Characterization and Structural Analysis of Egg Yolk Plasma

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Egg yolk plasma is the primary contributor to the emulsifying and gelling properties of egg yolk due to its high content (85 %) of low-density lipoproteins (LDLs) (Anton, 2013). Although LDLs are generally considered a homogeneous population, their broad reported size range suggests potential structural heterogeneity that may influence functionality. In this study, egg yolk plasma was prepared under varying extraction conditions (0.1 and 0.2 M NaCl; 10.000×g and 40000×g) to investigate whether changes in ionic strength and centrifugal force reveal structural differences within the LDL population, and whether such differences translate into measurable functional effects. Structural differences induced by these variations were characterized using small-angle X-ray scattering (SAXS). In addition, temperature-dependent SAXS measurements (5-80 °C) were performed to investigate structural evolution during heating. The functional properties of plasma obtained under these different extraction conditions were subsequently evaluated and compared. Interfacial properties were assessed using drop tensiometry to determine adsorption kinetics and equilibrium interfacial tension, while heat-induced gelation and viscoelastic properties were analyzed by rheology. Compositional analysis showed that increasing ionic strength reduced total lipid content, while higher centrifugal force enriched the plasma fraction in neutral lipids and decreased the relative proportion of polar lipids. Despite these differences, particle size distributions consistently exhibited a dominant LDL population centered at 40-50 nm. SAXS measurements from the four samples revealed several characteristic features. The scattering data displayed smeared form-factor oscillations due to particle polydispersity, an increase in intensity at low q at higher temperatures, indicative of aggregation, and the development of a more pronounced high-q shoulder upon heating. Between 5 and approximately 65 °C, all data sets were similar, reflecting only minor changes in particle structure. Above ~65 °C, aggregation became increasingly significant, as evidenced by systematic changes at low q. The data were modeled using a polydisperse core-shell ellipsoid model that incorporates random-walk aggregation and an internal shell structure. Consistent with the SAXS results, all samples formed elastic gels upon heating (~80 °C), with plasma obtained at 40.000×g forming the stiffest gels. All samples showed a rapid decrease in interfacial tension, indicating quick adsorption of surface-active lipids and proteins from egg yolk plasma. At the interface, plasma prepared at 10.000×g exhibited lower equilibrium interfacial tension and higher interfacial viscoelastic moduli, suggesting more efficient interfacial stabilization, potentially due to higher phospholipid content and the presence of additional minor surface-active components.

Keywords:
egg yolk plasma, low-density lipoprotein, SAXS, interfacial tension, gelation

References:

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