, Pico Rivera, CA). Doughs were immediately placed in 9.5- × 4.5- × 3.0-in. pans and proofed according to the research design. All loaves, except the 75°F proof temperature, were kept in a proof box at a set temperature with 85% rh. The 75°F proof was carried out under ambient conditions. All loaves contained adequate yeast to proof in 50–55 min at temperatures of 75, 85, 95, 105, 115, and 125°F. All loaves were proofed to a height of 0.5 in. over the top of the bread pan before baking at 425°F in a four-rack, reel-type experimental oven (Chubco, Oakland, CA) for 21 min. Immediately upon removal from the oven, volume was measured using a 1-lb loaf volumeter (National). The products were cooled for 60 min and sliced. Times, temperatures, and volumes were recorded averages of at least duplicate determinations on separate days. Loaf volumes differing by more than 71 cm^3 were statistically significant at $P = 0.05$. Correlation coefficient of loaf volume and proof temperature was $r = -0.95$ ($n = 61$).

Dough temperature during proofing, baking, and cooling was measured using a temperature probe (Datatrace, Wheat Ridge, CO). The range of the probe was 10–150°C (50–302°F), with an accuracy of ± 0.5°C (1°F). The probe was programmed to record temperature at 30-sec intervals through proofing, baking, and cooling to record dough temperatures at the various proof temperatures.

RESULTS

To keep proof time constant through a range of proof temperatures, varying amounts of yeast were necessary. All yeast changes were performed at dough stage so that no fermentation changes during the sponge would be observed. Figure 1 illustrates the amount of dough-side yeast necessary at each temperature to keep proof constant.

Figure 1 shows two effects: 1) a nearly linear relationship exists between the amount of yeast necessary to keep proof times constant and the temperature of proof; and 2) this relationship breaks down at high proof temperatures. It takes the same amount of yeast to proof at 125°F as at 115°F. This may be due to high temperature stress on the yeast.

We used a dough temperature probe to monitor internal temperature of doughs during proof, baking, and cooling. A typical plot of this process is given in Figure 2. Differences in dough temperature caused by proof were shown by placing the probe in the very center of the molded dough piece. Dough warms by convection, so any other placement of the probe would magnify any differences because the center of the dough would warm last. The temperatures of the recording probes during proof are shown in Figure 3. There is ~25°F spread in center dough temperatures when entering the oven, based on proof temperatures. The overall quality of the bread produced is affected by this significant temperature difference.

Loaf volume was perhaps the most notable effect we found when varying proof temperatures. The cooler the proof was, the larger the loaf volume (Fig. 4). There was ~700-cm^3 difference between the loaf volumes at the high and low proof temperatures. The doughs from cooler temperatures had greater oven spring and bolder exterior appearance; those of high proof temperature had little to no oven spring and signs of dough weakness.

Crumb grain is a difficult parameter to quantify. Figure 5 shows representative slices from bread at each of the proof temperatures used in this study. As proof temperatures decreased, the crumb grain and texture improved.

DISCUSSION

The internal temperature of doughs and the exterior temperature in the proof box are highly related and affect the volume and grain of pan bread. The volume changes observed could be due to the shorter oven times necessary to reach thermal death of yeast cells or enzymes. If denaturation occurs at 140°F, then a dough proofed at 115°F would reach that temperature in a shorter period of time than would a dough proofed at 80°F. This longer time period may produce additional oven spring in a dough or perhaps even additional gas production and expansion.

It is possible that there is substantially higher enzyme activity (protease and amylase) in doughs proofed at the higher temperatures (Q_{10}). These higher enzyme rates would result in weaker doughs and substantially less oven spring.

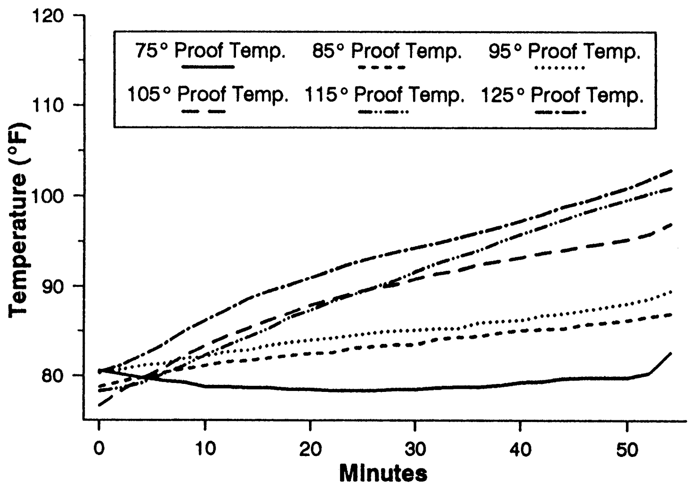

Fig. 3. Internal dough temperatures recorded during proof at 75, 85, 95, 105, 115, and 125°F.

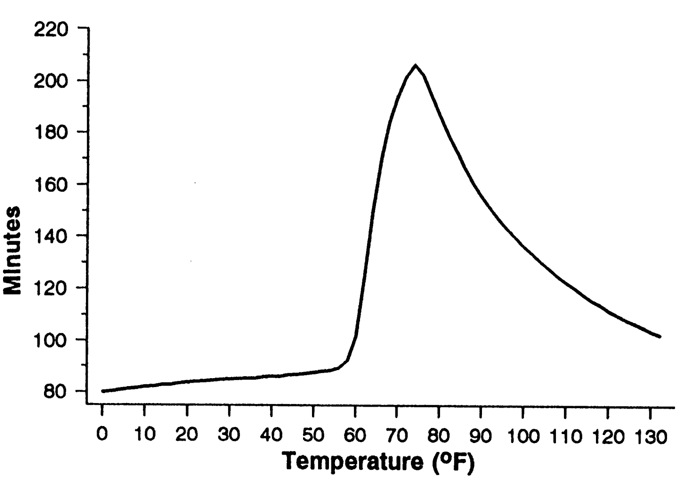

Fig. 2. Internal dough temperatures recorded during proofing (at 95°F), baking, and cooling.

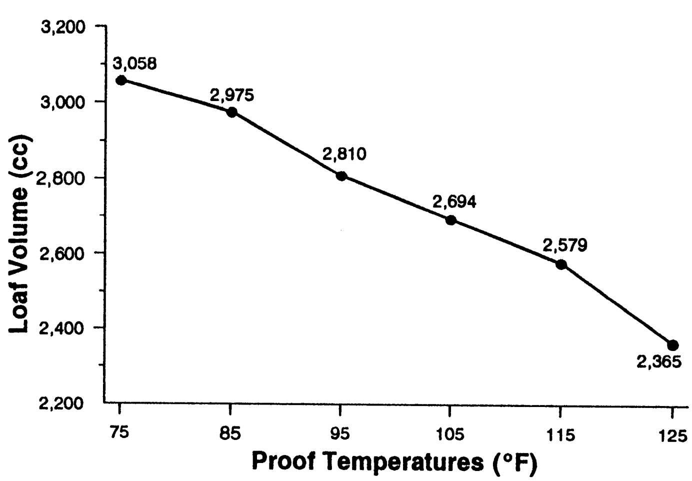

Fig. 4. Mean bread volumes (cm^3) of doughs during proof at 75, 85, 95, 105, 115, and 125°F.

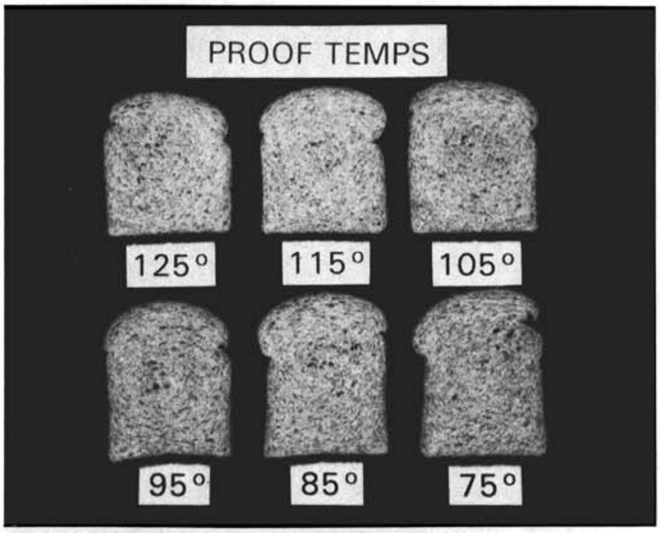

Fig. 5. Center slices of bread from doughs proofed at 75, 85, 95, 105, 115, and 125°F.

It is also possible, although not probable to the authors, that the increased number of yeast cells in the cooler doughs in some way produce substantially more CO_2 in the first few minutes of baking. This could result in increased volume for those samples containing more yeast cells. Because denaturation occurs relatively soon after baking begins (Fig. 2) and the temperature increase is quite steep, this explanation seems less plausible.

Proof temperatures have gradually been increased over the past 20 years because commercial bakeries use this method to push additional product through the proof box. Lower temperatures exhibit stronger dough characteristics, so commercial bakeries would do well to consider decreasing the temperature of their proof. A good, moderate proof temperature is 95–100°F. A minimum proof box temperature of no less than the region's summer ambient temperature should be used to eliminate seasonal variations in proof time.

Yeast levels need to be increased when proof temperatures are decreased. However, this additional expense would be offset by energy savings in maintaining a cooler proof box and by an improved finished product. This proposed production adjustment may compensate somewhat for the absence of potassium bromate as the bread industry faces formulations without traditional oxidation systems. The authors are pursuing additional research in this area.

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