Effect of water on the molecular dynamics of amorphous amylopectin

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Amylopectin, which is a branched polymer of glucose, is a major component of starch. When amylopectin is heated with water, the double helices of amylopectin unfold, and the amylopectin becomes amorphous. The amorphous amylopectin turns to glassy state by the drying. It is known that glass transition of amylopectin is important factor for the texture control of low-moisture starchy foods [1]. In a previous study [2], mean square displacement of atoms (MSD) of hydrated amylopectin was investigated using a neutron scattering measurements. They reported that the temperature dependence of MSD increased at a temperature as similar to hydrated protein. This event has been commonly described as dynamical transition. In the case of protein, the dynamical transition temperature (T_d) corresponds closely to glass transition temperature (T_g). However, the T_d of amylopectin was much lower than the T_g determined by differential scanning calorimetry. In addition, the MSD of amylopectin near room temperature was higher than that of amorphous glucose (monomer). As a possible interpretation for the results, amorphous amylopectin is low-density because of the branched segments; many gap spaces are generated in the system. This may cause the greater molecular dynamics than amorphous glucose. When amorphous glucose is added into the amorphous amylopectin, the glucose fills the gap space of amorphous amylopectin [3]. The molecular dynamics of amorphous amylopectin may be suppressed by the added glucose. The purpose of this study was to clarify the suggestions in the view of neutron scattering.

Amorphous amylopectin and amylopectin-glucose mixture powders were prepared by freeze-drying. The powders were fully dried by vacuum-drying (dry powders). The powders, on the other hand, were equilibrated under a water activity condition using saturated NaCl at 25 °C (water activity 0.75) for 7 days (wet powders). Neutron scattering experiment was carried out using AGNES. The energy resolution was 49μeV, and covered Q range was 0.20–2.06 Å^{-1} (λ = 5.50 Å, high resolution mode). The sample was cooled to 3 K and heat-scanned up to 353 K at 0.2 K/min. MSD calculated from Q-dependence of the elastic intensity.

As a representative result, temperature-dependence of MSD for wet amylopectin is shown in Fig. 1. It was found that the temperature-dependence of MSD increased at a temperature. Although dry amylopectin was also showed a similar, the increased level was lower than that of wet amylopectin. Dry and wet amylopectin-glucose mixtures were slightly lower MSD than dry and wet amylopectin powders. These results support the interpretations suggested earlier.

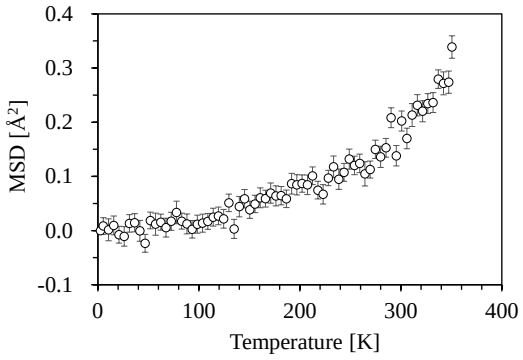

Fig. 1. Temperature-dependence of MSD for wet amylopectin powder.

References

[1] T. Sogabe *et al.*, J Texture Stud., **52**, 347 (2021).

[2] M. Di Bari *et al.*, Chem. Phys. **292**, 333 (2003).

[3] J. S. Jothi *et al.*, J Food Eng, **267**, 109731 (2020).