Abstract of thesis

Studies on functional properties of soy lipophilic protein and its potential for food applications

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Soy lipophilic protein (LP) was recently discovered as a new fraction of soy protein isolate (SPI) and accounts for about 31% of SPI. LP is composed of several protein molecules and includes polar lipids, mainly consisting of phospholipids (Samoto, 2007). The main component of LP is a complex of phospholipid and oleosin which originally envelop neutral lipids to form oil body, molecular assembly for oil storage, in soybean seeds and remain in defatted meal after extraction of neutral lipids. Since LP was difficult to be stained by the dye used for detecting proteins after electrophoresis, the presence of LP fraction has been overlooked. Functional properties and applications for food production of β-conglycinin (7S) and glycinin (11S) have been extensively studied, but only a few reports on those of LP have been published. In this study, functional properties including solubility, foaming properties and emulsifying properties were investigated to know the potential use of LP for food applications. Soy protein fractions including 7S, 11S, LP and SPI were prepared without heat treatments to avoid heat denaturation to use in this study. SDS-PAGE analyses showed that LP was composed of oleosin and other proteins including residual subunits of 7S, 11S, lipoxygenase, 35 kDa protein (Glym 1).

In chapter 1, solubility of LP was compared to that of other soy proteins. Solubility of LP in water and other buffer conditions was lower than that of other soy protein fractions, that is, 7S, 11S and SPI. Solubility of LP was increased constantly by elevating temperature until $90^{O}C$, whereas that of 7S and 11S dropped at high temperature. Temperature-dependent

changes of solubility of SPI might reflect the combination of that of 11S, 7S and LP. DSC curves reveled clear endothermic peaks for 7S, 11S and SPI reflecting thermal denaturation i.e., unfolding of globular conformation, but no endothermic peak was observed for LP. Such a difference in thermal behavior may affect the temperature dependent-change of solubility for each soy protein fraction.

In chapter 2, surface and foaming properties of LP were compared to those of 7S and 11S. Surface tension decreased more rapidly for LP than for other soy proteins, indicating the efficient surface adsorption at the air-water interface. All soy proteins formed elastic films at the air-water interface. The most rapid formation of elastic film was shown for LP, suggesting the rapid reorganization and interaction of LP molecules at the interface. LP can produce fine bubbles with high drainage stability. The superior surface and foaming properties of LP may be due to the complex formation of phospholipids and proteins. On the other hand, the inferior surface and foaming properties could be attributed to the rigid globular conformation of 7S and 11S molecules as suggested by DSC results. The surface and foaming properties of 7S and 11S were dramatically improved by heat treatments, which could be relevant to heat-induced changer in particle size, zeta-potential and surface hydrophobicity of 7S and 11S molecules. For LP, the foaming ability was declined by heating, but the foam stability was increased to maintain the foam volume up to the final stage of observation. Medium sized bubbles as well as fine bubbles were produced in the foam stabilized by heated LP. The improved foam stability may be attributed to the combination effect of the delayed drainage from the lamellar phase of fine bubbles and the increased resistance to the bursting of medium sized bubble. The outstanding stability of heated LP foam showed that LP has great potential for using as an ingredient in food products including bubbles.

In chapter 3, emulsifying properties of LP were investigated especially on the tunability of physical properties of resultant emulsions which is closely relevant to actual food applications. LP dispersion (1 wt%) could emulsify the relatively high content of soybean oil (50 wt% in the final emulsion). Particle size distribution measurement and Cryo-SEM observation revealed that the diameter of most of emulsified oil droplets was less than 5 μm, indicating the high emulsifying activity of LP, but oil droplets were flocculated immediately after the preparation possibly because of high aggregation tendency of LP molecules adsorbed at the oil-water interface. During storage for 8 weeks, creaming was progressed within initial 2 weeks with approximately 15% of creaming index. However, flocculation and coalescence of the LP emulsions were scarcely progressed indicating the high long-time stability of LP-stabilized emulsions. The addition of NaCl (1-2% wt) or sucrose (5-10% wt) resulted in a slight decrease in viscosity, which might be attributed to the weakening of attractive interaction among oil droplets. Acidified LP emulsions exhibited a change from liquid to semisolid forms by tuning–the pH. Viscoelasticity properties of acidified LP emulsions at pH ranging from 5.7 to 4.5 suggested the gel-like network structure leading to the cream cheese-like texture or appearance after storage. The excellent emulsifying activity, emulsion stability and gel-like networking of LP emulsions demonstrate a great potential for application to emulsion food products.

In conclusion, solubility of LP was lower than that of other soy protein fractions, although heating is shown to be applicable for the solubility increase. LP has superior surface and foaming properties as compared to other soy proteins irrespective of heat treatments. Furthermore, LP exhibited excellent emulsifying properties, that is, an ability to produce fine oil droplets that were highly stable during long storage. Physical properties of LP-stabilized emulsions were shown to be tunable by acidification under the limited pH range. These results indicate that LP has a great potential for applications to various types of food product. The findings of this study should not only promote the commercial use of LP as a new soy protein fraction in food products, but also stimulating the fundamental and applied studies on functional properties of SPI, a representative of commercialized soy protein, from the viewpoints that LP accounts for the major part of SPI.

Key words: soy lipophilic protein, solubility, foaming properties, emulsifying properties, tuning of physical properties