SANS analysis on nanostructure of hydrated solids of wheat protein gliadin

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A lot of food materials are served as hydrogel or concentrated hydrated matter forms. Therefore nanostructural analyses on soft matters are also effectively applicable to food materials. Wheat protein gliadin is a component of gluten that affects the physical properties of wheat flour dough. It is responsible for viscosity of wheat dough, while glutenin, the other protein component of gluten, is responsible for elasticity of wheat dough. It is necessary to elucidate physical properties of gliadin in relation to its nanostructure for improving processability and taste of wheat food products. It has been known that gliadin are soluble in 60-70% alcohol or dilute acetic acid, and therefore various investigations have been performed with gliadin extracted into such kinds of solvents. Recently, Urade et al. have found that gliadin can be extracted into distilled water from dough containing NaCl. The properties of gliadin extracted in water are expected to be closer to those in real wheat dough. We have been conducting the Small-Angle X-ray Scattering (SAXS) study of nanostructure of gliadins in water over a wide concentration range and have already reported the following results (N. Sato et al., Molecular assembly of wheat gliadins into nanostructures: A small-angle X-ray scattering study of gliadins in distilled water over a wide concentration range, J. Agric. Food Chem., 2015, 63, 8715): At concentrations below 10 wt%, gliadin is soluble in water and present as monomers except for a small amount of dimers and oligomers. With increasing concentration, it forms larger associates with interparticle interference among themselves owing to the electrostatic repulsion. At concentrations above 15 wt% gliadin becomes insoluble and forms hydrated solids, but the SAXS profile still resembles that of 10 wt%. Above 15 wt%, it forms dense solids with density fluctuation inside. These findings contribute to the fundamental understanding of the behavior of gliadin assembly in water. However, the rapid scattering profile changes owing to X-ray irradiation damage should be avoided, and wider q-range measurements are required to observe expected larger structure found in the further lower-q region at high concentrations. Small-Angle Neutron Scattering analysis can be effectively employed in this situation. Here, we report the results of SANS measurements of hydrated gliadin solids over a wide q-range.

SANS measurements were performed at QUOKKA beamline of Bragg Institute, ANSTO, Australia. The hydrated solids were prepared with powder gliadin extracted from wheat dough and heavy water at concentrations 15 and 40 wt%. The samples were place in demountable cells with 1-mm-thick gap between quartz windows. The wavelength of the neutron beam was 5 Angstrom and the sample-to-detector distance was 20, 12, and 1.3 m. Measurement temperature was changed from 26 to 66 degrees Celcius.

Figure shows scattering profiles of gliadin hydrated in heavy water at concentration of 40 %. In the q-range of 0.01 - 0.25 inverse Angstrom, broad peak due to the density fluctuation within gliadin aggregates, as seen in the previous SAXS measurements. As the temperature is raised, the peak shifts to lower q and becomes broader. In the low-q region below 0.01 inverse Angstrom, steep upturn is observed, indicating that large aggregates are formed in the submicrometer region. At 66 degree, the slope of upturn becomes small, which suggests that boundary of aggregates get more disordered.

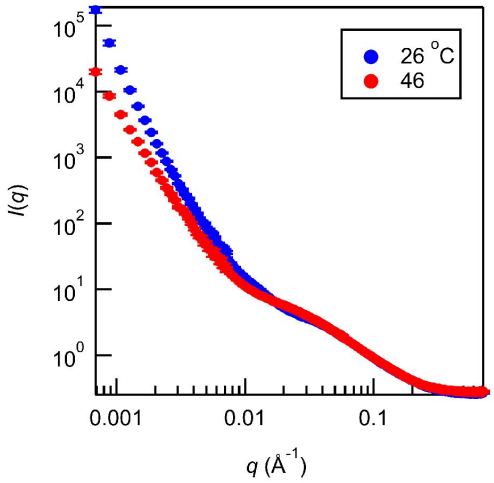

Fig. 1. SANS profiles of 40% gliadin hydrated solids in heavy water