VISCOELASTIC CHARACTERISTICS OF BREAD CRUMB AND GRAPHIC ANALYSIS OF COMPRESSION CREEP CURVE

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ABSTRACT

An optimum loading condition for the creep test of bread crumb has been established experimentally, and a four-element rheological model has appeared to be appropriate for describing the viscoelastic behavior of crumb. Both creep and recovery of crumb were analyzed by a simple graphic method. All of the elastic moduli and viscosity coefficients have been found to increase with increasing storage time indicating marked change within 12 hours after baking and with a decrease in storage temperature. They were also affected by various baking conditions such as molding method, baking temperature and baking loss.

INTRODUCTION

The viscoelastic characteristics of solid foods are of great importance to textural evaluation and structural analysis. Most of solid foods are considered as composite uniform viscoelastomers and their viscoelastic behaviors have been discussed. However, little work has been conducted on the viscoelasticity of bread crumb from the viewpoint of rheology[1].

This paper describes an optimum loading condition in creep test and characterizes the viscoelastic behavior of crumb with a 4-element rheological model by a simple graphic method. The effects of storage time and temperature on the viscoelasticity of crumb will also be reported.
MATERIALS AND METHODS

White breads of 230 G in weight were baked at 230°C by the sponge-dough procedure. After baking, loaves were wrapped in polyethylene bags and then stored at 20°C for at most 7 days. Viscoelastic characteristics were measured with a developed creep test system by using 4cm cubic crumbs sampled from 16x8x8 cm loaves.

RESULTS AND DISCUSSION

In order to perform creep measurement successfully, an optimum loading condition for bread crumb was investigated experimentally. It was suggested that a constant stress from 300 to 2500 Pa was to be applied and kept for 100 s in creep test. The 5 g initial load was used to avoid incomplete compression and lessen the effect of unevenness of specimen caused in preparing procedure.

Figure 1 shows a typical compressive creep curve of crumb exhibiting the ranges of instantaneous elasticity(ab), retarded elasticity(bc) and viscous flow(cd). The instantaneous deformation occupied 64% of total deformation and the viscous flow had 12% of that.

It was found that the creep behavior could be represented by the 4-element Burgers model. Creep strain $\varepsilon$ can be calculated as follows.

$$\varepsilon = \frac{\sigma_0}{E_0} + \frac{\sigma_0}{E_1} (1 - \exp(-\theta)) + \frac{\sigma_0}{\eta_2^\theta} \tau_{kv}$$  \hspace{1cm} (1)

where $\sigma_0$ means constant stress, $\theta$ is time, $E_0$ and $E_1$ are elastic modulus, $\eta_1$ and $\eta_2$ are viscosity coefficient. $\tau_{kv}$ is defined by $\eta_1/E_1$.

To determine the coefficients, the method of successive residuals and the simple graphic method[2] were applied and the latter was found to be convenient and useful indicating the relative errors within 3% in creep(Figure 1) and recovery curve for curve fitting.

![Figure 1. A typical compressive creep curve of crumb and curve fitting](image-url)