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学 位 論 文 要 旨
Dissertation Abstract

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学位論文題目：
Title of Dissertation Pregelatinized waxy rice starch as an emulsifier for oil−in−water emulsion
(O/W エマルションの乳化剤としての部分糊化もち米デンプン)

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Starch-based emulsifiers have an essential role in the development of healthy food. Starch is a carbohydrate extracted from agricultural raw materials, which is abundantly available and inexpensive. Starch has been used as a stabilizer in the emulsion system, and some modified starches are used as emulsifiers. Some non-chemically modified starch that can act as an emulsifier has been reported, such as gelatinized waxy rice, non-waxy rice, and waxy maize. The present study aimed to investigate the performance of pregelatinized waxy rice starch (PWRS) to the emulsification and the stability of emulsion under the influence of the temperature for gelatinization (65, 75, and 85°C), and PWRS concentration (3, 5, 7, and 9wt%) for the first step of research; and under the influence of type of oil (coconut oil and hexadecane), stirring speed (8000, 11000 and 15000 rpm), and environmental conditions around emulsion (static condition and thermal treatment) for the second step of research. Emulsification of coconut oil emulsion was undertaken at the stirring speed of 11000 rpm for the first step of research. The emulsions for the second step of the research contained 10% of oil content, with 5wt% of PWRS in the emulsion. Emulsion characterizations investigated in the present study were microscopic analysis, determination of rheological parameters fixed by Herschel-Bulkley equation, emulsion stability to creaming and coalescence, small-angle X-ray scattering (SAXS) analysis, Proton Nuclear Magnetic Resonance (H-NMR) analysis, and differential scanning calorimetry (DSC).

Gelatinization temperature significantly affects the ability of PWRS as an emulsifier. Kratky plot of SAXS analysis showed that attractive interaction was occurred in PWRS gelatinized at 65°C, while the PWRS produced at 75 and 85°C showed repulsive interaction. Gelatinization at 65°C produced PWRS with many granules that could not absorb on the oil surface, then generated the emulsion that

looked stable to creaming but was unable to resist coalescence actually. The higher degree of gelatinization at 75°C produce better stabilization of emulsion to coalescence, but the creaming occurred in the emulsions for all concentration of PWRS gelatinized at 75°C. Complete gelatinization generated at 85°C for 10 minutes produced PWRS that performed as an emulsifier and generated stable emulsion within 3 weeks of storage at PWRS concentration more than 5wt%.

Amylopectin, the main ingredient in waxy rice starch, is sensitive to shear st ress. Consequently, different stirring speed during the emulsification process produ ced different characteristics of pregelatinized starch in both the aqueous phase and emulsion. The fast stirring speed (15000rpm) during emulsification has caused str uctural changes in PWRS and has decreased its ability to prevent creaming and c oalescence. Besides stirring speed, coalescence also influenced by the type of oil and environmental conditions around the emulsion. Even though H NMR analysis i ndicated that PWRS was better adsorbed on coconut oil droplet surface than on h exadecane droplet surface, but in static conditions of storage, coconut oil that had higher apparent viscosity than hexadecane, exhibited a lower ability to coalescenc e. However, under the thermal treatment (temperature −30 to 50°C for three cycle s), coconut oil emulsion showed better stability than hexadecane. The higher coale scence in hexadecane emulsion under thermal treatment than those in coconut oil was caused by the irregular shape of hexadecane crystal with a sharp edge on so me part. The crystallization temperature of coconut oil in the emulsion was not af fected by the droplet size. In contrast, the size of the droplet affected the temper ature of the crystallization of hexadecane droplets.

Emulsions stabilized with PWRS exhibited shear thinning behavior. The unnoticed yield stress was found in the emulsions except in the coconut oil emulsion with PWRS produced at 65˚C at concentration 3 wt% for the first research; emulsion emulsified at 8000 rpm, and hexadecane emulsion emulsified at 11000 rpm for the second research. The stirring speed of 11000 rpm produced an emulsion with the highest consistency coefficient and stability

In conclusion, PWRS exhibited emulsifier properties when PWRS produced in an appropriate process. Emulsification process, oil type, and environmental conditions around the emulsion were factors that affect the stability of the emulsion. The necessary further researches include basic research into more detailed characteristics of PWRS, such as interfacial rheology, long-term storage, interactions with other oils, and also include applied research on the use of PWRS for various products.