Effect of Metal Salts on Fractal Structure of Protein Aggregate Gels and Their Elastic Behavior

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Summary

Metal salts influence mechanical properties such as viscosity and elasticity of food gels. Many researchers have investigated the effect of salts added on mechanical properties, but the relationship between the microscopic structure of the gels containing metal salts and physical properties of the gels has not been clarified due to disordered shape of the inner structure. Recently, fractal analysis has attracted attention as a quantitative analytical method that can characterize many kinds of disordered shapes.

In this study, fractal structure of the protein aggregates containing metal salts such as NaCl was measured, and the elastic behavior of protein aggregate gels was analyzed with a concept of fractal.

First, the structure of aggregates formed by heating dilute BSA solution containing metal ions was analyzed using the static light scattering method. BSA was dissolved in HEPES buffer at pH 7.0 and heated at 95 °C. For the aggregates prepared by heating BSA solutions with NaCl, the values of D_f were evaluated to be 2.1 to 2.8, increasing with the increase in NaCl concentration. On the other hand, for the aggregates prepared by heating BSA solutions with $CaCl_2$, the fractal structure was not observed.

Second, the fractal structure of aggregates in protein gels and those containing metal salts was examined: four proteins were used; (1) BSA, (2) β-lactoglobulin (β-LG), (3) 11S soybean globulin, (4) casein. From the concentration dependence of the gel elasticity, the fractal dimension D_f of the aggregates in the gels was evaluated, using the theory of Shih et al. It was confirmed that both the strong- and weak-link type gels in the theory of Shih et al. were obtained by varying the types and concentration of metal salts. In addition, a micrometer scale structure of the aggregates in the gels was observed using confocal scanning microscopy. As for the BSA and β-LG gels containing $CaCl_2$ (weak-link type), the values of D_f were also evaluated from the analysis of the gel image obtained with confocal scanning laser microscopy, the values being close to those evaluated from the gel elasticity measurements.