Doctoral Thesis

Effect of Maltodextrin on the Glass Transition Properties of Freeze-Dried Mango Powder

(SUMMARY)

SUWALEE FONGIN

Graduate School of Biosphere Science
Hiroshima University

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SUMMARY

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 aw (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