

Boson peak of starch

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Low energy excitation peak, called as Boson peak, is commonly observed in amorphous materials [1]. The peak is a broad peak observed in a low-frequency region of inelastic neutron scattering, Raman spectra and terahertz time-domain spectroscopy. The origin of the boson peak is a subject of debate in the field of condensed-matter physics. This peak is also commonly observed in the biomaterials, such as protein [2,3]. Hydration, pressurization, and cooling shift the boson peak position to higher energy and depress the peak intensity [3]. It was found that the correlation between the boson peak and cavity volume in a protein. The peak of a starch was observed in terahertz time-domain spectroscopy [1].

In this study, the inelastic neutron scattering measurements were performed with various starches in the dry state at the cryogenic temperature (Figure 1). Boson peaks were observed regardless of starch type. In order to evaluate the intrinsic boson peak position and intensity, the spectra were fitted by the traditional lognormal expression [3]. The boson peak positions of starches are shown below,

Potato	3.87 meV
Rice	3.57 meV
Mochi	3.62 meV
Tapioka	3.70 meV
Waxy corn	3.76 meV

In the case of protein, hydration shift the boson peak position in the higher energy and the hydrogen bonding interaction strongly affect the boson peak position. It was also discussed that a decrease of cavity volume means the increase of rigidity, which is the origin of the boson peak shift. However, the position of the boson peak with different types of starch is not well understood. Our preliminary analysis indicates that there does not appear to be a relationship between amylose content and boson peak. It was

shown that boson peak depends on the macroscopic shear modulus G [4]. In particular, the boson peak frequency is proportional to G . These results provide a positive correlation between the boson peak, shear elasticity, and the glass transition temperature. Macroscopic properties of starch are important for food quality, such as texture. The boson peak may be a valid indicator of the physicochemical properties of starch.

- [1] W. Terao *et al.*, *Spectro. Acta A.* **192**, 446 (2018).
- [2] H. Nakagawa *et al.*, *Biophys. J.* **95**, 2916 (2008).
- [3] H. Nakagawa *et al.*, *Biophys. J.* **117**, 229 (2019).
- [4] N. Tomoshige *et al.*, *Sci. Rep.* **9**, 19514 (2019).

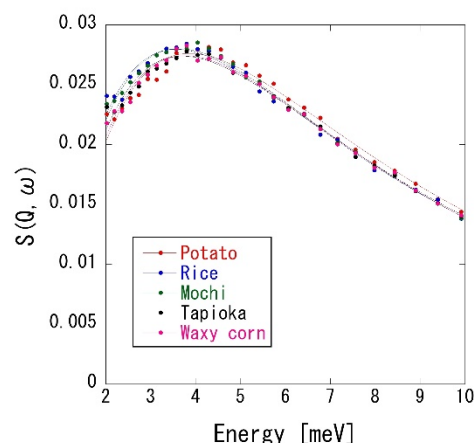


Fig. 1. Boson peaks of several starches of potato, rice, mochi, tapioca and waxy corn observed by inelastic neutron scattering.