Thermodynamic Incompatibility and Phase Inversion in Emulsions Stabilized by Uncracked Vegetal Byproducts

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Optimizing the valorization of byproducts from the agri-food industry is highly relevant given the large quantities of valuable matter that is still currently lost, and developing sustainable pathways to recover and upcycle this biomass is therefore imperative. In this context, research is made in the use of byproducts minimally processed for the stabilization of clean-label dispersed systems. These ingredients, that show complex compositions, offer a promising route toward circular and resource-efficient formulations. [1][2]

The present study focuses on mixes of micronized pistachio shell (PS) and rice bran wax (RBW) powders to stabilize emulsions. Both O/W and W/O emulsions could be stabilized with these byproducts, depending on their mass fractions. Furthermore, bi-continuous systems were also obtained with close proportions of oil-water and PS-RBW. These results were directly related to the chemical composition of the 2 byproducts. PS contains a high fraction of structural polysaccharides (around 80%, with 10-20% of cellulose and 30-40% of hemicellulose) and approximately 5% of proteins. A recent study demonstrated the foaming and emulsifying properties of the PS powder [3]. By contrast, RBW contains significantly lower protein and fibrous contents (approximately 2% and 40% respectively), and studies showed that this ingredient is composed predominantly of long-chain fatty-acid crystals, conferring increased hydrophobicity and a strong affinity for the oil phase [4].

A phase diagram was constructed to delineate domains corresponding to O/W, W/O and bi-continuous systems. Stability was assessed across the formulation space, and stable systems were characterized by confocal microscopy. Formulations enriched in oil and RBW preferentially produced W/O emulsions, with aqueous droplets of several tens of micrometres. Conversely, more aqueous formulations fortified with pistachio-shell powder (PS) yielded O/W emulsions containing much smaller oil droplets (typically a few micrometres). Considering the bi-continuous system that was also obtained, various stabilization mechanisms can take place: in some regions (e.g. bi-continuous) a hybrid mechanism takes place, whereas in more extreme formulations one ingredient predominates. In particular, interfacial protein adsorption appears to drive O/W formation, while abundant insoluble particles and RBW favour Pickering-type stabilization of W/O systems by functionalizing the oil phase.

These results contribute to the knowledge in formulation of dispersed systems using upcycled materials with complex compositions and offer promising prospects for minimizing processing while maximizing material valorization in dispersed system stabilization such as food and cosmetic products.

Keywords:
Clean-label Emulsions, Phase Inversion, Bi-continuous System, Vegetal Byproducts, Upcycling

References:

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