Which molecular parameters predict foaming properties – A soft matter approach

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Predictive tools are needed to provide rapid, accurate values for techno-functional behavior of ingredients. Especially, as new alternative protein sources and varieties are constantly being explored and produced. Experimental assessment of each ingredient is time consuming and resource intensive. However, developing reliable predictive models, using e.g. neural networks or other machine learning models, requires good quality data. But at this point, it is unknown which molecular data from protein ingredients is needed to build accurate models. In this work, we used a soft matter approach to identify molecular parameters that best predict foaming performance of soy proteins, obtained via lab- and industrial-scale extraction. The analysis showed that solubility and surface tension are general predictors of foamability because high solubility leads to faster diffusion of particles to the interface, significantly lowering the surface tension. However, for foam stability, solubility is a general predictor, while in laboratory-extracted proteins, enthalpy, particle size, the 11S/7S ratio, and surface charge also play critical roles. Hence, the predictive power of molecular properties strongly depends on processing history, making generalization across lab-extracted and commercial proteins challenging. These findings provide deeper insights into the molecular parameters that determine the foaming properties of lab-extracted and commercial proteins. The determined key parameters provide a predictive framework for the foaming behavior of soy proteins and offer a foundation for modeling protein functionality in general.

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