COMMUNICATION TO THE EDITOR

Effects of High-Voltage Electric Field Treatment on Wheat Dough and Bread-Making Properties

To the Editor:

Various methods of treating water with electric fields (Asakawa 1976) have been used by the food-processing industry. Retrogradation of amylose and amylopectin has been enhanced when starch and wheat flour are allowed to stand in an electric field of 10–50 kV for longer than 1 hr (Manpuku 1991). Under the proper conditions, however, this treatment may become a useful tool for extending the shelf life of baked products. In this article, the effects of high-voltage electric field (HVEF) treatment on wheat dough and bread-making properties are investigated.

Bread flour (Superking, Nisshin Milling Co., Tokyo, Japan) was used in the following formulation. The experimental formula contained flour (750 g), salt (15 g), instant dry yeast (15 g), sugar (37.5 g), shortening (37.5 g), and water (450 g). Small bread loaves (60 g of dough) were baked in a conventional gas oven (model 21-303A, Osaka Gas Co., Osaka, Japan) for 13 min at 180°C, and large bread loaves (430 g of dough) were baked for 25 min at 200°C (Fig. 1). The large loaves were used for texture analysis during storage. Bread was stored in polyethylene bags at 23°C unless otherwise noted. The firmness of bread was measured by a rheometer (Rheoner RE-3305, Yamaden Co., Tokyo, Japan).

Bread samples were cut into 2-cm-thick disks (26 mm in diameter) by a bread slicer (FK-18N, Fujishimakoki Co., Kobe, Japan). The loaf volume of the bread was measured by a rapeseed method. Water loss during baking was calculated by subtracting the bread weight from that of the dough before baking. For HVEF treatment, wheat dough was put into a glass ball after mixing and subjected to a 50-kV HVEF treatment for the first 20 min of the 40-min fermentation period, using an HVEF-generator as shown in Figure 2. A piece of wheat dough was removed just before the process of dividing and molding and was frozen in liquid nitrogen. The small frozen fragments of the doughs then were subjected to ion-sputter coating with gold using an ion coater (IB-3, Eiko Co., Mito, Japan). The structure of wheat doughs was observed by a scanning electron microscope (Hitachi S-450 SEM) at 1.5 kV.

Scanning electron microscopy images of wheat dough treated in HVEF seemed to be different from those of untreated dough (Fig. 3). As shown in the microphotographs, gluten fibers of the treated dough (Fig. 3C) appeared to be thinner than those of the untreated dough (Fig. 3A). Gluten fibers apparently adhered to the surface of the starch granules. This may explain the increased surface adhesiveness of the treated dough.

The comparison of baking performance between treated and untreated breads showed that loaf volume was not affected by the treatment but increased linearly depending on final proof time (Table I). However, water loss during baking markedly changed when the proof time was longer than 15 min (Fig. 4). The weight of treated breads therefore increased, and the loaf-specific volume was lower (Table I). Generally, lowering the water loss during baking gives low loaf volumes. In this study, however, the loaf volumes of the treated bread were not reduced in spite of less water loss during baking.

Axford et al (1968) showed that as the loaf-specific volume increased, both the rate and extent of staling (that is, firming rate and firmness) decreased in a linear manner. However, firming rate of the treated bread decreased although the loaf-specific volume diminished.

The HVEF-treated bread stored at room temperature unexpectedly kept its softness for one or two days longer than the

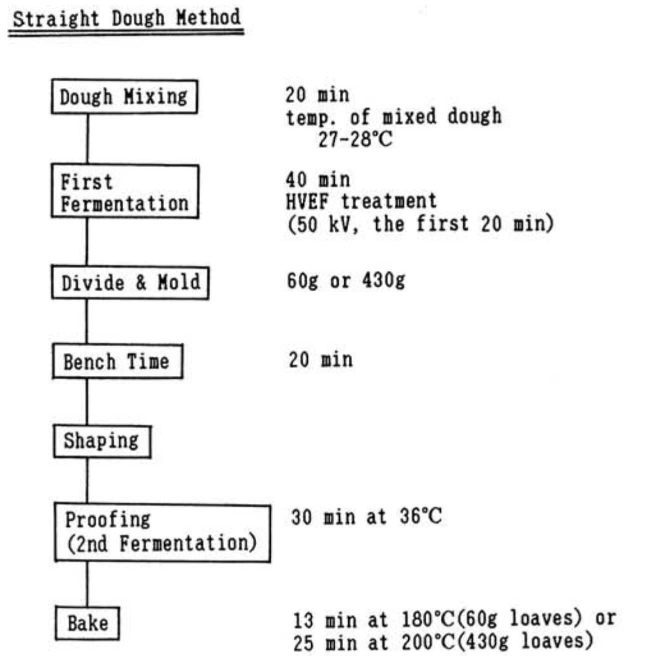

Fig. 1. Straight dough method baking procedure. HVEF = high-voltage electric field treatment.

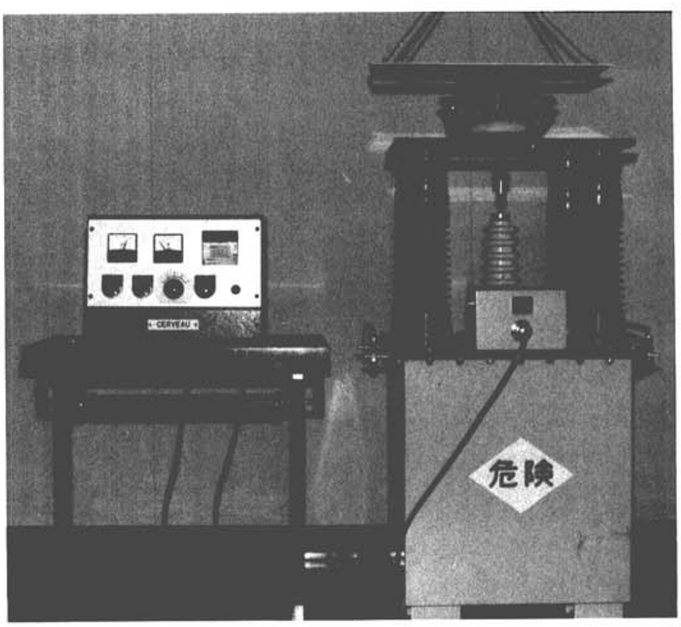

Fig. 2. High-voltage electric field (HVEF) treatment of wheat flour dough by an HVEF-generator.

TABLE I
Effects of High-Voltage Electric Field Treatment and the First Proof Time on Bread Volumes

	First Proof Time (min)					
Volume	**0**	**5**	**10**	**15**	**20**	**25**
Loaf volume (cm^3)[a]						
Untreated	170.2 ± 4.0	198.2 ± 7.5	203.0 ± 9.0	211.2 ± 9.7	238.2 ± 4.0	250.2 ± 14.2
Treated	170.0 ± 5.2	197.6 ± 5.3	198.1 ± 2.3	206.1 ± 6.8	237.7 ± 6.4	248.1 ± 7.6
Loaf-specific volume (cm^3/g)						
Untreated	3.29	3.86	3.99	4.19	4.77	5.06
Treated	3.24	3.84	3.88	4.06	4.72	4.94

[a] Values for 60 g of dough.

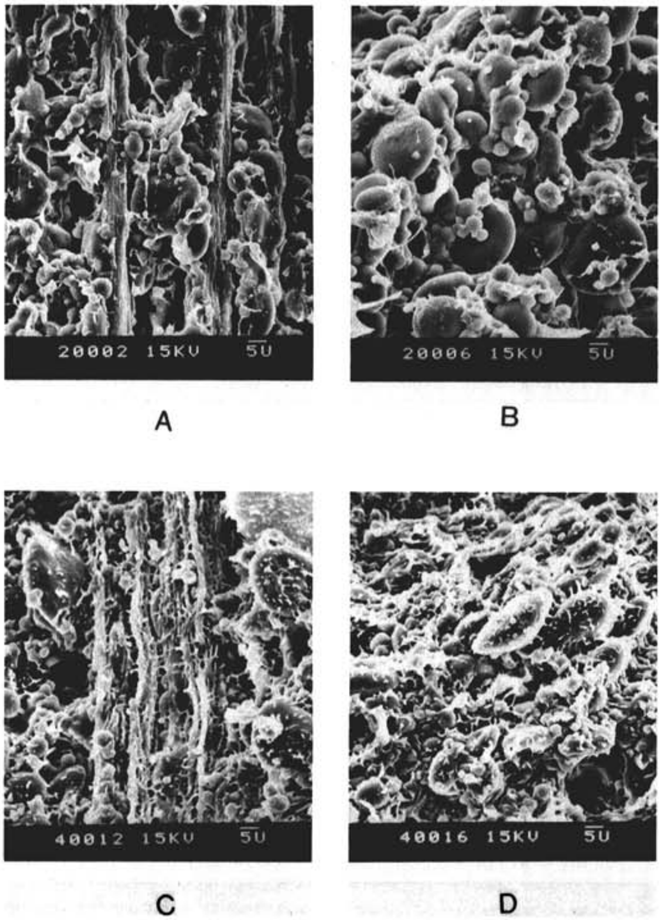

Fig. 3. Scanning electron micrographs of wheat doughs. **A,** Gluten fibers of the untreated dough. **B,** Starch granules of the untreated dough. **C,** Gluten fibers of the treated dough. **D,** Starch granules of the treated dough. Bars = 5 μm.

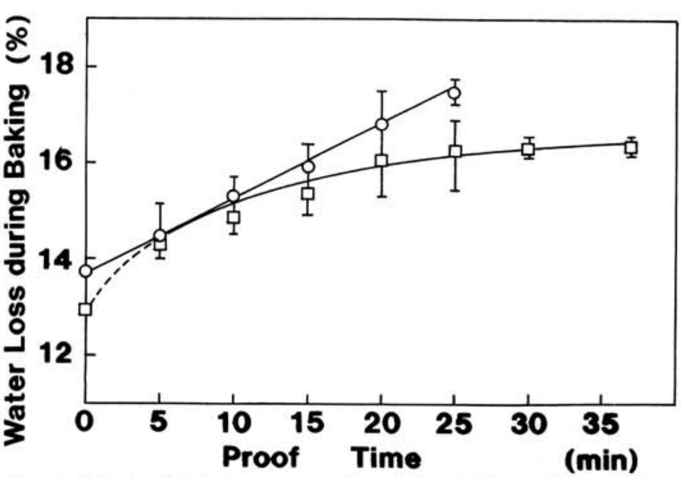

Fig. 4. Relationship between water loss during baking and proof time. □ = Bread treated with high-voltage electric field; ○ = untreated bread.

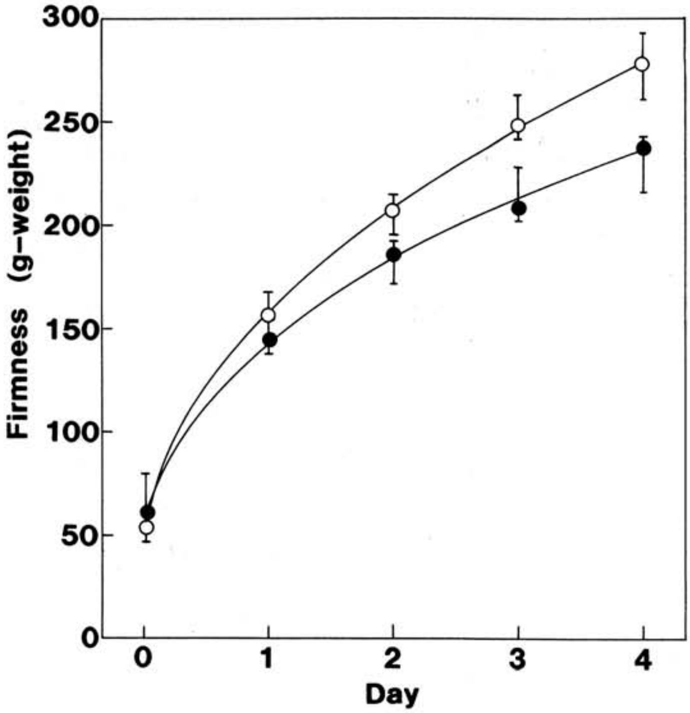

Fig. 5. Change in bread firmness during storage. ● = Bread treated with high-voltage electric field; ○ = untreated bread.

untreated bread (Fig. 5). Crumb moisture content has been shown to strongly influence the rate of bread firming (Rogers et al 1988, He and Hoseney 1990), and high-moisture bread firms at a slower rate than does low-moisture bread. Martin et al (1991) suggested that fewer and/or weaker entanglements and cross-links between starch and gluten result in reduced bread firming. They also reported that the antifirming phenomenon of bread baked by electric resistance could not be explained by increased moisture content alone.

In our study, gluten fibers were deformed by HVEF treatment (Fig. 3C) more than were starch granules. Alteration in the interactions between gluten and starch due to changes in protein might influence the ability of the dough to retain water during baking or the ability of the bread to firm during storage. The mechanism of the phenomena obtained from HVEF-treated bread is now under study.

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