

Fundamental Study of Solidification State Assessment of Yogurt based on Dielectric Spectrum Measurement under High Voltage

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Introduction

Yogurt is widely consumed in Japan in various forms, including drinks and solids. From a food engineering perspective, managing the fermentation process is crucial for quality assurance and texture control. Impedance measurement is appropriate for internal state evaluation due to its non-destructive nature, but commercial systems often lack sensitivity because of voltage limitations.

Experimental Procedures

Yogurt is formed when casein proteins in milk coagulate through the activity of lactic acid bacteria. During this process, the solid phase retains liquid whey produced as fermentation progresses. Therefore, the whey content can be considered an effective indicator of the fermentation state. In this study, yogurt samples with controlled whey content (0, 10, and 100 vol%) were prepared. High-voltage pulses (rise time 10 ms, fall time 1 s, approximately 1.5 kV) were applied externally to the sample containers. Along with the input signal, the terminal voltage across a filter (97 nF/1 MΩ) connected in series with the sample was recorded. The acquired signals were then correlated in the frequency domain to calculate the impedance spectrum.

Results and Discussion

The impedance trajectory is shown in Fig. 1, and the dependence of capacitance on whey content is presented in Fig. 2. In general, the Random Arranged Model is commonly used to calculate the dielectric constant of a composite material consisting of a matrix and a filler, based on their respective volume fractions. Assuming the sample to be a parallel-plate capacitor, the dielectric constants of yogurt and whey were calculated as $\epsilon_y = 44.8$ and $\epsilon_w = 58.1$, respectively. Using these values, the capacitance estimated for 10 vol% whey content by the Random Arranged Model showed good agreement with the experimental results. The fermentation process of yogurt was also evaluated using the same measurement method. By investigating the whey content during fermentation and examining its correlation with the present results, it is suggested that the degree of solidification of yogurt can be effectively estimated from the whey content.

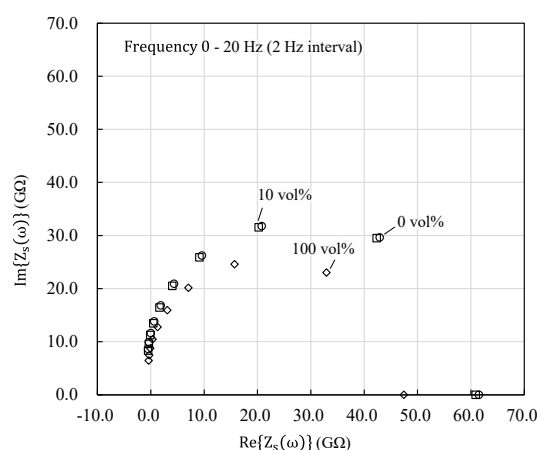


Fig. 1 Impedance trajectory

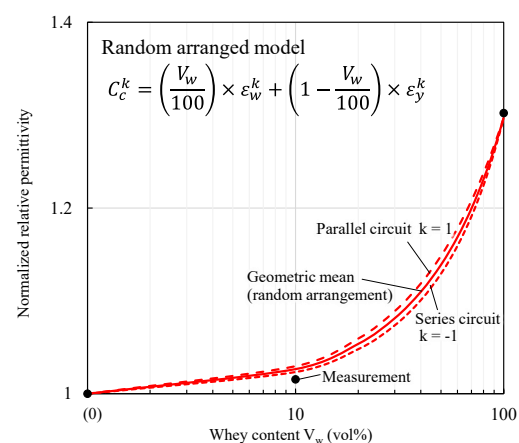


Fig. 2 Dependence of capacitance on whey content

References

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