A new embedding wall material prepared by silkworm pupa protein-polyphenol complex and its application

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Functional structural lipids are rich in unsaturated fatty acids, which can provide nutrition and energy for people's growth and development(Kucerka et al., 2015). However, this structure makes structured lipids easily oxidized, which severely limits the application and storage of structured lipids. At the same time, in the process of oil absorption, the strong acid environment in the stomach will destroy the structure of unsaturated fatty acids, thus affecting the absorption of unsaturated fatty acids(Tracey et al., 2018). Therefore, to maximize the nutritional function of structural lipids, the encapsulation of structural lipids is necessary and meaningful.

Microencapsulation is now considered to be a very effective technique for strengthening highly unsaturated fatty acid-structured lipids(Tracey et al., 2018). Microencapsulated structured lipids can control the release of substances inside capsules during processing, processing, and storage, and can effectively prevent their oxidation. Therefore, microencapsulation of the prepared structured lipids is the best choice to solve the above problems(Koelmel et al., 2017). How to correctly select the emulsifier and wall material determines the success of the microencapsulation process.

The amino acid composition of silkworm pupa glutenin is better than that recommended by WHO/FAO(Rebolj et al., 2007), but its solubility and emulsification are poor, which limits its application in food processing. Natural polyphenols have many important biological characteristics(Efimova et al., 2022). They can bind to proteins through non-covalent and/or covalent interactions to change the structure of proteins(Sun et al., 2018), improve functional properties, and broaden the scope of application(Leftin et al., 2015). Therefore, the construction of a protein-polyphenol emulsifier can not only improve the bioavailability of polyphenols but also exert the potential of polyphenols to reduce protein sensitization.

Here, silkworm pupa glutelin and plant polyphenols such as caffeic acid and tannic acid were used to successfully prepare silkworm pupa glutelin-polyphenol complexes. Microfluidic droplet embedding technology was used to embed structural lipids with protein-polyphenol complex as wall material. The prepared microcapsules had good emulsion stability without adding an exogenous emulsifier.

Figure.1 shows the antioxidant activity of the caffeic acid-protein complex and tannic acid-protein complex. It can be found that the antioxidant properties of protein-polyphenol complexes were significantly improved compared with silkworm pupa glutelin. Therefore, the complex is expected to be an embedded wall material for structural lipid antioxidants.

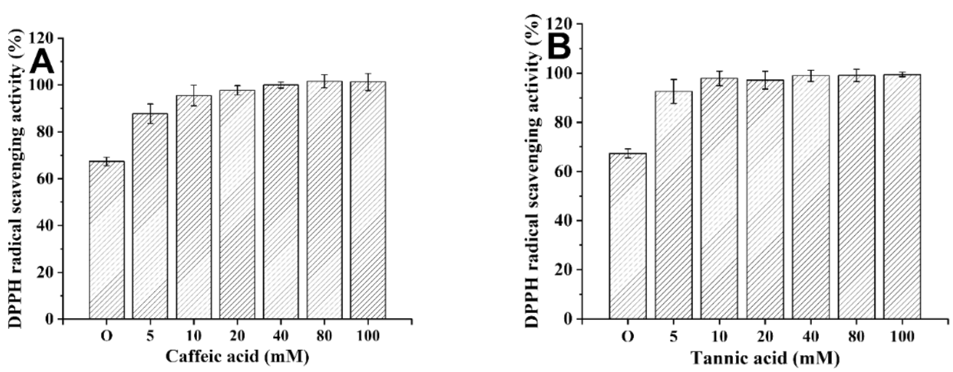

Figure.1 Antioxidant activity of two polyphenols-silkworm pupa protein complexes, (A) Caffeic acid-pupa protein complex; (B) Tannic acid-silkworm pupa protein complex.

Monodisperse chips and microfluidic technology were used to prepare structured lipid microcapsules. Figure.2 shows the structural lipid microcapsules embedded in two protein-polyphenol complexes. The microcapsules embedded in the protein-polyphenol complex had uniform size and good emulsion stability.

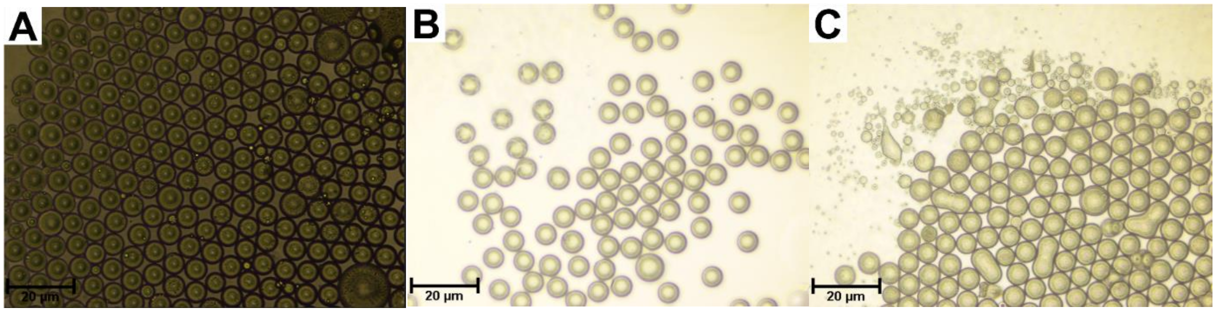

Figure.2 Two polyphenol-chrysin complexes and chrysin-embedded structured lipid microcapsules. (A) silkworm pupa protein; (B) Caffeic acid-pupa protein complex; (C) Tannic acid-pupa protein complex.

In summary, two protein-polyphenol complexes with good antioxidant and emulsifying properties were prepared. Microfluidic droplet technology was used to prepare structured lipid microcapsules with protein-polyphenol complex as the embedding wall material. The prepared structured lipid microcapsules had uniform size, good emulsification stability, and oxidation resistance. While preventing the oxidative damage of structural lipids, it can also supplement proteins and polyphenols, which are more conducive to human absorption and nutritional supplementation.

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References:

[1] Kucerka, N., Heberle, F.A., Anbuvahini, N.A., Pan, J.J. Katsaras, J., 2015. 'Structural Significance of Lipid Diversity as Studied by Small Angle Neutron and X-ray Scattering'. *MEMBRANES*, 5 (3):454-472.

[2] Tracey, T. J., Steyn, F. J., Wolvetang, E. J., Ngo, S. T., 2018. 'Neuronal Lipid Metabolism: Multiple Pathways Driving Functional Outcomes in Health and Disease'. *FRONTIERS IN MOLECULAR NEUROSCIENCE*, 11 (10): 1-25.

[3] Koelmel, J. P., Kroeger, N. M., Ulmer, C. Z., Bowden, J. A., Patterson, R. E., Cochran, J. A., Beecher, C. W. W., Yost, R. A., 2017. 'LipidMatch: an automated workflow for rule-based lipid identification using untargeted high-resolution tandem mass spectrometry data'. *BMC BIOINFORMATICS*, 18 (1): 331.

[4] Rebolj, K., Ulrih, N. P., Macek, P., Sepcic, K., 2007. 'Steroid structural requirements for interaction of osteolysis, a lipid-raft binding cytolysin, with lipid monolayers and bilayers'. *BIOCHIMICA ET BIOPHYSICA ACTA-BIOMEMBRANES*, 1758 (3):1662-2006.

[5] Efimova, A. A., Abramova, T. A., Popov, A. S., Grokhovskaya, T. E., 2022. 'Interaction of Chitosan with Anionic Liquid Liposomes: Reversibility of Structural Rearrangements in Lipid Bilayer'. *RUSSIAN JOURNAL OF GENERAL CHEMISTRY*, 92 (11):2429-2435.

[6] Luchini, A., Delhom, R., Deme, B., Laux, V., Moulin, M, Fragneto, G., 2018. 'The impact of deuteration on natural and synthetic lipids: A neutron diffraction study'. *COLLOIDS AND SURFACES B-BIOINTERFACES*, 168: 126-133.

[7] Sun, Z., Glebe, U., Charan, H., Böker, A., Wu, C., 2018. 'Enzyme–Polymer Conjugates as Robust Pickering Interfacial Biocatalysts for Efficient Biotransformations and One-Pot Cascade Reactions'. *ANGEWANDTE CHEMIE INTERNATIONAL EDITION*, 57 (42):13810-13814.

[8] Leftin, A., Molugu, T. R., Job, C. P., Brown, M. F., 2015. 'Area per Lipid and Cholesterol Interactions in Membranes from Separated Local-Field C-13 NMR Spectroscopy'. *BIOPHYSICAL JOURNAL*, 107 (10):2274-2286.