

Note

Factors Affecting Apparent Viscosity of Heat-Treated Wheat Flour Paste

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Millers in Japan are aware that the apparent viscosity of heat-treated wheat flour paste is higher than that of untreated flour. Factors affecting flour paste viscosity must be known to obtain replicable viscosity data. Heat treatment was most effective at 110°C for 15 min using an autoclave. The apparent flour paste viscosity under specific conditions decreased as measurement time increased.

Keywords: viscosity, wheat flour, batter, heat treatment

The apparent viscosity of heat-moisture treated wheat flour is higher than that of untreated wheat flour (Kurahashi & Hizukuri, 1998). Millers in Japan are aware of similar behavior of wheat flour milled commercially, and heat-treated wheat flour is distributed as batter. Despite the commercial use of heat-treated wheat flour, little is known about genetic viscosity diversity or about mechanisms in heat treatment that increase paste viscosity. No appropriate method has been reported for obtaining replicable results in determining the viscosity of heat-treated flour paste. We examined several factors affecting viscosity during wheat flour heat treatment and measurement of paste viscosity, and propose a way to determine heat-treated wheat flour paste viscosity.

Grains of the winter wheat cultivars Horoshirikomugi and Chihokukomugi grown in an upland field of the National Agricultural Research Center for Hokkaido Region at Memuro were milled on a Bühler test mill (Sennhof, Switzerland). For heat treatment, about 10 g of wheat flour was sealed in an aluminum laminate bag and heated in a water bath (70°C), oil bath (90, 110°C), or autoclave (110°C). Flour pastes were prepared by pre-mixing the above flour (7.98 g) containing 13.5% moisture and distilled water (15 ml) with a hand mixer (Pencil Mixer, Sansyo Co., Ltd., Tokyo) in a 70 mm×30 mm polypropylene tube, followed by mixing with a stirrer (Lab-Stirrer Model LH 400D, Yamato Scientific Co., Ltd., Tokyo) at 1500 rpm for 1 min. To measure paste viscosity, we used a single-spindle rotational viscometer with a small sample adapter (Toki Sangyo Model RB80H, Toki Sangyo Co., Ltd., Tokyo) and a temperature-controlled bath. Three spindle sizes were used to cover the range of apparent viscosity in our experiment. Based on the manufacturer's instructions, aliquots of paste were put in the sample cup using a 10 ml disposable syringe. After the spindle was soaked into the cup placed in a temperature-controlled bath, the spindle was rotated at 100 rpm and apparent viscosities over elapsed time were measured.

Flour of wheat cv. Horoshirikomugi and Chihokukomugi was

heat-treated for 4 h at 90°C, after which apparent viscosities of heat-treated flour paste were measured at 25°C for 20 min (Fig. 1). Viscosity decreased with increasing measurement time and differences in viscosities among varieties were observed at all spans of measurement time. Using the flour of 35 wheat cultivars, we confirmed differences in viscosity and that the ranking of viscosity among cultivars did not vary with measurement time (data not shown). Based on these results, we used apparent viscosity after 1 min for a rapid assay of viscosity.

Relationships between the apparent viscosities at 25°C and heating time over the range measured are shown in Fig. 2. When flour was heated at 70°C, viscosity increased with increased heating time. At 90°C, viscosity plateaued at 8 h. At 110°C, viscosity peaked at 0.5 h and decreased in longer heating. Similar behavior was reported by Sair (1967) with heat-moisture treated potato starch. Maximum apparent viscosity was observed for 15 min at

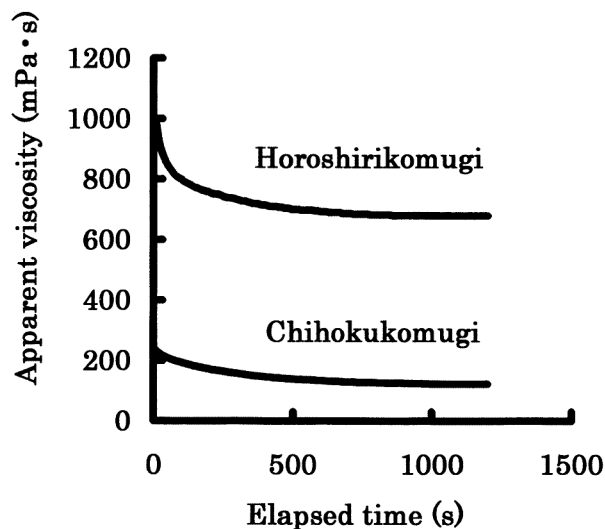


Fig. 1. Time dependence of apparent viscosity of heat-treated flour paste of wheat cv. Horoshirikomugi and Chihokukomugi.

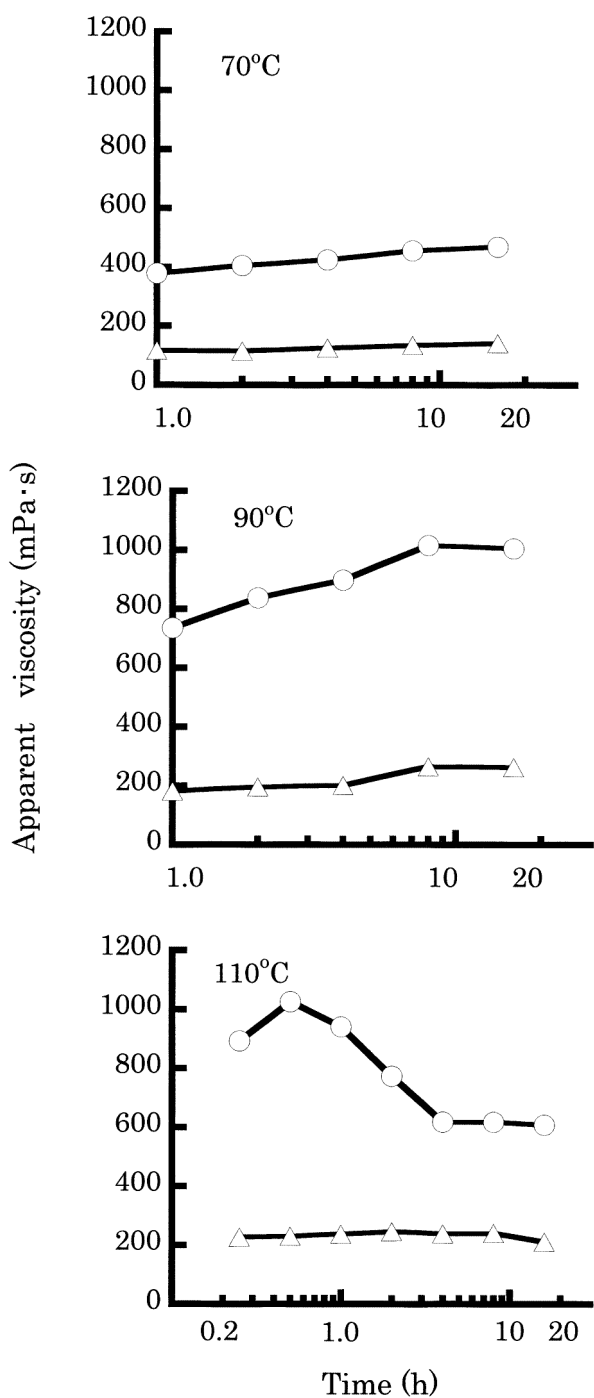


Fig. 2. Effect of elapsed time of heat treatment on apparent viscosity of heat-treated flour paste of wheat cv. Horoshirikomugi (○) and Chihokukomugi (△) at 70°C, 90°C, and 110°C. Standard deviation for means was within 24 ($n=4$). Apparent viscosity of untreated flour was 370.0 mPa·s for Horoshirikomugi and 97.7 mPa·s for Chihokukomugi.

110°C autoclaving, so, in subsequent experiments, we heated wheat flour at 110°C using an autoclave (Sanyo MLS-2400, Sanyo Electric Biomedical Co., Ltd., Moriguchi) for 15 min to obtain the highest viscosity rapidly.

We studied the viscosity of heat-treated wheat flour at temperatures from 15 to 35°C and at concentrations from 25 to 32%. We prepared pastes containing 25.2 to 32% flour using the procedures mentioned above. Viscosity decreased with increasing

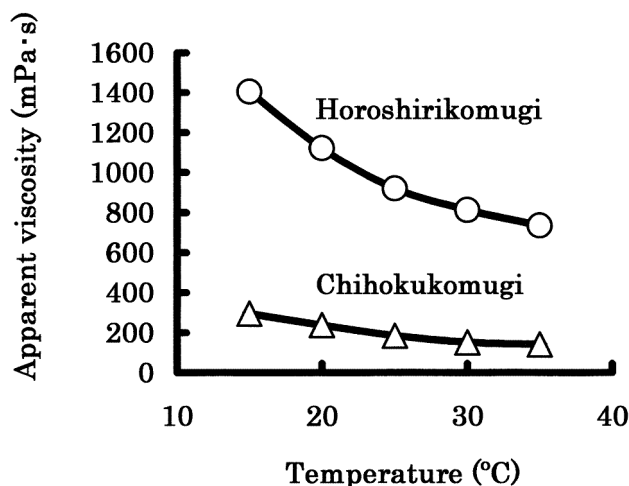


Fig. 3. Effect of temperature on apparent viscosity of heat-treated wheat flour paste of wheat cv. Horoshirikomugi (○) and Chihokukomugi (△). Standard deviation for means was within 12 ($n=4$).

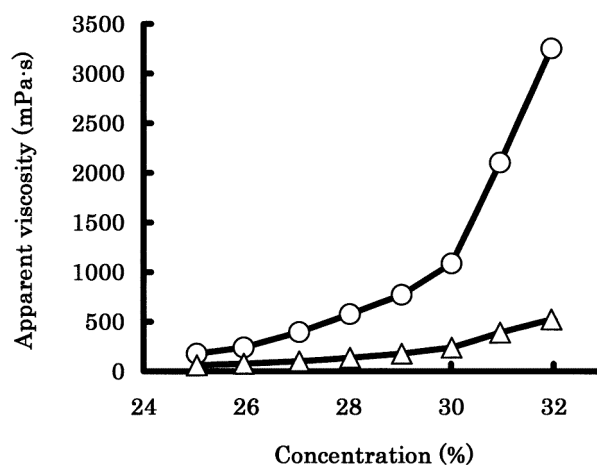


Fig. 4. Effect of flour concentration on apparent viscosity of heat-treated flour paste of wheat cv. Horoshirikomugi (○) and Chihokukomugi (△). Standard deviation for means was within 26 ($n=4$).

temperature (Fig. 3) and increased with flour concentration (Fig. 4).

To determine the effects of flour moisture content before heat treatment of heat-treated flour paste viscosity, we changed the moisture content from 12 to 23% by spraying distilled water on flour or drying flour at room temperature before heat treatment. We found that the moisture content of flour before heat treatment changed the viscosity significantly: viscosity increased when moisture content was low, decreased especially at 14–18% and increased above 18% (Fig. 5). Viscosity exceeding 20% moisture was higher than that at 13.5%. The moisture content physically changes in starch subjected to heat-moisture treatment (Donovan *et al.*, 1983; Kulp & Lorenz, 1981; Sair, 1967), so our results imply that the effect of moisture content on viscosity is due to different levels of physical change in starch during heat treatment.

We studied the influence of elapsed time between mixing to produce paste and the start of measurement. After paste was

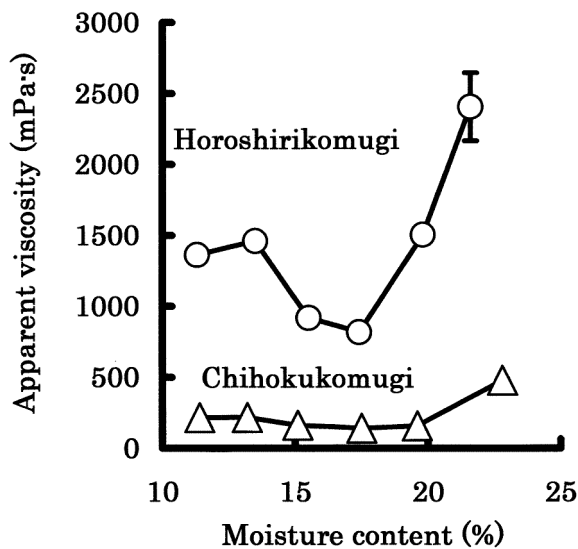


Fig. 5. Effect of moisture content of wheat flour on apparent viscosity of heat-treated flour paste of wheat cv. Horoshirikomugi (○) and Chihokukomugi (△). Each value represents mean±standard deviation ($n=4$).

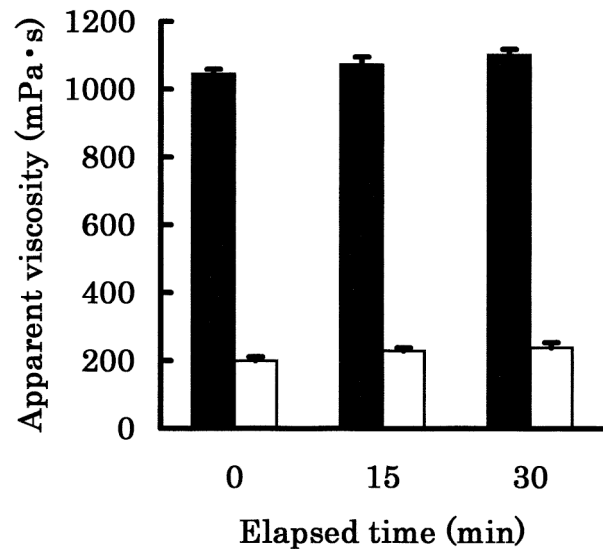


Fig. 6. Effect of elapsed time after mixing on apparent viscosity of heat-treated flour paste. Each value represents mean±standard deviation ($n=4$). ■ Horoshirikomugi; □ Chihokukomugi.

poured into a sample cup soaked in a temperature-controlled bath at 25°C, viscosity was measured at 0, 15, and 30 min. We found that viscosity increased with elapsed time (Fig. 6).

Our results suggest four factors are important in the heat treatment of wheat flour and in measurement of heat-treated wheat flour paste viscosity: (1) flour moisture content must be fixed; (2) heat must be set at 110°C for 15 min when an autoclave is used to obtain the highest viscosity and fastest treatment; (3) elapsed time between mixing to produce paste and the beginning of viscosity measurement must be fixed; and (4) the flour concentration and temperature at which viscosity is measured must be constant.

In experiments currently underway, we use wheat flour with 13.5% moisture content to produce paste containing 30% flour, set the elapsed time between mixing time to produce paste and

the start of measurement as 5 min, and measure apparent viscosity 1 min after the start of rotation of the spindle at 25°C. The genetic diversity and interaction among growth conditions and genotypes in viscosity will be reported elsewhere.

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