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THE ENHANCEMENT OF SURIMI GELS BY UTILIZING COCONUT OIL PRE-EMULSION LOADED WITH PTEROSTILBENE AND TEMPO MODIFIED CELLULOSE

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I. INTRODUCTION

This study addresses the critical technical challenges in regulating the gel properties of *Miichthys miiuy* surimi, focusing on resolving the inherent contradictions in traditional processing—lipid/flavor loss from washing and gel strength reduction caused by oil supplementation[1-2]. For the first time, a ternary composite pre-emulsification system integrating Tempo-oxidized cellulose (TOC), pea protein isolate (PPI), and pterostilbene (PTE) is developed: TOC enhances myosin intermolecular interactions through its anionic properties [3], PPI ensures interfacial stabilization [4], and PTE synergistically contributes antioxidant and structural reinforcement effects [5]. This tri-component synergy overcomes the limitations of conventional binary systems. The research aims to achieve precise oil-phase distribution via interfacial engineering and establish a sodium-independent gel strengthening pathway, thereby resolving the technical dilemma between salt reduction (NaCl $\leqslant$1.5%) and gel strength maintenance. We hypothesize that the addition of P-C-T-P pre-emulsion to surimi can effectively offset the decline in gel properties caused by the direct addition of liquid oil. ultimately enhancing low-salt surimi gel strength by 39.42% and water-holding capacity by 11.5%. These findings provide theoretical foundations for developing advanced surimi products with superior nutritional and functional profiles.

II. MATERIALS AND METHODS

The pre-slaughtered brown croaker was obtained from Qiangneng Food Co., Ltd. in Wenzhou, China. Native cellulose fibers were from Dalian Yangrun Trading Co., Ltd. Coconut oil and pterostilbene were sourced from Macklin Co., Ltd. Pea protein isolate was purchased from Tianmen Hengchang Chemical Co., Ltd. TEMPO, sodium bromide, and sodium hypochloritewere obtained from Sigma-Aldrich. PPI was dissolved in distilled water and magnetically agitated for 3 h. After thoroughly mixing in the surfactant tempo-oxidized cellulose, Pterostilbene and pea protein solution, the required amount of pure water was added, and magnetic stirring continued for 10 min at 30 °C. Subsequently, a high-speed homogenizer operating at 12000 ×g was utilized for 5 min of homogenization, followed by 540 w and 3 min of ultrasound to produce the initial pre-emulsion. The fish meat was washed three times with cold water, cut into 3 cm3 pieces, and minced for 2 min. (2) The minced surimi with NaCl (2.5 %) was further chopped and blended in a blender for 3 min. (3) 10%wt of coconut oil and emulsion were incorporated into the above-mentioned surimi mixture, and meanwhile, the water was supplemented to adjust the moisture content of the surimi mixture to 78 % wt. (4) Finally, the surimi mixture was packed into polyvinylidene chloride shells with a diameter of 2.5 cm and sealed at both ends. Heating was performed using a two-stage method (40 °C, 30 min + 90 °C, 20 min), then cooling in ice water for 20 min and storage at 4 °C.

III. RESULTS AND DISCUSSION

Surimi is widely appreciated for its preferred texture and nutritional profile. However, maintaining its superior gel-forming properties while preventing nutrient loss caused by the washing process remains challenging. In this study, pre-emulsions made from pea protein isolate (PPI), pterostilbene (PTE), TEMPO-oxidized cellulose (TOC), and coconut oil (CO) were used as a fat substitute to improve the gel properties of surimi. These were incorporated into brown croaker (*Miichthys miiuy)* surimi. The results showed that the PPI-CO-TOC-PTE pre-emulsion (P-C-T-P) had a small d4,3 particle size (283.5 nm). Molecular docking simulations demonstrated that TOC enhanced hydrogen bonding interactions between PPI and PTE. Adding P-C-T-P significantly improved the gel strength (2002.33 ± 48.74 g × mm) and water-holding capacity (91.40 ± 0.37 %) of the surimi gels. Furthermore, the protein network structure was denser in the P-C-T-P group. The surimi with P-C-T-P showed higher storage and loss moduli and the highest levels of hydrogen bonding, hydrophobicity, and β-sheet content. Thus, P-C-T-P addition improved surimi gel properties compared with directly supplying lipids to surimi.

Table 1 – The TPA profiles of surimi gels added with P-C, P-C-T, P-C-T-P and P-C pre-emulsion.

Samples	Hardness (g)	Springiness	Gumminess (g)	Chewiness (g)	Cohesiveness
CON	307.00 ± 5.35^{a}	3.69 ± 0.15^{a}	246.90 ± 1.82^{a}	8.59 ± 0.08^{a}	0.77 ± 0.01^{a}
P-C	366.67 ± 8.38^{c}	3.83 ± 0.09^{bc}	331.60 ± 1.31^{c}	12.46 ± 0.37^{c}	0.82 ± 0.01^{a}
P-C-T	454.67± 17.99^{d}	3.74 ± 0.23^{ab}	401.47 ± 1.02^{d}	13.12 ± 0.31^{d}	0.78 ± 0.01^{a}
P-C-T-P	507.67± 3.09^{e}	3.87 ± 0.54^{c}	452.90 ± 2.05^{e}	15.66 ± 0.78^{e}	0.82 ± 0.01^{a}
P-C-P	344.00 ± 4.32^{b}	3.69 ± 0.19^{a}	285.50 ± 4.21^{b}	9.46 ± 0.90^{b}	0.76 ± 0.01^{a}

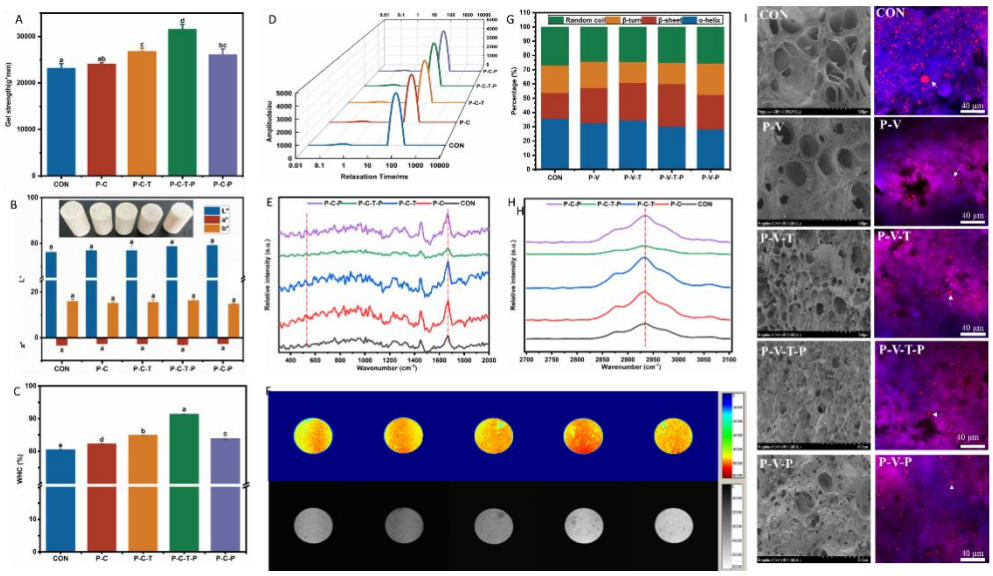


Figure 1. Change of surimi gel after adding pre-emulsion

IV. CONCLUSION

In this study, a pre-emulsion (P-C-T-P) containing modified cellulose, pterostilbene, pea protein isolate, and coconut oil was developed. It significantly enhanced the gel properties of brown croaker surimi by filling structural gaps, improving water retention, and promoting protein interactions. P-C-T-P increased surimi hardness from 307.00 g to 507.67 g, water-holding capacity from 80% to 91.4%, and gel strength from 1436.18 g×mm to 2002.33 g×mm. Pterostilbene's hydroxyl groups facilitated hydrophobic interactions and hydrogen bonding, while the emulsion induced a conformational transition of myofibrillar protein from α-helix to β-folding. The study highlights the potential of pterostilbene and modified cellulose in food applications and suggests further research on surimi storage and flavor changes.

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