（第３号様式）(Form No. 3)

学位論文要旨
Dissertation Abstract

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学位論文題目：
Title of Dissertation　　Effect of sugar on the physical properties of starch edible film
（可食性デンプンフィルムの物理的性質に対する糖の影響）

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The effect of sugar on starch edible film properties during storage time was investigated. At first, the effect of some sugars (maltose, sucrose, and D-allulose) on different starch sources (normal corn, normal rice, waxy corn, and waxy rice) to produce edible film was studied. Samples were prepared by drying 3% (w/w) starch suspension with 20% (w/w) sugar. The X-ray diffraction of starch film showed that the relative crystallinity of the starch film increased with both adding sugar and the storage of the starch film. The thickness of the starch films was increased with adding sugar. The morphology of the film surface became homogeneous by adding sugar. Sugar decreased breaking stress and increased breaking strain immediately after preparation and during storage. The flow behavior of all the starch film suspensions showed shear-thinning property that was determined by using the Power law model. The apparent viscosity of the film suspensions changed during the drying process due to the type of sugar and starch. Sugar showed different effects on relative crystallization, thickness, mechanical properties of the film, morphology of the film surface, and flow behavior of the starch suspension during drying. The interaction of both sugar types and starch types was an effect on inhibiting starch chain mobility that due to the size and the hydroxyl group of sugar.

Secondly, the effect of sugar concentration on rice starch film was investigated both in monosaccharide and disaccharide. The effects of monosaccharide (glucose, sorbitol, allose, and allitol) and disaccharides (sucrose, maltose, and trehalose) on the physical properties of rice starch film were studied by adding 10, 20, and 30% monosaccharide or disaccharide as a plasticizer into 3% rice starch suspension. On the day of preparation, thickness, moisture content and water solubility of the film increased and transparency of that decreased with an increase in concentration of sugars. The breaking stress of the film without sugar increased and the breaking strain of the film without sugar decreased with an increase in storage time. On the day of preparation, breaking strain increased with increasing monosaccharide

concentration except for 30% allitol addition. However, breaking strain of all monosaccharides decreased after 28 days storage. Disaccharide decreased breaking stress of the film with an increase in storage time. The breaking strain of the films with 10% disaccharide was higher than that of the film without sugar. The breaking strain of the films with 20% of all three disaccharides and 30% sucrose and trehalose were not different to that of the film without sugar, while that of the film with 30% maltose was less than that of the film without sugar on the day of preparation. On the day of preparation, X-ray diffraction showed the relative crystallinity of the film was decreased with the high concentration of monosaccharide addition. The recrystallization of the film added 20% and 30% allitol was increased after storage due to anti-plasticization effect at high allitol concentration; hygroscopic nature or crystal characteristic of allitol affected the crystal growth and phase separation in SEM result. The relative crystallinity of the film increased with an increase in concentration of sucrose and decreased with an increase in concentration of maltose and trehalose on the day of preparation. After storage, the relative crystallinity increased with an increase in concentration of disaccharides. The chemical shift of proton (^{1}H) NMR showed the interaction of monosaccharide added to the starch system had different effect at C-2, C-3 and C-6 ^{1}H hydroxyl (OH) group in anhydroglucose unit of starch due to high number of OH group of sugar alcohol and C-3 primer of rare sugar. The rice starch film with 30% disaccharide addition is considered homogeneous matrix by SEM and lower frequency chemical shift of proton OH group from NMR on the day of preparation. However, chemical shift of proton OH group at C-6 position of the film with 30% maltose showed higher frequency than that of the film with 30% sucrose and trehalose, and the cross-section of the film with 30% maltose addition had fractured after 28 days storage. The concentration and the structure of sugar as a plasticizer were important factors that affected the physical properties of rice starch film.