

# 学 位 論 文 の 要 旨

論文題目      Effect of Maltodextrin on the Glass Transition Properties of Freeze-Dried Mango Powder  
(マルトデキストリンが凍結乾燥マンゴー粉末のガラス転移特性に及ぼす影響)

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## SUMMARY OF THE THESIS

Dried fruits are commonly in an amorphous state. Amorphous solids undergo evident rheological changes at a glass transition temperature ( $T_g$ ), and glass transition also occurs at certain levels of water content or water activity ( $a_w$ ), even at a constant temperature, because the  $T_g$  of amorphous solids decreases with an increase in water content. Thus,  $T_g$ -curves ( $T_g$  versus water content) and water sorption isotherms (water content versus  $a_w$ ) are practically important criteria for the physical stability of dried fruits.

Mango (*Mangifera indica* L.) is one of the most important agricultural products in oriental regions. Because mango contains a large amount of low-molecular carbohydrates (sucrose, fructose, and glucose), glass transition occurs readily with water sorption, followed by physical deterioration such as caking of powder.

Maltodextrin (MD) has a much higher  $T_g$  than low-molecular carbohydrates and so has been used as a physical modifier of dried fruits. There have been many studies on the effect of MD on the  $T_g$  of dried fruits, but no systematic data as yet for freeze-dried mango powder. The purpose of this study was to understand systematically the effect of

MD addition on water sorption, glass transition, and the caking properties of freeze-dried mango pulp and solute.

Chapter 1 presented brief background information and the purpose of this thesis.

Chapter 2 presented the fundamentals of mangoes, freeze drying, water activity, glass transition, caking, and physical modification by an addition of MD, with a literature review.

Chapters 3 described the effect of MD addition on the water sorption, glass transition, and caking properties of mango pulp. The water sorption isotherms for the freeze-dried mango pulp–MD mixtures at 25 °C showed a sigmoidal shape (type II), and the behavior was analyzed by the Guggenheim, Anderson, and de Boer (GAB) equation. The anhydrous  $T_g$  ( $T_{g(as)}$ ) increased with an increased MD content, because MD has a much higher  $T_{g(as)}$  than mango pulp. The  $T_{g(as)}$ -change for the mango pulp–MD system showed discontinuous behavior, with an abrupt change in  $T_{g(as)}$  observed between 60% and 70% MD content. The change suggests that the amorphous mixtures have heterogeneous molecular dynamics. The  $T_g$  decreased with increased water content because of water plasticizing, and the behavior was analyzed by the Gordon–Taylor (GT) equation. The critical water content ( $W_c$ ) and critical  $a_w$  ( $a_{wc}$ ) were evaluated from the  $T_g$ -curve and water sorption isotherm. As the MD content increased,  $W_c$  and  $a_{wc}$  increased. The degree of caking for samples with 40%–100% MD increased drastically above a certain  $a_w$  condition. This  $a_w$  condition could correspond to  $a_{wc}$ . It was found that caking property could be improved by the addition of MD.

Chapters 4 described the effect of MD addition on the water sorption, glass transition, and caking properties of mango solute. The water sorption isotherm for the 80% MD sample showed a type II, similar to that for the mango pulp–MD system. Conversely, the other samples (mango solute with 20%–60% MD) exhibited J-shaped

(type III) isotherms. The  $T_{g(as)}$  for mango solute was slightly lower than that for mango pulp. This suggests that pulp has an elevating effect on  $T_g$  of mango. The  $T_g$  decreased with increased water content because of the water plasticizing effect. In addition,  $T_g$  increased with increased MD content. These results were consistent with those for the mango pulp–MD mixtures. As with the mango pulp,  $W_c$  and  $a_{wc}$  increased with increased MD content. The  $W_c$  and  $a_{wc}$  were lower for the mango solute–MD samples than for the mango pulp–MD samples, suggesting that pulp can improve the physical stability of freeze-dried mango powder.

Chapter 5 summarized these results and discusses them in the context of previous results in literature, and proposes an empirical model to predict the plasticizing effect of water on dried fruits ( $T_g$ -depression and caking). This will be useful for understanding the physical stability of dried fruits based on a minimum experiment.

Key words: freeze-dried mango, maltodextrin, water sorption, glass transition temperature, caking property