Application of Gelatinized Kudzu Starch as Stabilizer to Food Dispersion Systems

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Abstract of thesis

Food has been recognized as one of the complex dispersed systems, consisting of one or more phases dispersed into the continuous phase, such as milk, ice cream, yogurt and cheese. To improve the stability of food dispersion systems, synthetic surfactant, phospholipids, protein, and polysaccharides, are commonly utilized as stabilizer in food area. Due to the potential toxicity of some synthetic stabilizers after the intake of high content, natural stabilizers including protein and polysaccharide have been paid more attention in the food industry. Starch is the cheap and abundant polysaccharide, and has some potential abilities to be used as stabilizer and texture modifier. However, the information regarding gelatinized starch as stabilizer or emulsifier is still limited. From preliminary experiments, emulsions stabilized by gelatinized kudzu starch showed better stability as compared to other starches of corn, wheat, etc. Kudzu starch is isolated from the radix of kudzu, and has been developed into nature healthy foods, such as kudzu biscuit, kudzu noodles, kudzu warabi-mochi and sesame tofu. Although there are all kinds of food products regarding kudzu starch in the market, its market is getting small and is replaced by other plant starches because of their prices. Hence, it is important to study about characteristics of gelatinized kudzu starch and application of native and modified kudzu starch to food dispersion systems.

Firstly, oil-in-water (O/W) emulsions have been formulated using gelatinized kudzu starch and their stabilities were observed in Chapter 2. The types of homogenization methods and the effects of oil types, oil weight fractions, and kudzu starch concentrations on the formulation and stability of O/W emulsions were investigated. The results showed that the rotor-stator homogenization in combination with high-pressure homogenization was suitable method for formulation of O/W emulsions. The O/W emulsions containing 10% (w/w) soybean oil could be stabilized by 3% (w/w) gelatinized kudzu starch. Although emulsion could be stabilized using gelatinized kudzu starch, its stability was limited considering oil droplet size. Hence, kudzu starch should be modified to

improve its emulsification capacity.

The dodecenyl succinic anhydride (DDSA) modified kudzu starch was formulated and was characterized in Chapter 3. After modification, granule size of kudzu starch was bigger in comparison with native kudzu starch as well as the viscosity of gelatinized DDSA-modified kudzu starch. However, there was no detectable surface change of kudzu starch granules before and after modification. To elucidate the esterification between DDSA groups and kudzu starch molecules, the characteristic peaks of DDSA-modified kudzu starch was determined using Fourier transform infrared spectroscopy (FT-IR). Moreover, differential scanning calorimetry (DSC) thermograms revealed that the gelatinization of modified kudzu starch started at lower temperature. The oil droplet size of emulsions stabilized by DDSA-modified kudzu starch was smaller compared with native kudzu starch. The results of emulsions after storage and confocal laser scanning microscopy (CLSM) analysis suggested that smaller droplet size was produced with high DDSA-modified kudzu starch concentration. Furthermore, the stable emulsions were observed in samples containing 2–3% (w/w) DDSA-modified kudzu starch during storage at 25 ^{o}C up to 30 days.

Later, Kudzu starch was also esterified with octenyl succinic anhydrate (OSA) as a food-grade emulsifier to formulate O/W emulsions in Chapter 4. In addition, the difference between the physicochemical properties and emulsifying ability of native kudzu starch and those of OSA-modified kudzu starch was investigated. Granules of the OSA-modified kudzu starches increased in size as well as viscosity after gelatinization. The interfacial tension between soybean oil and gelatinized OSA-modified kudzu starch was lower than that of native kudzu starch. To achieve the smaller and more uniform size of emulsions, homogenization conditions were investigated, and the droplet size was decreased to 186 nm at 100 MPa for three passes. Emulsions stabilized using gelatinized OSA-modified kudzu starch were less stable when exposed to different ionic strengths, than when exposed to different pH levels. The results of oil droplet size and confocal laser scanning microscopy analysis indicated that emulsions containing 2 to 5% (w/w) OSA-modified kudzu starch remained stable at room temperature for 30 days. Compared to native kudzu starch, both DDSA-modified kudzu starch and OSA-modified kudzu starch expressed better stability, and could produce smaller oil droplets emulsion. However, OSA modification has been approved as food ingredients. Therefore OSA-modified kudzu starch is more suitable to be applied to food industry, considering food safety and the reaction efficiency of modification.

In Chapter 5, the formulation of complex coacervates between gelatin and OSA-modified kudzu starch was investigated by turbidimetric analysis as a function of pH and ratio of gelatin and OSA-modified kudzu starch. The interaction between gelatin and OSA-modified kudzu starch yielded a dense liquid coacervate phase, leading to phase separation, and the optimum conditions for their coacervation was pH 6.0 and the mixed ratio of 1:1 (w/w). To characterize the complex coacervates, DSC thermograms revealed that the endothermic peak temperature of coacervates increased due to the interaction between these two polymers, and SEM suggested that gelatin and OSA-modified kudzu starch were interconnected, forming a network structure through electrostatic attraction. Moreover, FT-IR spectra indicated that coacervates were formulated between the carboxyl groups of OSA-modified kudzu starch and the amino groups of gelatin. The astaxanthin (AST) extract was encapsulated in complex coacervates and its stability was observed during 10 days of storage time. The results revealed higher retention of AST encapsulated in complex coacervates in comparison with gelatin. Therefore, kudzu starch after modification could be used as wall material to perform the microencapsulation of bioactive compounds.

The findings obtained in this study suggested that gelatinized native or modified kudzu starch could be used as stabilizer to emulsions for developing a new application of kudzu starch. Comparing with gelatin, complex coacervates of gelatin and gelatinized OSA-modified kudzu starch could improve the chemical stability of AST, which could be used as wall materials for microencapsulation of hydrophobic bioactive compounds.