Effect of heating on molecular dynamics of starches

H. Nakagawa[A], T. Yamada[B]

[A]JAEA, [B]CROSS

Starch is a major component of cereals and a staple food for people in countries and regions around the world. Therefore, although it has been studied for a long time, the elucidation of its physicochemical properties has lagged behind that of other nutrients such as proteins and fats. The structural properties of starch are characterized by its uniform molecular composition, but changes in its molecular structure, morphology, and moisture state, such as gelatinization and retrogradation, alter its macroscopic quality. In particular, from the perspective of food processing and culinary science, starch gelatinization by heating in the presence of water is an important process for making starch ready for human consumption.

DSC of potato starch during the heating process shows an endothermic reaction at around 65°C, which is called gelatinization [1]. However, the dynamic properties of starch during the heating process of starch have not yet been clarified. In this study, we directly observe the fluctuations in the molecular structure of starch during the heating process of starch by incoherent neutron scattering (INS) to clarify the molecular-level interpretation of the previously known DSC results.

INS experiments were performed on starch prepared by adding D_2O to a water content of 62% with an AGNES spectrometer in the temperature range from 30°C to 120°C. The energy resolution was 120 μeV. Figure 1 shows the temperature dependence of the mean square displacement (MSD) of starch evaluated from the Q-dependence of the incoherent elastic scattering intensity. At the 1st heating, the MSD increases in a sigmoidal manner, and the MSD has transition around 65°C. On the other hand, at the 2nd heating, the MSD increased monotonically with increasing temperature, and no abrupt change in MSD was observed. These results indicate that starch molecular motion increases with gelatinization, and that once heated, the starch does not return to its initial state even if the temperature is lowered. In the future, we plan to investigate the dynamics of starch in more detail by analyzing quasi-elastic scattering.

Physical properties of foods are involved in all aspects of food production, quality control, preservation, distribution, and cooking, and understanding them is an important basis for improving food productivity, quality, and environmental tolerance. This research is expected to lead to the elucidation of food structural properties (molecular structure and its dynamics) characterized by nanoscale dynamic behavior.

[1] J. W. Donovan, Biopolymers. **18**, 263 (1979).

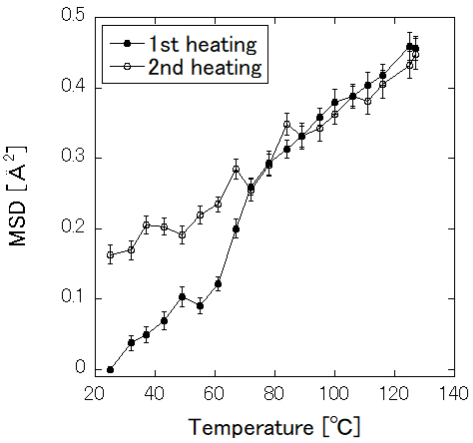

Fig. 1. Mean square displacement (MSD) of the potato starch at hydration level of 62 % observed AGNES spectrometer during heating in the temperature range from 30°C to 120°C. For the second heating measurement, the sample that had been temperature increased once (1st heating) was brought back to room temperature before measurement.