NOTE

Combining Flour Heating and Chlorination to Improve Cake Texture

P. Fustier[1] and P. Gélinas[1,2]

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Flour chlorination is commonly used to produce high-sugar-ratio cakes that do not collapse and have an improved volume and a finer grain when compared to cakes made with nonchlorinated flour (Yamazaki and Kissell 1978). Cake flour is normally chlorinated at ≈1,500 mg of Cl_2/kg, but Kissell and Yamazaki (1979) reported that cakes with acceptable volume and texture may be produced with flours treated at lower chlorine concentrations (600–1,200 mg of Cl_2/kg).

Concerns over the potential safety of chlorine have led to the identification of alternative methods to produce acceptable cakes, such as heating flour at 120°C (Russo and Doe 1970). Reducing flour moisture before heat treatment also improves cake characteristics (Thomasson et al 1995). Chlorination and heating flour have similar effects on the texture of fresh cakes: increased hardness (Gough et al 1978, Conforti and Johnson 1992) and reduced gumminess or stickiness (Kissell and Yamazaki 1979, Gaines 1982). But data on stored cakes are scarce.

Considering that chlorine may be used at relatively wide concentrations for treating flour and still give acceptable cakes, the aim of this study was to provide information on the impact of heating flour previously treated with substandard chlorine concentration on the texture of both fresh and stored high-sugar-ratio cakes.

MATERIALS AND METHODS

Flours Samples

Nonchlorinated (control, pH 6.1, redox potential 209 mV), half-chlorinated (850 mg of Cl_2/kg, pH 5.1, redox potential 329 mV), and fully chlorinated (1,700 mg of Cl_2/kg, pH 4.5, redox potential 372 mV) soft wheat flours (Velvet, Robin Hood Multifoods Inc., Montreal, QC) were obtained from the same lot (7.35% protein, 0.41% ash, 12.8% moisture, a_w = 0.51). Flour pH was determined according to Approved Method 02-52 (AACC 1995). Oxidation-reduction potential was measured on the supernatant of a solution containing 10 g of flour in 100 mL of distilled water using a combined (Ag/AgCl, PE) redox electrode (model 6.0412.18MC, Metrohm, Herisau, Switzerland) previously calibrated at 250 mV with a standard solution (Metrohm). Flour moisture content was determined according to Approved Method 44-40 (AACC 1995). Water activity (a_w) was measured with an Aqua Lab CX-2 a_w analyzer (Decagon Devices Inc., Pullman, WA).

Flour Heat Treatments

Before heating, flour moisture was fixed to 1, 7, or 12.8% (standard, not adjusted). For 1% moisture tests, a freeze-dryer was used (model SE-5, Lyo-Tech, Lyo-San Inc., Lachute, QC). For 7% moisture tests, flour was evenly distributed in an aluminum pan and heated at 30°C in a convection oven (model 18EM, Precision Scientific Group, Chicago, IL).

Nonchlorinated and half-chlorinated flour (850 mg of Cl_2/kg) were heated at 90 or 125°C for 5, 22, 39, or 56 min. Flour (≈0.5 cm thick) was evenly distributed on a 60 × 30 × 2.5-cm aluminum pan and placed in a convection oven (S.A. Baker's Pride Inc., Lachine, QC). After heating, flour was cooled and tempered in a fermentation cabinet set at 85% rh and ≈25°C until flour a_w reached 0.51 ± 0.02 (equivalent to 12.8% moisture).

Cake Preparation

High-sugar-ratio white layer cakes were prepared. Proportions of ingredients in the formula were: flour 100, sugar 140, water 130, shortening 50 (Biscot-140; Les Aliments CanAmera Montreal, QC), nonfat dry milk 12 (high-heat, Agropur, Granby, QC), dried egg whites 9 (Henningsen, Inc., White Plains, NY), baking powder 8 (Nabisco Ltd., Etobicoke, ON), and salt 3. Batches of 3 kg of batter were prepared in a 10-kg bowl (model A-120, Hobart). Mixing conditions were similar to Approved Method 10-90 (AACC 1995), except that low and medium speeds corresponded to 106 and 196 rpm, respectively. Portions of batter (140 g) were deposited into 18 × 145-mm (height × dia.) greased pans. Baking was performed at 205°C for 18 min in an electric reel oven (Equipement de boulangerie L. P., Victoriaville, QC). After cooling in pans for 20 min and on a grid for 20 min, cakes were cut vertically in half, placed individually into sealed films (Bicor SPW-L; Mobil Chemical, Stone Mountain, GA) and stored at 21°C and 50% rh. Film water permeability was 1.62 g/25 µm/m^2/day/atm at 21°C and 100% rh, as determined by a Permatran analyzer (Mocon Modern Control Inc., Minneapolis, MN).

Batter and Cake Analyses

Immediately after mixing, 100 g of batter were poured into a 100-mL beaker and viscosity was measured at 20 rpm with spindle no. 5 of a viscometer (model RV; LR 21380; Brookfield Engineering Lab. Inc., Stoughton, MA). Cake texture was determined with a texture analyzer (TA-XT2, 25-kg model; Stable Micro Systems, Godalming, Surrey, UK). A 30 × 30-mm square was cut from the center of cakes and compressed with a plunger (5.08 cm dia.) to 40% of original height at a 0.8-mm/sec cross-head speed. A double cycle was programmed with a 4-sec delay and texture profile was measured by Xrad software (Stable Micro Systems). Cohesiveness was calculated as area 2/area 1 (using XRad software). Cake volume was determined with a template according to Approved Method 10-91 (AACC 1995). Mean data were obtained from six measurements (2 × 3 half-cakes).

Statistical Analyses

A completely randomized design with one-way analysis of variance was used. Multiple simultaneous comparisons of means of the various treatments (flour chlorination level, heating temperature and time) were made with the AS STAT software release 6.11 (SAS Institute, Cary, NC) using the least significant difference test.

RESULTS AND DISCUSSION

Effect on Batter Viscosity

As shown in Fig. 1, flour chlorination increased batter viscosity. Batter made with untreated flour had a viscosity of 8,225 cP, com-

[1] Food Research and Development Centre, Agriculture and Agri-Food Canada, 3600 Casavant Blvd. West, St.Hyacinthe, Quebec, Canada J2S 8E3.
[2] Corresponding author. Phone: 450/773-1105 (ext. 221). Fax: 450/773-8461. E-mail: gelinasp@em.agr.ca

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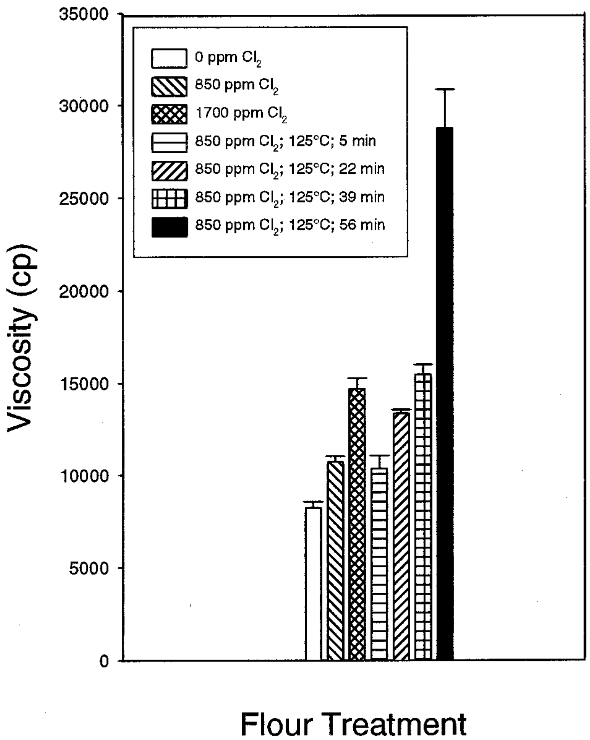

Fig. 1. Effect of heating (125°C) half-chlorinated flour (850 mg of Cl_2/kg) on cake batter viscosity (cP). Batters made with nonchlorinated or fully chlorinated flour (1,700 mg of Cl_2/kg) were used as references. All assays were performed in triplicate.

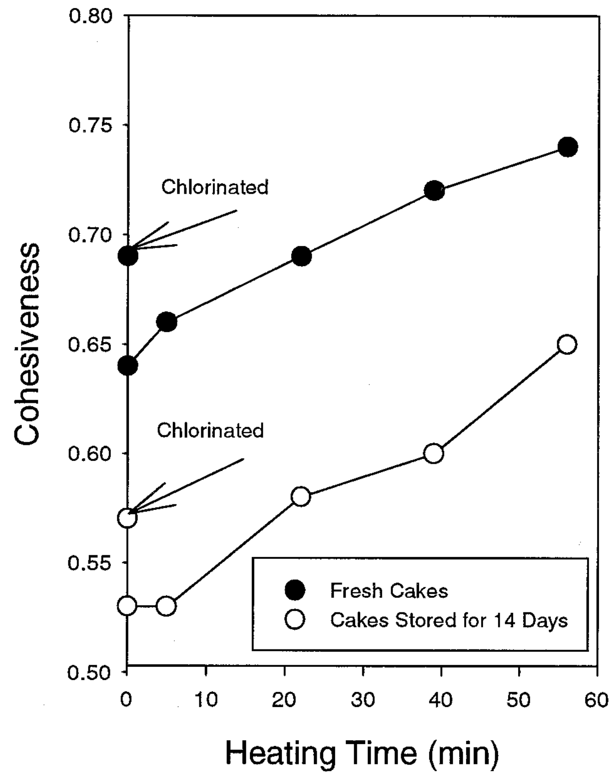

Fig. 2. Effect of heating (125°C) half-chlorinated flour (850 mg of Cl_2/kg) on the cohesiveness of cakes stored at 21°C for 0 or 14 days. Cakes made with fully chlorinated flour (1,700 mg of Cl_2/kg) and stored for 0 or 14 days at 21°C were used as references (arrows). Mean data were obtained from six measurements (2 × 3 half-cakes).

pared to 10,725 cP for half-chlorinated flour and 14,700 cP for chlorinated flour. However heating the flour at 125°C had a much greater effect, confirming results from the literature (Russo and Doe 1970). Heating half-chlorinated flour (850 mg of Cl_2/kg) for 39 min gave batter viscosity similar to that of fully chlorinated flour (1,700 mg of Cl_2/kg) ($P < 0.05$). However, treatment of the half-chlorinated flour for 56 min gave batters with an unacceptably high viscosity. At this viscosity, the batter was very difficult to transfer into pans. Heating nonchlorinated or half-chlorinated flour at 90°C for up to 56 min, or heating flour previously dried to 1 or 7% moisture at 125°C had no effect on batter viscosity ($P < 0.05$; data not shown).

Effect on Cake Texture

A storage period of 14 days at 21°C was selected to study cake texture. Preliminary tests showed that texture changed rapidly within that period and then stabilized. As shown in Fig. 2, cohesiveness of cakes prepared with half-chlorinated flour (850 mg of Cl_2/kg) was lower after storage for 14 days. Heating flour at 125°C increased (improved) the cohesiveness of cakes. The effect of heating time was similar for fresh or stored cakes. After heating for 56 min, the cohesiveness of stored cakes was equivalent to that of fresh cakes made with fully chlorinated flour (Fig. 2; top arrow). With nonchlorinated flour or half-chlorinated flour heated at 90°C, similar trends were observed, but cohesiveness of stored cakes was lower than that of cakes prepared with fully chlorinated flour ($P < 0.05$; data not shown).

Cake hardness increased over storage but heating nonchlorinated or half-chlorinated flour did not improve this texture parameter; data obtained for cake springiness or gumminess were inconsistent (data not shown). According to Seguchi and Matsuki (1977) and Seguchi (1990), chlorination and heating have similar effects on springiness (increased) and gumminess (decreased) of fresh pancakes, as determined by sensory evaluation. Results presented in Fig. 2 show that cake cohesiveness may be improved by the use of specific combinations of flour heat treatment and chlorination.

In accordance with results obtained by Kissell and Yamazaki (1979), reduction of the flour chlorination level (from 1,700 to 850 mg of Cl_2/kg), combined or not with heating, had no effect on cake volume (data not shown). Adjustment of flour moisture content to 1 or 7% before heat treatment had no positive effect on cake volume and texture ($P < 0.05$; data not shown), contrary to results reported by Thomasson et al (1995). It is possible that the small size of the cakes tested in this study did not reveal such effects on cake characteristics.

CONCLUSIONS

Compared to results obtained with fully chlorinated flour (1,700 mg of Cl_2/kg), cohesiveness but not hardness of high-sugar-ratio cakes was improved by using flour treated with half-chlorine level (850 mg of Cl_2/kg) and heated at 125°C. Storage for 14 days at 21°C had no effect on the rate of texture changes brought about by flour heat treatments. Viscosity of the batter increased markedly as a result of heating time at 125°C. The respective effects of flour heating and chlorination on cake texture deserve more attention, especially since acceptable high-sugar-ratio cakes may be produced with flour treated with reduced chlorine levels.

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