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论文摘要集

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目 录

三种食用菌多糖对鲢鱼鱼糜凝胶冻融稳定性的影响：持水特性、凝胶品质、结构性质

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摘 要：目的：提供新型天然植物多糖冷冻保护剂，开发高品质冷冻鱼糜产品，为创造“功能性鱼糜产品”提供新的见解。方法：将银耳多糖（TP）、金针菇多糖（FVP）和杏鲍菇多糖（PEP）添加到鲢鱼鱼糜中，通过测定其持水性能、凝胶特性、结构性质等，探究其对鱼糜冻融稳定性的影响。结果：经 5 次冻融循环后，加入 1.0% TP、1.0% FVP 和 1.0% PEP 的鱼糜凝胶的结合水含量分别比空白对照提高了 31.20%、26.44%和 29.33%，凝胶强度分别提高了 51.82%、39.05%和 36.95%。结论：1.0%的 FVP 和 1.0%的 PEP 具有最佳冷冻保护效果，而 1.0%TP 和 2.0%TP 之间无显著差异。同时，添加食用菌多糖减少了 α-螺旋结构的损失，有利于形成致密稳定的蛋白质凝胶网络。研究表明，三种食用菌多糖均具有良好冷冻保护能力，可作为潜在天然多糖冷冻保护剂。

关键词：食用菌多糖;冷冻保护剂;鲢鱼;凝胶强度

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Effects of Three Edible Mushroom Polysaccharides on the Freeze-thaw Stability of Silver Carp (*Hypophthalmichthys molitrix*) Surimi Gels: Water retention, Gel quality, and Structural properties

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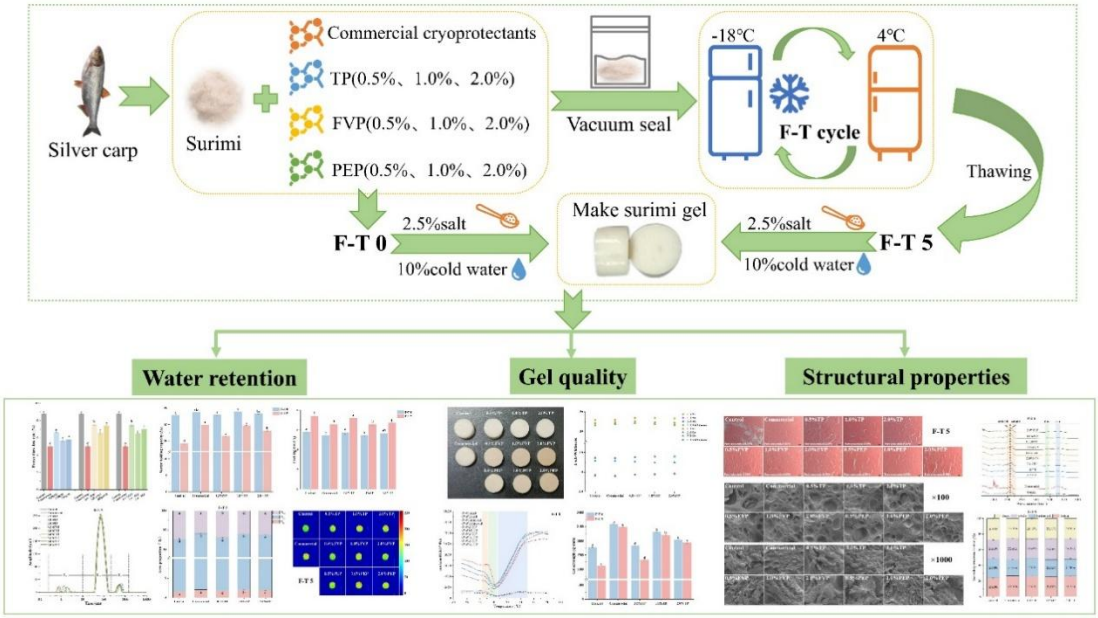
Abstract: [Objective]: To provide a new type of natural plant polysaccharide cryoprotectant to develop high-quality frozen surimi products with extended shelf life, and to offer new insights into the creation of "functional surimi products". [Methods]: *Tremella* polysaccharide (TP), *Flammulina velutipes* polysaccharide (FVP), and *Pleurotus eryngii* polysaccharide (PEP) were added to the surimi of silver carp. Their water-holding capacity, gel characteristics, and structural properties were determined to explore their effects on the freeze-thaw stability of the surimi. [Results]: After 5 freeze-thaw cycles, the bound water content of surimi gels with 1.0% TP, 1.0% FVP, and 1.0% PEP was increased by 31.20%, 26.44%, and 29.33% respectively, compared with the control, and the gel strength was increased by 51.82%, 39.05%, and 36.95% respectively. [Conclusion]: 1.0% FVP and 1.0% PEP have the most effective cryoprotective performance, while there is no significant difference between 1.0% and 2.0% TP. Meanwhile, the addition of edible mushroom polysaccharides reduced the loss of α-helical structure, which is conducive to the formation of a dense and stable protein gel network. This study showed that all three edible mushroom polysaccharides have good freeze-protective capabilities and can be used as potential natural polysaccharide freeze-protective agents.

Keywords: Mushroom polysaccharides; Cryoprotectants; Silver carp; Gel strength



姜黄素光动力灭活保鲜性能强化策略

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摘 要：姜黄素（Cur）作为一种兼具光敏活性和生物安全性的天然脂溶性光敏剂，在水产等食品光动力灭活保鲜领域具有广阔应用前景。但其作为食品级光敏剂仍存在水溶性差、光稳定性不足，以及光敏性能环境敏感性等技术瓶颈。为解决上述技术难题，基于前期创制的卤代姜黄素（X-Cur，X＝F、Cl、Br），采用分子工程策略合成了壳寡糖和聚乙二醇改性的新型姜黄素衍生物（COS-N-FCur 和 mPEG-NH-Cur）。结果表明，壳寡糖和聚乙二醇改性基团均能通过增强母体姜黄素与水分子间氢键等分子间相互作用而大幅提升其水溶性。同时，通过显著抑制母体姜黄素分子间聚集而提升单线态氧（$^1O_2$）产率，进而有效延长冷藏水产品货架期。研究成果为姜黄素及其衍生物介导的光动力灭活保鲜应用奠定了重要基础。

关键词：姜黄素；光动力灭活；分子工程；单线态氧；货架期

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Enhancement strategies for improving the photodynamic inactivation (PDI) preservation performance of curcumin

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Abstract: Curcumin (Cur), a natural lipophilic photosensitizer with both photosensitive activity and biological safety, holds significant potential for application in the field of photodynamic inactivation (PDI) preservation of aquatic products and other food items. However, as a food-grade photosensitizer, it faces several technical challenges, including poor water solubility, limited photostability, and environmental sensitivity of its photosensitive properties. To address these limitations, novel Cur derivatives were synthesized using molecular engineering strategies, building upon previously developed halogenated Cur (X-Cur, X = F, Cl, and Br), by modifying it with chitosan oligosaccharides (COS) and polyethylene glycol (PEG) (COS-N-FCur and mPEG-NH-Cur). The results demonstrated that both COS and PEG modification groups significantly improved the water solubility of the parent Cur by enhancing intermolecular interactions, particularly hydrogen bonding, between Cur and water molecules. Additionally, these modifications effectively increased the singlet oxygen ($^1O_2$) generation efficiency by inhibiting the intermolecular aggregation of Cur, prolonging the shelf life of refrigerated aquatic products. This study provides a crucial foundation for the further application of Cur and its derivatives in PDI preservation technologies.

Key words: curcumin; photodynamic inactivation; molecular engineering; singlet oxygen; shelf life

纳米纤维素抗冻活性及其改善肌原纤维蛋白乳液冻融稳定性机制研究

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摘 要:本研究旨在开发可应用于冷冻食品体系的高效生物基抗冻材料并用于改善肌原纤维蛋白乳液冻融稳定性。首先，通过酸水解和机械球磨法制备了纤维素纳米晶（CNC）和纤维素纳米纤丝（CNF），并构建了不同复配比例（0:5~5:0，w/w）的复合体系（CNC/CNF）。采用滴溅法、差示扫描量热法（DSC）及低场核磁共振（LF-NMR）等方法系统评价其冰重结晶抑制（IRI）活性。结果表明，CNC 和 CNF 均表现出较好的 IRI 活性，冰晶形貌均一且尺寸最小；同时 CNC/CNF 复配表现出显著的协同效应，当 CNC/CNF 复配比为 2:3 时，其抑制冰晶生长的效果最佳。将筛选出的 CNC/CNF 复合体系应用于鱼肌原纤维蛋白（MP）乳液体系。结果表明，添加 0.5%浓度能显著提高乳液的冻融稳定性，经 3 次冻融循环后，其乳析指数显著低于空白组及单一 CNC 或 CNF 分组。CNC 主要作用于界面，与 MP 协同增强界面膜强度并提高 MP 的界面吸附率；而 CNF 则主导连续相网络构建，有效抑制冰晶生长并缓解冻融应力导致的界面破坏和液滴聚集。本研究系统阐明了纳米纤维素复合物协同抑制冰晶及稳定乳液的机制，为开发冷冻食品提供理论依据。

关键词：纳米纤维素；冰重结晶抑制；肌原纤维蛋白；乳液；冻融稳定性

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Antifreeze Activity of Nanocellulose and Its Mechanism for Improving the Freeze-Thaw Stability of Myofibrillar Protein Emulsions

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Abstract: This study aims to develop efficient bio-based antifreeze materials applicable to frozen food systems and to improve the freeze-thaw stability of myofibrillar protein emulsions. Firstly, cellulose nanocrystals (CNC) and cellulose nanofibrils (CNF) were prepared through acid hydrolysis and mechanical ball milling, and different compounding ratios (0:5 to 5:0, w/w) of the composite system (CNC/CNF) were constructed. The ice recrystallization inhibition (IRI) activity of the samples was systematically evaluated by drop-spray method, differential scanning calorimetry (DSC), and low-field nuclear magnetic resonance (LF-NMR). The results showed that both CNC and CNF exhibited good IRI activity, with uniform ice crystal morphology and the smallest size; meanwhile, the CNC/CNF showed a significant synergistic effect. When the ratio of CNC/CNF was 2:3, its effect in inhibiting ice crystal growth was the best. The selected CNC/CNF composite system was applied to the fish myofibrillar protein (MP) emulsion system. The results show that adding a 0.5% concentration can significantly enhance the freeze-thaw stability of the emulsions. After three freeze-thaw cycles, its emulsion creaming index is significantly lower than that of the blank group and the groups with single CNC or CNF. CNC mainly acts at the interface, working in synergy with MP to enhance the strength of the interface membrane and increase the interface adsorption rate of MP; while CNF dominates the construction of the continuous phase network, effectively inhibiting ice crystal growth and alleviating the interface damage and droplet aggregation caused by freeze-thaw stress. This study systematically clarifies the mechanism of the nanocellulose complex in synergistically inhibiting ice crystals and stabilizing the emulsion, providing a theoretical basis for the development of frozen foods.

Key words : Nanocellulose; Ice recrystallization inhibition; myofibrillar protein; Emulsion; Freeze-thaw stability

Synergistic cryoprotection of L-proline and L-phenylalanine by gradient control of ice inhibition and osmolyte pressure regulation

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Abstract: The present work explored the synergistic effects and the corresponding mechanisms of L-proline and L-phenylalanine on frozen fish fillets. The results suggested that the combination of L-proline and L-phenylalanine (Pro+Phe) exerted synergetic cryoprotective roles on frozen fish fillets, as evidenced by lower mass loss (19.19%) and higher water holding capacity (71.54%). Besides, the structural stability of myofibrillar protein against F-T cycles was higher in the Pro+Phe, with comparable sulfhydryl contents and Ca^{2+}-ATPase activity with the commercial antifreeze. The large contact area with water molecules and the loose structure of L-phenylalanine accounted for their outstanding ice recrystallization inhibition (IRI) performance (lowest %MGS, 32.91%) relative to L-proline. Besides, the osmotic pressure regulation (7.05%) and freezing point depression (140.00%) of L-proline were largely responsible for preserving tissue integrity. Hence, the synergistic effects of the IRI activity of L-phenylalanine and osmotic pressure regulation from L-proline contributed to the improved quality of frozen fish fillets.

Key words: Cryoprotection; L-proline; L-phenylalanine; Ice recrystallization inhibition; Osmotic pressure regulation.

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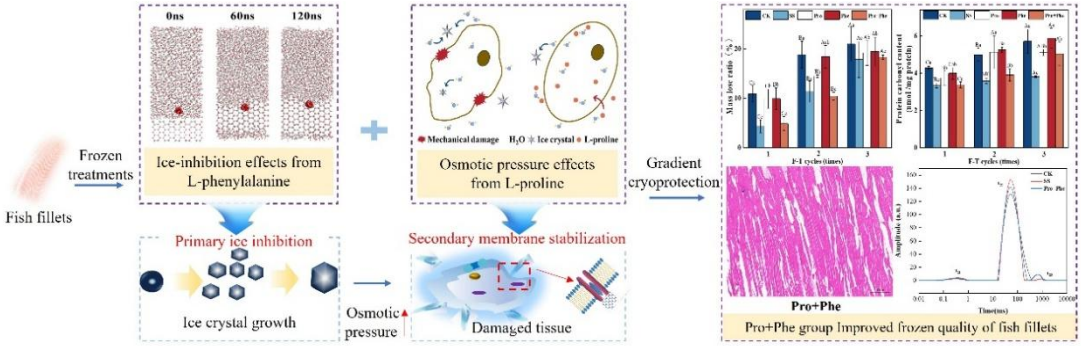

免漂洗鲜味鱼糜实用冰温技术

万金庆

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摘 要：为解决传统冷冻鱼糜加工中漂洗耗水、鲜味流失及贮藏品质劣化的行业痛点，本团队研发了“免漂洗鲜味鱼糜实用冰温技术”，该技术经专家评审入选 2024 年农业农村部“火花技术”成果培育库。本技术采用“冰温真空脱水”替代传统漂洗，再结合冰点调节剂的方法，即添加 2.5%的盐，将鱼糜冰点降至-4℃以下，实现（-2℃±2℃）条件下鱼糜非冻结流通，贮藏期 50 天以上，鱼糜鲜味倍增并且凝胶特性优异。该技术解决了食品冰温带狭小难题，不仅适用于新型鱼糜制品加工与贮藏，还可拓展至其他水产品及其预制菜研制，具有广阔的产业化应用前景，将助力水产加工行业的绿色发展。

关键词：免漂洗；鱼糜；凝胶；实用冰温技术；应用

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Practical Ice-Temperature Freshness Preservation Technology for Unwashed Umami Surimi

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Abstract: To address the industry pain points in traditional frozen surimi processing, such as water consumption during rinsing, loss of umami, and deterioration of storage quality, our team has developed the " Practical Ice-Temperature Freshness Preservation Technology for Unwashed Umami Surimi ". This technology was selected into the 2024 "Spark Technology" Achievement Database of the Ministry of Agriculture and Rural Affairs after expert evaluation. The technology replaces traditional rinsing with "ice-temperature vacuum dehydration" and combines it with a freezing point regulator method, specifically adding 2.5% salt to lower the freezing point of surimi

below -4℃. Surimi is circulated in a non-frozen state under the condition of (-2℃±2℃), with a storage period of more than 50 days. The umami of the surimi is doubled and its gel properties are excellent. This technology solves the problem of the narrow ice-temperature range for food. It is not only applicable to the processing and storage of new surimi products but can also be extended to the development of other aquatic products and their pre-prepared dishes, having broad prospects for industrial application. This technology will contribute to the green development of the aquatic product processing industry.

Key words: unwashed; surimi；gel；Practical Ice-Temperature Freshness Preservation Technology；Application

超声联合木瓜蛋白酶处理对赤道鱿鱼嫩度的影响：肌原纤维蛋白修饰方面

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摘 要：本试验探究了超声联合木瓜蛋白酶处理对赤道鱿鱼嫩度的影响及作用机制。超声功率为 200 W 时联合木瓜蛋白酶处理，剪切力下降了 23.35 %，鱿鱼的嫩度最高。肌原纤维蛋白结构分析表明，超声功率为 200 W 联合木瓜蛋白酶处理的肌原纤维蛋白分解程度最高，此时粒径最小，α-螺旋含量降低。300W 的超声波功率结合木瓜蛋白酶治疗也可以改善鱿鱼的嫩度，但这种处理增加了鱿鱼的水分流失程度，使肌原纤维更加紧密，增加了硬度。400 W 超声功率处理时木瓜蛋白酶活性降低，不利于鱿鱼的嫩化。这些发现可能为肉制品的嫩化提供新的思路。

关键词：超声功率；嫩化；木瓜蛋白酶；蛋白质结构

Effect of ultrasound combined with papain treatment on the tenderness of equatorial squid (*Dosidicus gigas*): in terms of myofibrillar protein modification

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Abstract: This study investigated the effect of combined ultrasonic and papain treatment on the tenderness of equatorial squid and its underlying mechanism. When ultrasonic power was set at 200 W and combined with papain treatment, shear force decreased by 23.35%, yielding the highest tenderness in squid. Analysis of myofibrillar protein structure revealed that the 200 W ultrasonication combined with papain treatment resulted in the highest degree of myofibrillar protein degradation, characterized by the smallest particle size and reduced α-helix content. Ultrasonic treatment at 300 W combined with papain also improved squid tenderness, but this treatment increased water loss, resulted in tighter myofibrils, and increased hardness. At 400 W

ultrasonic power, papain activity decreased, which was unfavorable for squid tenderization. These findings may provide new insights for tenderizing meat products.

Key words: Ultrasonic power; tenderization; papain; protein structure

Effects of Chitosan-Thymol Composite Emulsion on the Quality and Bacterial Community of Largemouth Bass (Micropterus salmoides) Fillets Stored at Different Temperatures

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Abstract:[Objective]To investigate the effects of a chitosan-thymol composite emulsion on the quality and microbial community of Micropterus salmoides meat during storage at 4℃ and 10℃;[Methods]Using the dorsal muscle of Micropterus salmoides as the raw material, 0.5% (m/v) chitosan solution (CH), 0.1% (m/v) thymol solution (TH), and their composite solution (CT) were prepared, with ultrapure water serving as the control (CK). During storage at 4℃ and 10℃, the following indices were measured: total volatile basic nitrogen (TVB-N), total viable count (TVC), pH, biogenic amine content, nucleotide composition, electronic nose response, sensory properties, and volatile compounds via GC-MS. Bacterial community diversity was analyzed by 16S rRNA gene sequencing;[Results]Compared to the CK group, the CT group extended the shelf life by at least 9 days and 3 days under storage at 4℃ and 10℃, respectively. The CT treatment significantly inhibited the formation of biogenic amines such as putrescine (Put), cadaverine (Cad), and histamine (His), reduced the accumulation of hypoxanthine (Hx), and resulted in the smallest pH fluctuation. Furthermore, it suppressed the accumulation of spoilage-related volatile compounds including hexanal, nonanal, and 1-octen-3-ol, while promoting the retention of flavor substances such as 2-pentanone and methyl butyrate. Sensory evaluation indicated that the CT group received higher scores in odor, color, and overall acceptability. Bacterial community analysis revealed that the dominant phyla were *Firmicutes*, *Actinobacteria*, and *Proteobacteria*. The CT group inhibited the growth of spoilage bacteria including *Acinetobacter* and *Pseudomonas*, reduced microbial diversity, and genera such as *Macrococcus* and *Acinetobacter* showed positive correlations with spoilage indicators including TVC, TVB-N, and methyl butyrate;[Conclusion]The chitosan-thymol composite emulsion effectively maintains the quality of Micropterus salmoides during refrigerated storage and extends its shelf life by inhibiting the growth of specific spoilage bacteria, delaying the formation of spoilage-related compounds, and promoting the retention of flavor substances. This

effect is particularly remarkable at 4℃.

Key words: Chitosan-Thymol composite emulsion,fish preservation,freshness indicator,microbial diversity

褐藻胶裂解酶的开发及应用

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摘要：褐藻胶寡糖是典型的褐藻特征糖，具有显著的生物活性，已广泛应用于医学、功能食品和绿色农业等领域。本研究运用基因工程技术，表达并表征了褐藻胶裂解酶；运用结构域重组的策略，获得了酶活力提升的褐藻胶裂解酶 AlyMc；运用蛋白结晶及 X 衍射的方法，解析其三维结构；运用 Hotspot Wizard 3.0 和 PoPMuSiC 软件预测 AlyMc 所有潜在的热稳定性突变位点，经筛选验证获得热稳定性明显提高的突变体 Q246V 和 K249V，并分析了其热稳定性提升的机制。为提升突变体的表达量，构建了含透明颤菌血红蛋白基因的重组质粒，运用高密度发酵，使酶活力提升 4 倍。探索了酶解条件，制备褐藻胶寡糖（AOS），并解析了 AOS 结构；将 AOS 作为益生元添加于刺身饲料中，结果表明，AOS 对刺参生长有促进作用且有益于刺参肠道健康。本研究为新型多糖工具酶的开发和功能性寡糖的生物催化提供了重要意义。

关键词：褐藻胶裂解酶；定向改造；高密度发酵；褐藻胶寡糖

The development and application of novel alginate lyases

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Abstract: Alginate oligosaccharides is a typical characteristic oligosaccharide of brown seaweed. Due to their significant biological activities, alginate oligosaccharides have been widely applied in medicine, functional foods, and green agriculture. In this study, we utilized genetic engineering techniques to express and characterize the alginate lyases. By employing a domain recombination strategy, an alginate lyase AlyMc with enhanced enzymatic activity was obtained. The three-dimensional structure was determined using protein crystallization and X-ray diffraction methods. All potential thermal stability mutation sites of AlyMc were predicted using Hotspot Wizard 3.0 and PoPMuSiC software, and 12 mutants with enzymatic activity were screened. After verification, two mutants, Q246V and K249V, with significantly improved thermal stability were obtained, and the thermal stability mechanism was also analyzed. To increase the expression level of the mutants,

recombinant plasmids containing the *Vitreoscilla* hemoglobin gene were constructed, the high-density fermentation conditions were optimized, the enzymatic activity increased by four times in optimal conditions. We explored the enzymatic hydrolysis conditions to prepare alginate oligosaccharides (AOS) and analyzed their structure. AOS was added as a prebiotic to the sea cucumbers feed, the results showed that AOS promoted the growth of sea cucumbers and was beneficial to their intestinal health. This study provides significant importance for the development of novel enzymes and the biocatalytic production of functional oligosaccharides.

Key words: alginate lyase; directed evolution; high-density fermentation; alginate oligosaccharides

电磁驱动荧光微流控平台的构建及其在水产品痕量危害物检测中的应用研究

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摘 要：水产品因其富含优质蛋白及必需营养素而广受消费者青睐。现有的水产品高密度养殖方式在提高水产品产量的同时也带来严重的水产品质量安全问题，危害消费者身体健康。本工作以水产品中常见的抗生素（四环素（TC）、氯霉素（CAP）、土霉素（OTC））和典型致病菌（副溶血性弧菌（Vibrio parahaemolyticus）为主要检测目标物，通过有效组合纳米荧光技术和电磁驱动微流控技术，利用磁材料对目标物的高效分离和荧光纳米颗粒对目标物的高灵敏荧光响应的特点，分别构建智能电磁驱动荧光/比色双模式传感器、磁分离荧光可视化传感器及近红外光热检测与灭菌双功能传感器：（1）构建了一种基于磁性碳量子点（M-CDs）结合 G-四链体 DNA 酶催化的荧光/比色双模式传感器，并结合智能电磁驱动微流控平台成功实现了罗非鱼中 TC 的检测；（2）构建了一种基于电磁驱动微流控与智能手机成像的荧光磁分离可视化传感器，用于罗非鱼中 CAP 与 OTC 的同步检测；（3）构建了一种集成近红外（NIR）光热检测与灭菌功能的双功能传感器，用于虾中 V. parahaemolyticus 的同步检测与原位灭菌。借助所构建的电磁驱动荧光微流控平台，显著提升对水产品中抗生素和致病菌检测的灵敏度、特异性及自动化水平，为水产品质量安全风险防控提供良好的解决方案。

关键词：荧光；磁性纳米颗粒；电磁驱动；微流控；抗生素；副溶血性弧菌

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《Journal of Analysis and Testing》青年编委、《集美大学学报（自然版）》编委、中国青年科技工作者协会会员、中国食品科学技术学会高级会员、中国化学会高级会员、福建省食品加工与贮藏学会理事、厦门市食品安全专家等，个人先后入选日本 JSPS 人才、全球前 2%顶尖科学家榜单（2021-2023）、福建省特支人才“双百计划”、福建省高等学校新世纪优秀人才支持计划、福建省高校杰出青年科研人才计划等。研究成果应用于食品质量安全溯源和食品加工智能监控，提升了食品安全风险发现与响应能力；开发食品真菌毒素、重金属离子的绿色高效消减技术，初步应用于食用油、果汁等加工产业链，守护了人民群众“舌尖上的安全”。

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基于风味变化的冷藏腌制鲈鱼货架期评价研究

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摘 要：本文探究了冷藏鲈鱼新鲜度变化对其清蒸风味货架期的影响机制。采用 2%食盐腌制鲈鱼，在 0-8 天冷藏期间，分别通过传统指标（TVB-N、TVC 和 K 值）与感官评价对其新鲜度及货架期进行评估，并利用电子鼻与 GC-MS 技术分析风味物质的动态变化。结果表明，随着冷藏时间延长至 8 天，鲈鱼新鲜度显著下降，TVB-N 上升至 16.5 mg/100g，TVC 增至 5.9 log CFU/g，K 值达到 38.61%。感官评价确定最佳食用期为 2 天，较传统方法确定的货架期（8 天）缩短 6 天。冷藏期间，酒石酸和肌苷酸含量显著降低、苦味氨基酸含量上升，同时 18 种关键风味物质变化明显，可能是导致风味劣变的主要因素。研究从风味物质变化角度揭示了新鲜度对清蒸鲈鱼风味货架期的影响机制，为水产预制菜货架期评估提供了新的理论依据。

关键词：腌制鲈鱼；冷藏；新鲜度；货架期；风味

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Evaluate the freshness and shelf life of refrigerated salted perch (*Perca fluviatilis*) focusing on the flavor change

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Abstract: This study investigated the impact of freshness changes in refrigerated perch (*Perca fluviatilis*) on its shelf life and the flavor of steamed perch. The shelf life of salted perch (treated

with 2% w/w salt) during cold storage (4 °C, 0-8 days) was evaluated using both conventional indices (TVB-N, TVC, and K-value) applied to raw fish and sensory assessment after steaming. Dynamic changes in flavor compounds were analyzed using an electronic nose and gas chromatography-mass spectrometry (GC-MS). Results indicated a significant decline in freshness as the storage period extended, with TVB-N content increasing to 16.5 mg/100 g, TVC reaching 5.9 log CFU/g, and the K-value attaining 38.6% by day 8. The optimal consumption period determined by sensory evaluation was 2 days, which was 6 days shorter than the shelf life indicated by conventional methods (8 days). During refrigeration, notable decreases in tartaric acid and inosine-5′-monophosphate (IMP) were observed, along with an increase in bitter-tasting amino acids and changes in 18 key flavor compounds, including 1-octen-3-ol, methyl trans-9-octadecenoate, hexanal, and nonanal. These changes were identified as major factors contributing to flavor deterioration. The findings offer novel insights into evaluating the shelf life of aquatic-prepared dishes.

Key words: Salted perch; Cold storage; Freshness; Shelf-life; Flavor

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整合非靶向代谢组学和脂质组学，揭示热风干制牡蛎风味发展的分子机制

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摘要：在牡蛎干制进程中，会生成挥发性风味化合物，诸如醛类、酮类、醇类、酯类化合物等。既往研究显示，脂质是挥发性风味化合物的关键前体。然而，干制牡蛎风味形成的机理仍尚不明确。本研究旨在探究牡蛎在热风干制（HAD）过程（0、4、8 和 12 小时）中挥发性风味物质与前体物之间的变化规律及其潜在关联。运用气相色谱—质谱联用（GC - MS）和超高效液相色谱—串联质谱（UPLC - MS/MS）技术，鉴定出 68 种挥发性风味物质、842 种脂质组分以及 641 种代谢产物。研究结果表明，伴随干制时间的延长，挥发性风味物质的含量相应增加，且主要生成于干制后期。从机制层面分析，脂质氧化诱导产生的脂肪醛类物质是牡蛎干挥发性风味化合物的主要构成结构。KEGG 代谢通路分析显示，牡蛎干制过程中的代谢途径主要为氨基酸代谢和生物合成。脂质氧化为形成基本风味框架提供前体分子，如醛和酮；美拉德反应构建杂环主链，赋予独特的杂环香气；氨基酸代谢填充含硫或氮基团的三维级联。这些过程最终在牡蛎干中构建起复杂的风味网络。

关键词：香港牡蛎；热风干燥；挥发性风味化合物；脂质氧化；脂质组学；非靶向代谢组学。

Integrated untargeted metabolomics and lipidomics to reveal molecular mechanisms underlying flavor development in hot-air-dried oysters

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Abstract: During the drying process of oysters, volatile flavor compounds such as aldehydes, ketones, alcohols, and esters are produced. Previous studies have shown that lipids are important precursors of these volatile flavor compounds. However, the mechanism of flavor formation in dried oysters remains unclear. This study aims to investigate the changes and potential relationships between volatile flavor substances and their precursors during hot-air drying (HAD) of oysters (at 0, 4, 8, and 12 h). Using GC-MS and UPLC-MS/MS, 68 volatile flavor compounds, 842 lipid components, and 641 metabolites were identified. The results revealed that the content of volatile flavor substances increased with drying time, primarily forming in the later stages of drying. Mechanistically, lipid oxidation-induced fatty aldehydes constitute the main structural components of volatile flavor compounds in dried oysters. KEGG analysis indicated that the primary metabolic pathways during oyster drying were amino acid metabolism and biosynthesis. Lipid oxidation supplies precursor molecules that form the basic flavor framework, such as aldehydes and ketones; the Maillard reaction constructs heterocyclic backbones, thereby imparting characteristic heterocyclic aromas; and amino acid metabolism fills in three-dimensional cascades containing sulfur or nitrogen groups. These processes contribute to the formation of the complex flavor network in dried oysters.

Key words: Crassostrea hongkongensis; Hot-air drying; Volatile flavor compounds; Lipid oxidation; Lipidomics; Untargeted metabolomics.

超声-热压预处理协同酶解促进牛蛙皮胶原蛋白释放新型抗糖尿病肽：生物信息学筛选、作用分子机制及应用潜力评价

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摘要：【目的】抑制 α-葡萄糖苷酶活性以降低葡萄糖的生成水平是目前防治 2 型糖尿病的主要途径，富含胶原蛋白的牛蛙皮是获取高活性 α-葡萄糖苷酶抑制肽（BS-GIP）的潜在来源。【方法】本研究通过超声协同高温-高压处理牛蛙皮胶原蛋白，采用酶解法获取牛蛙皮胶原蛋白酶解物。随后，采用多级分离纯化技术结合质谱鉴定获取肽序列，并运用生物信息学技术筛选高活性 BS-GIP。接着，采用分子对接技术和 IR-HepG2 细胞模型分别探究 BS-GIP 对 α-葡萄糖苷酶的抑制机制和改善葡萄糖代谢的功效。最后，对酶解物和 BS-GIP 进行消化稳定性、加工稳定性和食物基质稳定性评价。【结果】超声协同高温-高压处理可显著提升牛蛙皮胶原蛋白酶解物的 α-葡萄糖苷酶抑制活性。经过生物信息学筛选，获得两种新型 BS-GIP（P1 和 P2），其中 P1 表现出更强的 α-葡萄糖苷酶抑制活性和改善 IR-HepG2 细胞葡萄糖代谢的功效。酶解物和两种 BS-GIP 表现出良好胃肠道消化稳定性和加工稳定性，且其活性的发挥不受食物基质的影响。【结论】超声协同高温-高压处理对牛蛙皮胶原蛋白水解物活性的增强与分子量降低和 β-转角含量增加成正相关。氢键是驱动 BS-GIP 结合 α-葡萄糖苷酶形成复合物的关键作用力，从而可显著抑制 α-葡萄糖苷酶的活性。Gly1、Arg2 和 Ile9 是 P1 结合 α-葡萄糖苷酶活性位点的关键氨基酸，而 P2 的关键氨基酸则为 Arg6 和 Gly7。酶解物和 BS-GIP 良好的稳定性可为其活性的发挥和产品开发奠定基础。本研究以期为 2 型糖尿病的防治策略提供新思路和新型抗糖尿病功能性和特膳食品的开发提供科学依据。

关键词：牛蛙皮；α-葡萄糖苷酶抑制肽；生物信息学；抑制机制；葡萄糖代谢

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Preservative and bacteriostatic functions of citral nanoemulsion composite film on *Ostrea rivularis Gould* during refrigeration

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Abstract: *Ostrea rivularis Gould* is one common oyster species with large consumption and wide popularity around the world, however, it is prone to spoilage due to its endogenous enzymes and microbial proliferation. Currently, the application of active package is one effective way to maintain the quality of aquatic products. In this study, citral nanoemulsion (CNE) was prepared, and added into the composite film made by hydroxypropyl methylcellulose (HPMC) and fucoidin (FCD). The citral nanoemulsion composite film (HPMC-FCD-CNE) was utilized for quality preservation and control of microbial in *Ostrea rivularis Gould* under 4°C storage. The results showed that the HPMC-FCD-CNE had effective preservative and bacteriostatic properties, which was as indicated by changes in sensory score, total volatile base nitrogen (TVB-N), pH, K value, total viable count (TVC), and the colony number of specific spoilage organisms (SSOs). Compared to the control group without film package treatment, bacterial growth in oysters was significantly inhibited in all treatment groups by HPMC-FCD-CNE. Meanwhile, under the same storage day, the HPMC-FCD-CNE group showed higher sensory score, less TVB-N content and K value than other groups. The control group reached its shelf-life by day 10 (TVC: 7.383±0.250 lg CFU/g; TVB-N: 18.209 mg/100g; K value: 55.58%), while the HPMC-FCD-CNE group by day 14 (TVC: 7.194±0.157 lg CFU/g; TVB-N: 17.218 mg/100g; K value: 56.68%). Thus, this study verified that the shelf-life of oyster packaged by HPMC-FCD-CNE was extended to 4 days longer than the control group under 4°C storage, indicating the obvious preservative and bacteriostatic functions of HPMC-FCD-CNE to oyster, which can offer practical solutions for a better quality keeping and microbial control of *Ostrea rivularis Gould* under refrigeration.

Key words: Ostrea rivularis Gould; Citral; Composite film; Preservation;Shelf-life

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不同物理处理对莱茵衣藻蛋白聚集形态及其界面行为影响

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摘要：微藻被认为可作为未来食品生产体系中的重要可持续蛋白来源，通过各种手段调控其界面行为以满足多场景食品领域应用具有重要意义。本研究以莱茵衣藻蛋白为研究对象，重点考察热处理（40℃-70℃）、超声（120 w-480 w）、高压均质（200 Bar-800 Bar）等物理条件对其聚集形态以及界面稳定性的影响。研究结果表明，各种处理条件均引起二级结构的变化，其特征为 β-折叠含量增加及 α-螺旋含量减少。同时界面稳定性与蛋白质聚集状态密切相关。经超声或高压均质处理后，莱茵衣藻蛋白可能解离为小分子片段或形成新的聚集体，从而导致其粒径分布更为分散。综上所述，不同物理处理方式可作为生态友好手段改善微藻蛋白功能特性，拓展其应用并促进可持续发展。

关键词：莱茵衣藻蛋白；界面行为；功能特性

Study on the regulatory effect of saponins from the Crown-of-thorns starfish(Acanthaster planci) on high-fat diet induced lipid metabolism disorders

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Abstract: The aim of this research was to investigate the alleviating effect of Acanthaster planci saponins(ASPs) on high-fatdiet induced lipid metabolism disorders. This study used ultrasound-assisted alcohol extraction to extract ASPs and optimized its process conditions. Liquid-liquid extraction, macroporous adsorption resin separation and purification, combined with biological activity tracking method, isolated significantly active components for liver lipid metabolism disorders, and identified by LC-MS. Induction of lipid metabolism disorder models in HepG2 and zebrafish using free fatty acids(FFA) and cholesterol, respectively. Based on general physiological indicators, pathological sections of liver and HepG2 cells, and lipid metabolism indexes, the alleviating effect of ASPs on lipid metabolism disorders induced by high-fat diet was evaluated. Our results showed that the extraction yield of Crown-of-thorns saponins was optimized to 6.821%, under the condition of 81% ethanol as solvent, sample-solvent ratio of 17:1 (mL:g), and ultrasonic time at 22 min. Five components were separated using macroporous adsorption resin, among which P5 component significantly reduced the formation of lipid droplets in HepG2 cells, showed high activity, and improved metabolic disorders caused by lipid deposition in cells. Through LC-MS identification, the component contains saponin compounds. After P5 was administered to zebrafish with lipid metabolism disorders, it was found that the weight gain trend of zebrafish was obviously slowed down, the blood glucose and lipid levels tended to return to normal, the cavity phenomenon of liver tissue was ameliorated, and the lipids weresignificantly reduced. To sum up, ASPs can effectively ameliorate the disorder of lipid metabolism.

Keywords: Acanthaster planci; Starfish saponins; Hepg2 cell; Zebrafish; Disorders of lipid metabolism

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化敌为友：棘冠海星皂苷激活线粒体介导的凋亡途径抑制肝癌细胞增殖

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摘要：近年来，刺冠海星的暴发对海洋生态系统和人类安全造成严重威胁，资源化利用迫在眉睫。本研究旨在探究刺冠海星总皂苷（CSE）的抗肿瘤活性及其作用机制。采用超声辅助乙醇提取法、柱层析法获得 CSE，利用 UHPLC-MS 分析其化学成分，并在体外 HepG2 细胞模型中评估其抗肿瘤活性，围绕线粒体凋亡通路探究其潜在作用机制。结果表明，CSE 的主要成分为二萜皂苷，能够抑制 HepG2 细胞增殖（IC50 40.83 μg/mL）和迁移（抑制率 < 32.65%），并诱导细胞凋亡，早期凋亡细胞占比 34.29%。机制上，CSE 在蛋白质水平激活促凋亡蛋白 Bax、Bad，改变线粒体膜通透性并释放细胞色素 C（cyt c）。Cyt c 与 Apaf-1 结合，招募并激活 caspase-9，进而启动 caspase 蛋白酶级联反应，促进细胞凋亡。综上，本研究初步揭示了 CSE 诱导 HepG2 细胞凋亡的机制，为刺冠海星资源合理利用提供了新的理论依据。

关键词：棘冠海星；HepG2 细胞；线粒体凋亡途径

Turning Foe into Friend: COTS Saponin Inhibits the Proliferation of Liver Cancer Cells by Inducing the Mitochondrial-mediated Apoptosis Pathway

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Abstract: In recent years, the outbreak of crown-of-thorns starfish (COTS) has caused serious threats to Marine ecosystem and human security, so the utilization of resources is imminent. This study aims to investigate the anti-tumor activity and mechanism of the saponins (CSE) from CSE. The CSE was prepared through ultrasound-assisted ethanol extraction and column chromatography, and its composition was determined by UHPLC-MS. The anti-tumor activity was evaluated in HepG2 cell models in vitro, with its underlying mechanism explored by focusing on mitochondrial apoptosis pathways. Results showed that CSE inhibited HepG2 proliferation (IC_{50} 40.83 μg/mL) and migration (<32.65 %), and induced apoptosis via phosphatidylserine exposure and nuclear condensation with 34.29% early apoptotic cells. Mechanistically, CSE up-regulated Bax and Bad, disrupted mitochondrial membrane integrity, and triggered cytochrome c (cyt c) release. The released cyt c formed an apoptosome with Apaf-1, activating caspase-9 and the downstream caspase cascade, culminating in apoptosis. Our findings reveal that CSE exerts anti-tumour activity via the intrinsic mitochondrial pathway and provide a theoretical basis for converting COTS into a valuable antitumor resource.

Key words: Crown-of-thorns starfish; HepG2; Mitochondrial Apoptosis Pathway

微生物发酵剂对低盐红鳍笛鲷品质及风味的影响

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摘要：红鳍笛鲷(Lutjanus erythropterus)，俗称红鱼，是广泛分布于海南西海岸的一种经济鱼类，其加工方式以干制和腌制为主，口感及风味单一，缺少新鲜感。目的：为了更好地开发利用红鱼，提高红鱼制品的品质，创新风味。方法：以红鱼为原料，接种植物乳杆菌（Lactobacillus plantarum）、戊糖乳杆菌（Lactiplantibacillus pentosus）和酿酒酵母菌（Saccharomyces cerevisiae）作为发酵剂，以水分含量、AW、pH、总酸、色度、质构、氨基酸态氮含量（AAN）、硫代巴比妥酸值（TBARS）、挥发性盐基氮 (TVB-N)、电子鼻成分分析等为主要指标，研究不同微生物发酵剂及其混合发酵剂对低盐红鱼品质及风味的影响。结果：与自然发酵相比，微生物发酵剂能明显降低红鱼的水分含量和AW，降低pH，改善鱼肉色泽及质构，增加AAN含量和TBARS值，同时抑制TVB-N的形成。与单一微生物发酵相比，3种微生物制得的混合发酵剂（比例为1∶1∶1）制备的发酵红鱼获得了更加丰富的风味。结论：微生物发酵剂能改善红鱼品质，抑制红鱼腐败变质，丰富低盐发酵红鱼的风味。

关键词：红鳍笛鲷；微生物；发酵；风味

烤制条件对预制烤鱼不同部位杂环胺及晚期糖基化终产物形成的影响

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摘　要：目的：探究烤制温度与熟制程度对预制烤鱼不同部位杂环胺（HAs）和晚期糖基化终产物（AGEs）形成的影响，为优化烤制参数调控其生成提供参考。方法：按特定参数烤制草鱼，测定各组结构特性、感官特性、烤鱼肉/皮中 HAs 和 AGEs 含量，分析烤制温度和熟制程度的影响。结果：250℃烤制时随中心温度从 50℃升至 80℃，鱼肉 HAs 总量增 8.5%，AGEs（CML+CEL）增 107%，鱼皮 HAs 与 AGEs 呈现先增后降变化趋势，峰值均在 65℃。以中心温度 65℃为烤制终点，随烤温升高，鱼肉和鱼皮的 HAs 峰值分别出现在 280℃和 250℃，而 AGEs 呈现持续上升趋势，相较于 220℃烤制，鱼肉和鱼皮 AGEs 在 310℃烤制时分别增加 70%和 24%。在相同烤制条件下，鱼皮 HAs 与 AGEs 含量均显著低于鱼肉。结论： 烤制条件对调控烤鱼产品中 HAs 和 AGEs 形成有显著影响，当烤制温度≤250℃、中心温度≤65℃时，预制烤鱼 HAs 和 AGEs 含量均较低。

关键词：预制烤鱼；杂环胺；晚期糖基化终产物；烤制参数

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Effects of Grilling Conditions on the Formation of Heterocyclic Amines and Advanced Glycation End Products in Different Parts of Pre-made Grilled Fish

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Abstract: [Objective]: Investigating the effects of grilling temperature and degree on the formation of heterocyclic amines (HAs) and advanced glycation end products (AGEs) in different parts of pre-

made grilled fish provides a reference for optimizing grilling parameters to regulate their formation. [Methods]:Grilled grass carp according to specific parameters, determine the structural characteristics and sensory properties of each group, measure the HAs and AGEs content in the grilled fish meat/skin, and analyze the effects of grilling temperature and degree. [Results]:At 250℃ grilling, as the core temperature rose from 50℃ to 80℃, total HAs in fish meat increased by 8.5%, while AGEs (CML+CEL) increased by 107%. HAs and AGEs in fish skin showed an initial increase followed by a decrease, with peaks occurring at 65℃. With a center temperature of 65℃ as the grilling endpoint, the peak HAs levels in fish meat and skin appeared at 280℃ and 250℃, respectively, as grilling temperature increased. AGEs showed a continuous upward trend, increasing by 70% and 24% in fish meat and skin, respectively, at 310℃ compared to 220℃ grilling. Under identical grilling conditions, both HAs and AGEs levels in fish skin were significantly lower than those in fish meat. [Conclusion]: Grilling conditions significantly influence the formation of HAs and AGEs in grilled fish products. When grilling temperature is ⩽250℃ and center temperature is ⩽65℃, both HAs and AGEs content in pre-made grilled fish remain low.

Keywords: Pre-made grilled fish; Heterocyclic amines; Advanced glycation end products; Grilling parameters

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Comparison of Flocculation Methods for Sodium Alginate and Characterization of Its Structure and Properties

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Abstract： This study investigated how different extraction parts of raw materials and different flocculation methods affect the extraction yield, structure, and properties of sodium alginate. The aim was to improve the quality of sodium alginate and provide theoretical guidance for upstream enterprises. In this study, Lessonia nigrescens (LN) was used as a raw material. The alkali treatment conditions were optimized. The optimal extraction conditions were determined to be a 2% sodium carbonate concentration, a duration of 4 h, a material-to-liquid ratio of 1:40, and a temperature of 60 °C, achieving an extraction yield of 43.03%. LN was categorized into blades, stipes, holdfasts, and whole seaweed for comparative analysis, and sodium alginate was flocculated using the acid, calcium, and ethanol methods. Structural and physicochemical analyses showed that the mannuronic acid/guluronic acid (M/G) ratios of the twelve sodium alginate samples ranged from 5.73 to 8.76. The LN part had a greater influence on the M/G ratio than the flocculation method. The relative molecular weight (2343–3074 kDa) and viscosity (170–331 mPa·s) exhibited consistent trends. For the same part, the effect of the flocculation method on the molecular weight followed the order ethanol > acid > calcium. The physicochemical properties of the extracted sodium alginate met the requirements specified in the physicochemical index standard GB 1886.243-2016 of China.

Key words： *Lessonia nigrescens*; Sodium alginate; Extraction process; Structural analysis

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Preparation and by incorporating the molecular pathways discussed in the fucoxanthin and conjugated linoleic acid complex liposomes

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Abstract：Fucoxanthin (FX), a carotenoid derived from marine algae, exhibits a range of biological activities including anti-obesity, anti-oxidation, and anti-inflammatory properties. Conjugated linoleic acid (CLA) comprises multiple isomers with both cis- and trans-conjugated double bonds, demonstrating functional activities such as anti-obesity, anti-diabetes, and anti-cancer effects. The complex liposomes formed by FX and CLA may possess synergistic anti-obesity effects. In this study, we investigated the anti-obesity effects and underlying mechanisms of FX, CLA, a combination of FX and CLA, fucoxanthin and conjugated linoleic acid complex liposome (L), and sodium alginate and chitosan modified fucoxanthin and conjugated linoleic acid complex liposome (S-C-L). To achieve this objective, we used an obese mouse model to measure body weight, fat mass, serum biochemical indices, liver oxidative stress, and AMPK/ACC1/SREBP-1c/FAS/UCP1/PPAR-γ signaling pathway expression. Our findings indicated that all samples reduced body weight and fat mass in obese mice, improved oxidative stress. Additionally, S-C-L was found to decrease ACC1 enzyme activity, down-regulate the relative mRNA expression levels of SREBP-1c, FAS, and PPAR-γ, and up-regulate the relative mRNA expression levels of UCP1 by activating the AMPK signaling pathway. The up-regulation of UCP1 protein and down-regulation of PPAR-γ and C/EBPα proteins promoted energy expenditure and inhibited adipocyte differentiation, thereby exerting an anti-obesity effect. Furthermore, it was observed that the combination of FX and CLA enhanced the anti-obesity effect, with L and S-C-L demonstrating superior anti-obesity efficacy. S-C-L holds potential for development and practical application in anti-obesity foods and health care products.

Key words: fucoxanthin, conjugated linoleic acid, complex liposome, anti-obesity activity

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Comparative analysis of organic sodium salts on improving quality and flavor of large yellow croaker (Larimichthys crocea)

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Abstract： Sodium acetate (SA), sodium citrate (SC), and sodium lactate (SL), are colorless, non-toxic, low-calorie organic sodium salts (OSSs) that can serve as substitutes for sodium chloride, thereby reducing sodium intake. These salts are widely used to enhance the sensory qualities of meat, prevent microbial growth, and extend shelf life. However, their application in the curing and preservation of seafood is limited. Therefore, this study investigated the quality changes of large yellow croaker (LYC) during freezing storage at -18 °C for 8 weeks, focusing on moisture migration, texture and color, microbial growth, microstructure, protein changes, and flavor compounds.

The results indicated that curing with 5% OSS significantly improved the water-holding capacity, texture, and color of LYC, promoting the formation of a denser microstructure and slowing the migration of bound and immobilized water into free water. Additionally, OSS-curing reduced protein denaturation and oxidative damage. As freezing time increases, the overall water retention and texture properties decreased, while total volatile basic nitrogen and total microbial count increased. Curing with 5% organic sodium salts also reduced ice crystal formation in LYC. Sulfhydryl content increased initially and then decreased over time, while disulfide bond content followed the opposite trend. Furthermore, α-helix and β-sheet structures decrease, while β-turns and random coils increase, indicating that freezing affects the stability of protein spatial conformation. Among the treatments, 5% SC and 5% SL exhibited the best performance in maintaining the quality of LYC. This study provides new insights and technical support for the development of low-sodium food products in industrial applications.

Keywords: Large yellow croaker, organic sodium salts, quality, flavor characteristic, GC-IMS.

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有机钠盐对大黄鱼（*Larimichthys crocea*）质量和风味提升的比较分析

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摘要：乙酸钠（SA）、柠檬酸钠（SC）和乳酸钠（SL）是无色、无毒、低热量的有机钠盐（OSSs），可作为氯化钠的替代品，从而减少钠的摄入。这些钠盐广泛用于提升肉类的感官品质、抑制微生物生长并延长保质期。然而，它们在水产品腌制和保鲜中的应用却较为有限。因此，本研究在-18° C 冷冻贮藏 8 周期间，针对大黄鱼（LYC）的质量变化进行了研究，重点考察了水分迁移、质地与颜色、微生物生长、微观结构、蛋白质变化及风味化合物等方面。研究结果表明，使用 5%的有机钠盐腌制显著提高了 LYC 的持水性、质地和颜色，促进了更致密微观结构的形成，并减缓了结合水和不易流动水向自由水的迁移。此外，有机钠盐腌制减少了蛋白质变性和氧化损伤。随着冷冻时间的增加，整体水分保持和质地特性下降，而挥发性盐基氮总量和微生物总数增加。使用 5%的有机钠盐腌制还减少了 LYC 中的冰晶形成。巯基含量在初期增加，随后随着时间推移而下降，而二硫键含量则呈相反趋势。此外，α-螺旋和 β-折叠结构减少，而 β-转角和无规则卷曲结构增加，表明冷冻影响了蛋白质空间构象的稳定性。在所有处理组中，5%的柠檬酸钠和乳酸钠在保持 LYC 质量方面表现最佳。本研究为工业应用中低钠食品的开发提供了新的见解和技术支持。

关键词：大黄鱼；有机钠盐；质量；风味特征；GC-IMS

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Caspase-3 通过凋亡途径介导接种假单胞菌和溶血不动杆菌的大黄鱼的蛋白降解

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摘要：本研究探讨了 caspase-3 对大黄鱼接种假单胞菌和溶血不动杆菌（A. haemolyticus）后凋亡诱导蛋白降解的影响。接种假单胞菌的样品在 0、6 和 72 h 的 caspase-3 活性高于对照组（CK），接种溶血不动杆菌的样品在 0 和 72 h 的 caspase-3 活性高于对照组（$p < 0.05$）。大多数 Acetyl-Asp-Glu-Val-Asp-aldehyde（Ac-DEVD-CHO）处理的样品的 caspase-3 活性显著低于对照（$p < 0.05$）。此外，Ac-DEVD-CHO 处理的样品的羰基含量、肌原纤维断裂指数（MFI）和总巯基含量均显著高于对照组（$p < 0.05$）。这表明凋亡通路中的 caspase-3 活性可以减少蛋白质的降解。假单胞菌和溶血不动杆菌对蛋白质降解有影响，说明微生物通过影响细胞凋亡影响蛋白质降解。本研究为研究微生物引起的细胞凋亡蛋白的变化提供了基本思路。

关键词：Caspase-3；细胞凋亡；蛋白质降解

Caspase-3 mediates protein degradation in large yellow croaker inoculated with *Pseudomonas* and *Acinetobacter haemolyticus* via apoptosis pathway

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Abstract: The effect of caspase-3 on apoptosis-induced protein degradation in large yellow croaker inoculated with *Pseudomonas* and *Acinetobacter haemolyticus* (*A. haemolyticus*) was investigated. *Pseudomonas* samples had higher caspase-3 activity than Control Check (CK) at 0, 6, and 72 h and *A. haemolyticus* samples had higher caspase-3 activity than CK at 0 and 72 h ($p < 0.05$). Most of the treatments with Acetyl-Asp-Glu-Val-Asp-aldehyde (Ac-DEVD-CHO) had significantly lower caspase-3 activity than the control ($p < 0.05$). In addition, carbonyl content, myofibril fragmentation index (MFI), and total sulfhydryl content of the treatments with Ac-DEVD-CHO were significantly different from those of the control ($p < 0.05$). This suggested that caspase-3 activity in apoptosis could reduce protein degradation. *Pseudomonas* and *A. haemolyticus* samples had an effect on protein degradation, which suggested that microorganisms affected protein degradation by affecting apoptosis. This study provided a basic idea for studying the changes in proteins caused by microorganisms on apoptosis.

Key words: Caspase-3; Apoptosis; Protein degradation

Exploring the interactions between *Shewanella putrefaciens* and *Pseudomonas fluorescen* on protein degradation of refrigerated large yellow croaker (*Pseudosciaena crocea*)

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Abstract: Exploring the roles of dominant bacteria to spoilage are important in inhibiting spoilage. This study investigated related quality, protein degradation, and muscle microstructure in refrigerated large yellow croaker inoculated with *Shewanella putrefaciens* (S) and *Pseudomonas fluorescens* (P) as mono- or co-culture (SP). The P group had the most robust spoilage ability. The P and SP groups degraded major myofibrils protein and the links to disrupt muscle fibers, induced significant free water loss in muscle and formed amounts of trichloroacetic acid (TCA)-soluble peptides and TVB-N. Severe mutual separation in myofibers also occurred in the S group. The competitive interactions between the two spoilage bacteria inhibited spoilage in the co-culture, while the numbers of differentially abundant peptides in the SP group were enriched. Therefore, this study reveals competitive interactions of the co-culture of *S. putrefaciens* and *P. fluorescens*, which offered a thorough understanding of bacterial spoilage behavior in large yellow croaker.

Key words: Refrigeration; Myofibrillar proteins; Interaction; Microstructure; Peptidomics

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蛋白质氧化修饰介导的冷冻鳙鱼营养价值变化机制

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摘要：本研究探讨了冻藏期间鳙鱼肉蛋白质氧化对其营养价值的影响与机制。通过分析冻藏 6 个月内不同浓度（0、0.5 及 2.0 M）食盐处理鳙鱼肉的蛋白质氧化水平及蛋白体外消化特性，并结合大鼠肠囊外翻模型与蛋白质组学技术，揭示了蛋白氧化引起的鱼肉消化吸收特性变化机制。冻藏期间蛋白质氧化降低了鱼肉的体外消化率，2.0 M 处理组消化产物中来自肌球蛋白重链的氧化修饰氨基酸数量显著（$p < 0.05$）增加。冷冻鱼肉消化产物中检测出如双氧化、α-氨基己二酸半醛、γ-谷氨酸半醛及丙二醛加合物等多种蛋白氧化修饰产物。此类产物抑制了蛋白质的肠道转运吸收特性。总之，氧化修饰会导致鱼肉营养价值（蛋白质消化吸收特性等）变化，应在鱼肉加工与贮藏过程中予以重视。

关键词：鳙鱼；蛋白氧化；营养价值；消化性

Mechanism of protein oxidation-mediated changes in nutritional properties of frozen bighead carp

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Abstract: This study investigated the effects and mechanisms of protein oxidation on the nutritional properties of bighead carp during frozen storage. According to the analysis of protein oxidation levels and in vitro digestibility of 6-month frozen bighead carp treated with different salt concentrations (0, 0.5 and 2.0 M), combining with an everted-rat-gut sacs and proteomics techniques, the mechanism underlying changes in digestibility and absorption properties of bighead carp caused by protein oxidation was elucidated. Protein oxidation reduced in vitro digestibility during storage, with the salted group (2.0 M) showing a marked ($p < 0.05$) increase in oxidatively modified amino acids from the myosin heavy chain. Several types of oxidative modifications were identified, including di-oxidation,α-aminoadipic semialdehyde, γ-glutamic semialdehyde, and

malondialdehyde adducts. These modifications impaired intestinal transport and absorption of digested proteins. In conclusion, oxidative modifications adversely affect the nutritional properties of fish protein, highlighting the importance of controlling oxidation in fish processing and storage.

Key words: Bighead carp; Protein oxidation; Nutritional properties; Digestibility

基于非酶褐变探究鱿鱼在传统热风干燥过程中的色泽变化机理

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摘要：色泽是衡量干制鱿鱼品质的重要感官指标。本研究以非酶褐变为核心，系统分析了不同干燥温度和时间下鱿鱼色泽、关键褐变底物及中间产物的变化规律。结果表明，鱿鱼的亮度（L^*）随干燥的进行持续下降，而红度（a^*）和黄色度（b^*）则显著上升，整体色泽逐步加深褐变。研究发现，随着干燥时间延长，鱿鱼肉中还原糖与游离氨基酸的含量显著减少，表明其作为美拉德反应的主要底物被大量消耗。同时，中间产物 5-羟甲基糠醛（5-HMF）的含量以及褐变指数（BI）均呈现持续上升的趋势。此外，脂质氧化产生的羰基化合物也可能作为底物参与美拉德反应，对褐变起到协同促进作用。本研究为鱿鱼热风干燥过程的色泽调控与高品质干制品开发提供了理论依据和科学指导。

关键词：鱿鱼；色泽变化；热风干燥；非酶褐变；美拉德反应

Investigating the Mechanism of Color Change in Squid During Traditional Hot-Air Drying Based on Non-Enzymatic Browning

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Abstract :Color is an important sensory indicator for assessing the quality of dried squid. This study systematically analyzed the variation patterns of squid color, key browning substrates, and intermediate products under different drying temperatures and durations, with a focus on non-enzymatic browning. The results indicate that the brightness (L^*) of squid continuously decreased during drying, while the redness (a^*) and yellowness (b^*) significantly increased, resulting in a gradual deepening of the overall color and browning.Research has found that as drying time increases, the content of reducing sugars and free amino acids in squid meat decreases significantly, indicating that these compounds are extensively consumed as primary substrates in the Maillard reaction.Meanwhile, both the content of the intermediate product 5-hydroxymethylfurfural (5-HMF) and the browning index (BI) showed a continuous upward trend.Additionally, carbonyl compounds generated by lipid oxidation may also serve as substrates in the Maillard reaction, synergistically

promoting browning. This study provides a theoretical basis and scientific guidance for color regulation during the hot-air drying process of squid and the development of high-quality dried products.

Keywords :Squid; Color change; Hot-air drying; Non-enzymatic browning;Maillard reaction

Comparative analysis of different body composition, mucus biochemical indices, and body color in five strains of *Larimichthys crocea*

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Abstract: [Objective] The purpose of this study was to investigate the differences in body composition, mucus biochemical indices and body color in five strains of large yellow croakers (body weight: 347.01 ± 5.86 g). [Methods] To conduct genetic diversity analyses of the populations, a total of 50 tailfin samples were randomly chosen from the following populations of large yellow croakers: wild (LYC1), Dai-qu population (LYC2), Yongdai 1 (LYC3), Min yuedong population (LYC4), and Fufa 1 (LYC5). [Results] The findings demonstrated that the LYC3 group's pigment contents, crude protein, crude lipid, and chromatic values were comparable to those of the LYC1 group ($p > 0.05$). There was no significant difference between the LYC1 and LYC5 groups' mucus superoxide dismutase (SOD) and catalase (CAT) activities ($p > 0.05$). The alkaline phosphatases (ALP), acid phosphatases (ACP), and lysozyme (LYS) activities of the mucus in the LYC1 group were not significantly different from the LYC3 group ($p > 0.05$). The back skin mRNA expressions of tyrosinase (*tyr*), tyrosinase-related protein 1 (*tyrp1*), dopachrome tautomerase (*dct*), microphtalmia-associated transcription factor (*mitf*), and melanocortin 1 receptor (*mc1r*) were significantly up-regulated in the LYC2 and LYC4 groups compared to the LYC1, LYC3, and LYC5 groups ($p < 0.05$). Forkhead box d3 (*foxd3*), paired box 3 (*pax3*), purine nucleoside phosphorylase 4a (*pnp4a*), aristaless-like homeobox 4a (*alx4a*), cAMP dependent protein kinase (*pka*), anaplastic lymphoma kinase (*alk*), leukocyte receptor tyrosine kinase (*ltk*), and colony stimulating factor (*fms*) were among the mRNA expressions of the abdominal skin in the LYC1, LYC3, and LYC5 groups significantly higher than those in the LYC2 and LYC4 groups ($p < 0.05$). [Conclusion] In conclusion, the LYC3 group's crude protein, crude lipid, carotenoid, and lutein contents were most similar to those of the large yellow croaker found in the wild. Furthermore, the molecular mechanism underlying the variations in body color among the various strains of large yellow croakers was

supplied for additional research.

Key words: body composition; mucus biochemical indexes; body color; *Larimichthys crocea*

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不同冻结方式对调味扇贝肉冻藏过程中品质变化的比较

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摘要：为探究不同冻结方式对调味扇贝肉在冻藏过程中品质的影响，以扇贝肉为研究对象，探讨了四种冻结方式（超声辅助浸渍冻结，UIF；浸渍冻结，IF；鼓风冻结，BF；空气冻结，AF）对调味扇贝肉在 - 18 ℃冻藏 0-90 天过程中的持水率、解冻损失、水分分布、色泽、质构及微观结构的影响。UIF 组的冻结效率（335 s、6.05 cm/h）优于 AF 组（3547 s、0.40 cm/h）、BF 组（938 s、1.97 cm/h）。所有组随冻藏时间延长均出现品质劣变，其中 60 - 75 天劣变差异显著。在水分分布上，AF 组不易流动水（T_{22}）弛豫时间从 25.8 ms 上升至 29.82 ms，肌原纤维束缚水能力明显下降；UIF 组 T_{22} 仅从 24 ms 轻微上升至 25.8 ms，且自由水相对含量（M_{23}）增幅远低于 AF 组。此外，在质构方面，AF 组弹性、内聚性在此阶段明显下降，肌原纤维开始崩塌，UIF 组无明显变化。微观结构上，75 d 时 AF 组聚集体破裂严重，UIF 组仍保持完整。冻藏 90 d 时，UIF 组解冻损失为 2.45%（AF 组为 4.11%），且肌原纤维结构完整。这表明 UIF 可有效延迟关键节点的品质劣变，为工艺优化提供支撑。

关键词：冻结方式；调味扇贝肉；冻藏；品质变化

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基于汽爆法制备鲢鱼皮骨原生钙螯合 ACE 抑制肽及其筛选鉴定

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摘要：为实现鲢鱼加工副产物的高价值利用，本研究开发了一种结合蒸汽爆破和逐步酶解的绿色高效方法，以鲢鱼皮骨混合物制备原生钙螯合的 ACE 抑制肽。结果表明，最优酶解条件为碱性蛋白酶初始 pH 10，酶添加量 3000 U/g Pro，酶解时间 4 h；风味蛋白酶添加量 500 U/g Pro，酶解 1 h。此时，风味蛋白酶有效降低了碱性蛋白酶酶解产生的苦味。对最佳工艺下制备的酶解液进行超滤分级后得到分子量＜1 kDa 组分 ACE 抑制率最高（89%），其总钙含量为 1276.28 mg/100g，钙螯合率达 95.79%。LC-MS/MS 鉴定出新型十肽 Leu-Asp-Gly-Ala-Glu-Glu-Leu-Gly-Leu-Ala（LDGAEELGLA，分子量 986.5 Da），其主要通过氢键、疏水相互作用及静电作用等实现对 ACE 活性的高效抑制。本研究为水产加工副产物高值化利用及功能食品的开发提供新思路。

关键词：鲢鱼皮骨；蒸汽爆破；酶解；ACE 抑制肽；原生钙螯合

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鱼糜漂洗废水蛋白回收方法：低电压直流电场法与其他方法

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摘要：鱼糜漂洗废水（SRW）富含水溶性蛋白和化学需氧量（COD），直接排放造成资源浪费和环境污染。本研究比较六种处理方法：热絮凝（H）、酸碱偏移（pH）、壳聚糖絮凝（C）、酸碱偏移耦合壳聚糖絮凝（pHC）、低压直流电场（DC）和恒温低压直流电场（DC-CT），其中 DC 效果最优，蛋白质回收率达 89.97%，COD 去除率为 56.36%。结果表明，电处理显著降低蛋白粒径和 zeta 电位绝对值，增加 β-折叠和二硫键含量。SDS-PAGE 证实二硫键是蛋白聚集的主要驱动力；SEM 显示阳极蛋白形成致密网络结构，阴极蛋白呈无序块状。带电蛋白在电场中发生定向迁移，并在电解产生氧化性物质（·OH、Cl_2）的作用下交联成膜，最终形成漂浮于水面的固体蛋白膜。本研究提供了一种高效且环保的高蛋白废水处理技术。

关键词：鱼糜漂洗废水；低压直流电场；回收蛋白；蛋白质聚集；网络结构；

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海洋生物活性物质阻控食物过敏机制研究

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摘要：【目的】随着全球食物过敏发病率持续快速攀升，现有医学手段难以根治，亟需探索安全有效的防控策略。食品加工技术虽能部分降低过敏原致敏性，但存在局限性，而天然抗过敏活性成分的免疫调节作用为缓解食物过敏提供了新思路。海洋生物资源蕴含丰富的抗过敏物质，但其具体机制尚未系统阐明。【方法】本研究旨在探究海洋来源活性物质（如多酚、多糖、多肽）的抗过敏效果及作用机制，为开发新型抗过敏功能食品提供理论依据。针对上述瓶颈问题，本研究通过体外实验、细胞实验和小鼠动物模型，系统分析海洋动植物（如藻类、鱼类等）中具有抗过敏潜力的活性成分，包括其化学特性、提取方法及作用靶点。重点探讨这些成分通过调控 Th1/Th2 免疫平衡、抑制 IgE 介导的肥大细胞脱颗粒、调节肠道菌群等途径缓解食物过敏的分子机制，并评估其在体外实验、动物模型及临床前研究中的有效性。【结果】研究表明，海藻岩藻多糖可通过增强 Treg 细胞活性抑制过度免疫反应，调节肠道微生物组成，改善过敏症状；多肽（如鱼类和微藻酶解肽）能阻断过敏原与 IgE 结合，减少组胺释放；海藻多酚则通过抗氧化和抗炎作用减轻肠道黏膜损伤。海洋抗过敏功能活性成分在肥大细胞实验和小鼠动物实验中显示出对水产品等常见过敏原的显著缓解效果，且安全性较高。【结论】海洋生物活性物质因其结构多样性和独特作用机制，在缓解食物过敏领域展现出广阔应用前景。然而，其工业化提取、稳定性优化及临床转化仍需突破。未来研究应聚焦于成分协同效应、精准递送系统开发及人群试验验证，以推动海洋抗过敏物质从基础研究走向实际应用，为食物过敏防控提供创新解决方案。

关键词： 食物过敏；海洋食品；生物活性物质；阻控；机制研究

资助项目： 国家自然科学基金（32572710, 32102091）

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The Mechanisms of Marine Bioactive Substances on Controlling Food Allergy

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Abstract: [Objective] As the global prevalence of food allergy continues to rise rapidly, the existing medical approaches are difficult to cure it. It is urgent to explore safe and effective prevention and control strategies. Although food processing technology can partially reduce the allergenicity of allergens, it has limitations, and the immunomodulatory effects of natural anti allergic active ingredients provide new ideas for alleviating food allergies. Marine biological resources contain abundant anti allergic substances, but their specific mechanisms have not been systematically elucidated. [Methods] The aim of this study is to explore the anti-allergic effects and mechanisms of marine derived active substances, such as polyphenols, polysaccharides, and peptides, in order to provide theoretical basis for the development of new anti-allergic functional foods. In response to the bottleneck issues mentioned above, this study systematically analyzed the bioactive substances with anti-allergic potential in marine animals and plants (e.g. algae, fish) through in vitro experiments, cell experiments, and mouse animal models, including their physicochemical characteristics, extraction methods, and targets of action. Focus on exploring the molecular mechanisms by which these components alleviate food allergies through regulating Th1/Th2 immune balance, inhibiting IgE mediated degranulation of mast cells, regulating gut microbiota, and evaluating their effectiveness in in vitro experiments, animal models, and preclinical studies. [Results] Research has shown that algal fucoidan can inhibit excessive immune responses, regulate gut microbiota composition, and improve allergic symptoms by enhancing Treg cell activity; Peptides (e.g. fish and microalgae enzymatic peptides) can block the binding of allergens to IgE and reduce histamine release; Algal polyphenols alleviate intestinal mucosal damage through anti-oxidant and anti-inflammatory effects. Marine anti allergic functional active ingredients have shown significant relief effects on common allergens such as from aquatic foods in mast cell experiments and mouse animal experiments, with high safety. [Conclusion] It can be seen that the active ingredients of marine organisms have broad application prospects in alleviating food allergies due to their structural diversity and unique mechanisms of action. However, breakthroughs are still needed in its industrial extraction, stability optimization, and clinical translation. Future research should focus on the synergistic effects of ingredients, the development of precise delivery systems, and validation through population trials, in order to promote the practical application of marine anti-allergic substances from basic research and provide innovative solutions for food allergy prevention and control.

Key words: Food allergy; Seafood; Bioactive substances; Control; Mechanism study

鱼类主要过敏原小清蛋白的 B 细胞线性表位鉴定及关键氨基酸残基分析

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摘要：目的：基于免疫信息学方案筛选鱼类主要过敏原小清蛋白的 B 细胞线性表位及关键氨基酸残基，并评估其与小清蛋白致敏性的关系。方法：综合运用蛋白质组学、基因组学与免疫组学，对我国常见鱼类的小清蛋白进行分子表征，通过 Clustal W 软件对 92 种鱼类的小清蛋白进行多序列比对，并借助 DNAStar、IEDB 等软件预测 B 细胞线性表位，收集鱼类过敏人群血清，利用竞争性 ELISA 筛选预测表位；利用 BioEdit、DNAman 软件分析表位中氨基酸的频率及保守性，结合表位突变法和竞争性 ELISA 对关键氨基酸残基进行鉴定。结果：研究筛选出 16 个小清蛋白的线性 B 细胞表位，并鉴定其中 4 个氨基酸为关键残基。此外，关联性分析发现表位及特定氨基酸残基的排列位置对致敏性有显著影响。结论：过敏原 B 细胞表位及关键氨基酸残基的高通量鉴定需采用多组学策略，单一组学技术无法满足要求，本研究为揭示鱼类过敏的分子机制及诊断防治提供了理论依据。

关键词：小清蛋白；B 细胞线性表位；关键氨基酸残基；鱼类过敏；免疫信息学

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Identification of IgE Epitopes and Analysis of Critical Amino Acid Residues in Fish Parvalbumin

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Abstract: [Objective] This study aimed to explore the IgE epitopes of parvalbumin (PV) and identify critical amino acid residues, while systematically assessing their connection to the IgE-binding capacity. [Methods] PV from common fish species, which remains unstudied, was first characterized using proteomic, genomic, and immunoinformatic methods. β-PV isoforms from 92 fish species were comparatively analyzed with WEBLOGO and Clustal W, followed by epitope prediction with

DNAStar Protean system, BepiPred 3.0, and IEDB. Validation was subsequently conducted with indirect competitive ELISA. The critical amino acid residues of epitopes were confirmed using the substitution approach and indirect ELISA. [Results] Sixteen linear B-cell epitopes of PV were identified, and four amino acids were confirmed as the critical residues. Furthermore, the study revealed that the distribution and specific residue arrangements of allergenic peptides govern their IgE-binding potency. [Conclusion] High-throughput identification of allergen B-cell epitopes and critical amino acid residues requires multi-omics strategies, as single-omics technologies alone cannot meet the requirements. This study provides a theoretical basis for elucidating the molecular mechanisms of fish allergy and advancing their diagnosis and prevention.

Keywords: Parvalbumin; B-cell linear epitope; Critical amino acid; Fish allergy; Immunoinformatic

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基于喹醛酰氯衍生化策略的高效液相色谱-串联质谱法检测鱼油和南极磷虾油中的氯丙醇

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摘要：为探索更简便、高效的氯丙醇检测方法，本研究旨在开发一种高效、准确的分析方法，用于同时检测南极磷虾油和鱼油中 2-氯-1,3-丙二醇（2-MCPD）和 3-氯-1,2-丙二醇（3-MCPD）。采用喹醛酰氯新型衍生化策略，结合分散式硅胶破乳技术提升提取效率，并通过 UHPLC-MS/MS 进行检测。该方法有效克服了磷脂基质乳化难题，实现了 2-/3-MCPD 的高效提取与快速衍生。在两类油脂中均表现出良好的线性关系、高灵敏度与高回收率，并在实际样品分析中成功检测出 2-/3-MCPD，性能显著优于传统的 GC-MS 技术。本研究已在鱼油、虾油等复杂食品基质中实现了氯丙醇污染的准确分析，并初步揭示了不同基质中氯丙醇污染的分布规律，为后续系统研究其污染成因和形成机制提供了科学依据。研究不仅为复杂油脂中氯丙醇类污染物的监测提供了可靠方法，也为结合态氯丙醇酯的间接测定开辟了新途径，具有重要的方法学与实用价值。

关键词：氯丙醇；衍生化；液质检测；加工污染物；磷虾油

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Development of an HPLC-MS/MS Method with Quinaldoyl Chloride Derivatization for the Detection of Chloropropanols in Fish Oil and Antarctic Krill Oil

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Abstract: To explore a simpler and more efficient detection method for chloropropanols, this study aims to develop an efficient and accurate analytical method for the simultaneous detection of 2-chloro-1,3-propanediol (2-MCPD) and 3-chloro-1,2-propanediol (3-MCPD) in Antarctic krill oil and fish oil. A novel derivatization strategy using quinoline aldehyde acyl chloride was adopted, combined with dispersive silica demulsification technology to improve extraction efficiency, and detection was performed by UHPLC-MS/MS. This method effectively overcomes the emulsification problem of phospholipid matrices and achieves efficient extraction and rapid derivatization of 2-/3-MCPD. It showed good linearity, high sensitivity, and high recovery rate in both types of oils, successfully detected 2-/3-MCPD in actual sample analysis, and its performance was significantly superior to traditional GC-MS technology. This study has achieved accurate analysis of chloropropanol contamination in complex food matrices such as fish oil and shrimp oil, and preliminarily revealed the distribution pattern of chloropropanol contamination in different matrices, providing a scientific basis for subsequent systematic studies on the causes and formation mechanisms of contamination. The research not only provides a reliable method for the monitoring of chloropropanol contaminants in complex oils but also opens up a new approach for the indirect determination of bound chloropropanol esters, with important methodological and practical value.

Keywords: Chloropropanediols; Derivatization; Liquid Chromatography-Mass Spectrometry; Food Processing contamination; Antarctic Krill

基于氧化脂质组学技术的海洋油脂贮藏过程中的品质变化研究

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摘要：海洋油脂富含多不饱和脂肪酸（PUFAs），贮藏中易氧化生成多种氧化脂质。氧化脂质种类多、异构体复杂，分析难度大，传统方法难以实现多维度氧化产物的同步精准监控。本研究旨在建立氧化脂质组学分析方法，并系统比较不同海洋油脂在贮藏过程中的脂质氧化差异与转化规律。基于 UPLC-MS/MS 技术，构建了覆盖氧化脂肪酸（oxFAs，约 50 种）、氧化磷脂（oxPLs，135 种）、氧化甘油酯（oxTGs，100 余种）及氧化胆固醇酯（oxCEs，20 种）的高灵敏分析方法。结果表明，40℃贮藏 14 天后，EPA-oxFAs 以及 oxPE 的含量最高，且在海参油中首次检出缩醛型氧化磷脂。本研究发现环氧与多氧型氧化脂质的比值随贮藏时间呈指数衰减（$y = 6.27 \cdot e^{-0.025x} + 4.76$），可作为油脂的氧化新指标，且氧化脂质间存在相互转化关系。本研究为海洋油脂品质控制与氧化监控提供了重要的分析策略和理论依据。

关键词：海洋油脂；液相色谱-质谱联用；氧化脂质组学；氧化磷脂；氧化脂肪酸

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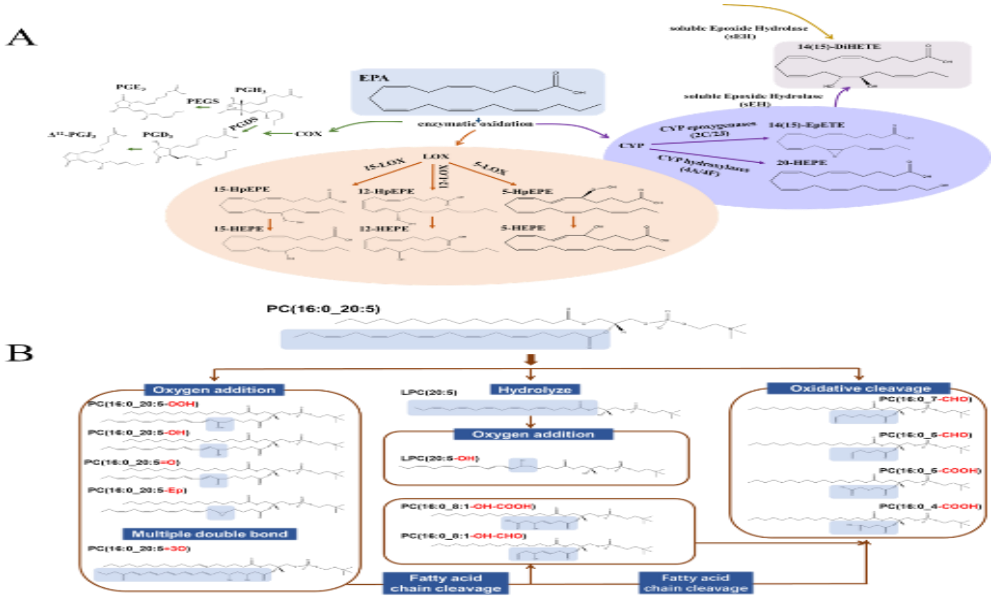

海洋水产品保鲜加工领域的相关研究

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摘要：目的应对海产品因高营养、中性 pH 和高水分含量而导致的极易腐坏的特性，旨在防止腐败、维持其高品质并延长货架期，最终满足消费者对优质海鲜日益增长的需求。方法采用了从“捕捞到消费”的全链条综合技术。核心方法是抑制微生物生长和酶活性，具体包括：低温保鲜、精深加工以及应用现代包装技术。结果通过系统性地应用上述一系列保鲜、加工和包装工艺，有效延缓了海产品的腐败变质速度，显著延长其保质期，从而保障优质海产品稳定可靠的市场供应。结论综上所述，通过在整个供应链中综合运用规范处理、科学保鲜、精深加工和现代包装等关键技术，海鲜行业能够成功克服其产品易腐的天然缺陷，最终实现保障品质安全和满足消费期望的双重目标。

关键词：极易腐坏；全链条综合技术；延长货架期；品质安全

Advances in Marine Seafood Preservation and Processing Techniques

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Abstract: Objective: This study aims to address the highly perishable nature of seafood, which results from its high nutritional value, neutral pH, and high moisture content. The primary goals are to prevent spoilage, maintain high quality, extend shelf life, and ultimately meet the growing consumer demand for premium seafood products. Methods:An integrated "catch-to-consumption" approach was employed, focusing on inhibiting microbial growth and enzymatic activity. Key techniques included low-temperature preservation, advanced processing, and modern packaging technologies. Results: The systematic application of these preservation, processing, and packaging methods effectively delayed the rate of seafood spoilage, significantly extended its shelf life, and ensured a stable and reliable supply of high-quality seafood to the market. Conclusion: In summary, by comprehensively implementing critical technologies such as standardized handling, scientific preservation, advanced processing, and modern packaging across the entire supply chain, the seafood industry can successfully overcome the inherent perishability of its products, thereby

achieving the dual objectives of ensuring quality safety and meeting consumer expectations.

Keywords: High perishability; Integrated whole-chain technology; Shelf-life extension; Quality and safety

玉米淀粉预糊化温度对罗非鱼肌原纤维蛋白乳液凝胶特性与 3D 打印性能的影响

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摘要：本研究分析不同预糊化温度（25、40、60、80、100 ℃）的玉米淀粉（corn starch，CS）对罗非鱼肌原纤维蛋白（myofibrillar proteins，MP）乳液凝胶特性和 3D 打印性能的影响。结果表明，CS 预糊化温度的增加能够显著提高乳液凝胶的储能模量（G′）与表观黏度，特别是当添加 CS 的预糊化温度为 60 ℃（CS60）时。拉曼光谱分析结果显示 MP 与预糊化 CS 之间不存在共价相互作用。凝胶作用力分析结果表明，乳液凝胶分子间主要维持作用力为氢键和疏水相互作用，这表明添加预糊化 CS 溶出的 CS 分子能够与 MP 在分子间相互作用力的作用下形成更加紧密的三维网络结构。此外，3D 打印效果显示，CS 预糊化温度的增加提高了乳液凝胶的质构特性，特别是在 CS60 时表现出了最佳的打印精度。本研究提出了预糊化 CS 改善 MP 乳液凝胶特性的可能内在机理，为预糊化 CS 在改善 MP 乳液凝胶特性及 3D 打印性能方面提供了一定的理论参考。

关键词：玉米淀粉；预糊化温度；乳液凝胶；凝胶特性；3D 打印

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Effect of Corn Starch Pregelatinization Temperature on Gel Properties and 3D Printing Performance of Tilapia Myofibrillar Protein Lotion

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Abstract: This study investigated the effects of pregelatinized corn starch (CS) at varying temperatures (25, 40, 60, 80, and 100 °C) on the gel properties and 3D printing performance of tilapia myofibrillar protein (MP) emulsions. The findings demonstrated that increasing the pregelatinization temperature of CS significantly enhanced both the storage modulus (G′) and apparent viscosity of the emulsion gel. The most pronounced improvement was observed when the pregelatinization temperature of CS was 60°C (CS60). Raman spectroscopy analysis indicated that no covalent interactions were formed between MP and pregelatinized CS. Gel strength analysis further revealed that hydrogen bonding and hydrophobic interactions were the dominant intermolecular forces stabilizing the emulsion gel. This suggests that the starch molecules released from pregelatinized CS can form a denser three-dimensional network with MP through these non-covalent interactions. In addition, the 3D printing results showed that higher CS pregelatinization temperatures improved the texture of the emulsion gel, with CS60 exhibiting the highest printing precision. Overall, this study elucidated the underlying mechanism whereby pregelatinized CS enhances the properties of MP-based emulsion gels and provides a theoretical basis for optimizing MP gel performance and 3D printability through starch modification.

Key words: corn starch; pregelatinized temperature; lotion gel; gel characteristics; 3D printing

热处理抗性玉米淀粉对肌原纤维蛋白复合乳液凝胶性能及 3D 打印特性的影响

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摘　要：本研究旨在探讨不同热处理温度（25、40、60、80、100 ℃）的抗性玉米淀粉（Resistant Corn Starch, RCS）对罗非鱼肌原纤维蛋白（Myofibrillar Proteins, MP）乳液凝胶流变性能、粒径分布、微观结构、离心稳定性、拉曼光谱及 3D 打印特性的影响。结果表明，不同热处理的 RCS 通过调控疏水相互作用显著影响乳液凝胶的流变特性与结构稳定性。当 RCS 热处理温度为 40 ℃时，RCS 适度溶胀，乳液凝胶具有最佳性能，表现出假塑性流体行为、高弹性及均匀粒径分布，其表观黏度、储能模量（G'）、触变恢复率显著提升，粒径分布更趋均匀，凝胶网络结构与稳定性增强，3D 打印挤出性和自支撑性优异，负载虾青素后仍能保持清晰结构。拉曼光谱分析证实，凝胶网络的形成主要依赖疏水作用力，无共价键参与。然而，当 RCS 热处理温度超过 60 ℃时，RCS 直链淀粉浸出，表观黏度、剪切应力下降。本研究揭示了热处理温度调控 RCS 影响 RCS-MP 乳液凝胶的形成机制，明确了 40 ℃是流变特性与 3D 打印性能的最佳处理温度，为开发高精度、个性化 3D 打印食品级油墨提供了重要理论依据，拓展了抗性淀粉在功能食品中的应用潜力。

关键词：抗性玉米淀粉，热处理，乳液凝胶，凝胶性能，3D 打印

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Effect of Heat Treated Resistant Corn Starch on Gel Properties and 3D Printing Properties of Myofibrillar Protein Composite Lotion

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Abstract: The present study investigated the effects of resistant corn starch (RCS) heat-treated at various temperatures (25, 40, 60, 80, and 100 ℃) on tilapia myofibrillar protein (MP) emulsion gel viscoelastic properties, particle size distribution, microstructure, centrifugal stability, Raman spectroscopy and three-dimensional (3D) printing characteristics. The results showed that the RCS heat-treatment temperature significantly modulated the hydrophobic interactions, thereby affecting the emulsion gel rheology and structural stability. At 40 ℃, the RCS swelled moderately, yielding the optimal emulsion gel performance: pseudoplastic behavior, high elasticity, and uniform particle size distribution. Apparent viscosity, storage modulus (G'), thixotropic recovery rate, and particle size uniformity increased significantly, thus enhancing the gel network structure and stability. This formulation exhibited excellent 3D printing extrudability and self-supporting ability, maintaining its structural integrity even after astaxanthin loading. Raman spectroscopy revealed that hydrophobic forces primarily governed gel network formation without covalent bond involvement. Temperatures of >60 ℃ caused amylose leaching, consequently decreasing apparent viscosity and shear stress. Collectively, this study elucidated the mechanism through which heat-treatment temperature regulates RCS to influence RCS-MP emulsion gel stability. The findings showed that 40 ℃ was the optimal temperature for enhancing rheology and 3D printing performance, thereby providing a crucial theoretical basis for developing high-precision, personalized 3D printing food-grade inks and expanding RCS applications in functional foods.

Key words: resistant corn starch; heat treatment; emulsion gel; gel properties; 3D printing

3D Printability of Lysine-Modified Myofibrillar Protein Emulsions

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Abstract: This study explores the potential of lysine (Lys) and tilapia myofibrillar protein (MP) composite particles in the formulation of highly inwardly directed emulsions (HIPEs). Infrared spectroscopy, potentiometric analysis, and molecular docking studies re-vealed that the interaction between Lys and MP is primarily governed by hydrogen bonding and electrostatic forces. The incorporation of Lys significantly influenced the particle size, secondary and tertiary structures, solubility, and turbidity of MP. Lys-MP stabilised HIPEs can form highly stable denser self-supporting gel network structures. Rheological analysis of the HIPEs stabilised by MP showed low energy storage modu-lus (G' 110.66 Pa) and water-oil separation, therefore preventing the 3D printing. However, HIPEs stabilised by Lys (especially 1.5 wt%) significantly improved energy storage modulus (G' 1002.10 Pa), increased viscoelasticity and thixotropic recovery, and reduced droplet size (10.84 μm), facilitating the use of HIPEs inks for 3D printing. Furthermore, HIPEs stabilised with 1.5 wt% Lys-MP demonstrated superior print ac-curacy (91.36%), resolution, and clarity in 3D printing applications. Overall, these findings offer a promising strategy for developing

Lys-MP composite parti-cle-stabilised HIPEs tailored for advanced 3D printing technologies.

Key words: Lysine; Myofibrillar protein; HIPEs; 3D printability

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Sous vide 对南美白对虾肌原纤维蛋白结合两种风味化合物（琥珀酸与 1-辛烯-3-醇）能力的影响

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摘要：本研究采用光谱学与分子对接技术，探究不同真空低温蒸煮（Sous vide，SV）加工组合下南美白对虾肌原纤维蛋白（MP）与琥珀酸、1-辛烯-3-醇的结合力、吸附作用及蛋白构象变化。结果显示，与新鲜组相比，无论是否添加风味物质，SV 处理组 MP 均呈表面疏水性增强、粒径增大的趋势，且趋势因风味物质种类而异，表明 SV 加工与风味物质种类均影响 MP 构象。SV 加工过程中，分子间作用力由离子键、氢键主导转为疏水相互作用主导。光谱结果证实，SV 加工中虾 MP 主要发生集聚；MP 与琥珀酸间存在氢键和静电相互作用，与 1-辛烯-3-醇间存在氢键；新鲜 MP 对琥珀酸吸附强于 1-辛烯-3-醇，该吸附关系随 SV 加工逆转。且随加热程度增加，热处理对 MP 构象变化的影响大于风味物质种类。分子对接明确，赖氨酸、苯丙氨酸是 MP 与两种风味物质的主要结合位点。本研究为 SV 加工中改善南美白对虾风味提供理论依据。

关键词：南美白对虾；肌原纤维蛋白；真空低温烹调；分子对接；风味吸附特性

Effects of α,β-Unsaturated Aldehydes on the Structural, Oxidative, and Digestive Properties of Oyster Protein during Thermal Processing

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Abstract: Objective: This study aims to systematically investigate the effects of α,β-unsaturated aldehydes on the oxidative modification, conformational alterations, and digestive behavior of oyster protein.Methods: The effects of 10 various α,β-unsaturated aldehydes on the physical state, surface hydrophobicity, secondary structure, oxidative cross-linking, amino acid composition, and protein digestibility of MP were analyzed. Next, two α,β-unsaturated aldehydes most significantly affecting MP's oxidative damage and digestibility were chosen to examine oxidative modification, conformational alterations and digestive behavior of oyster sarcoplasmic protein (SP), myofibrillar protein (MP), and collagen (CO).Results: Aldehyde treatment altered the SP, MP and CO conformation, characterized by increased hydrophobicity, decreased fluorescence intensity and reduced solubility. These structural changes coincided with enhanced protein oxidation, depletion of free amino and sulfhydryl groups, and loss of total and essential amino acids. Furthermore, aldehyde-modified SP, MP and CO showed reduced in vitro gastrointestinal digestibility, lower hydrolysis degree, and altered molecular weight distribution. In monoenal series (C3-C10), oxidative aggregation displayed a decreasing-then-increasing trend with chain length, while conjugated dienals generally caused greater oxidative damage and digestibility loss than monoenals. Among all 10 various α,β-unsaturated aldehydes, acrolein exerted the strongest oxidative and digestive impacts on MP, followed by trans,trans-2,4-decadienal. In addition, acrolein and

trans,trans-2,4-decadienal exerted the most pronounced effects on structural changes, oxidative damage, and digestibility of SP rather than MP, whereas CO exhibited the weakest oxidative damage and strongest resistance to digestion.Conclusion: These findings reveal the structure-activity relationships of lipid oxidation-derived α,β-unsaturated aldehydes and their detrimental impacts on seafood protein quality and nutritional value, with implications for processing strategies.

Key words: oyster; protein; α,β-unsaturated aldehydes; oxidation; digestibility

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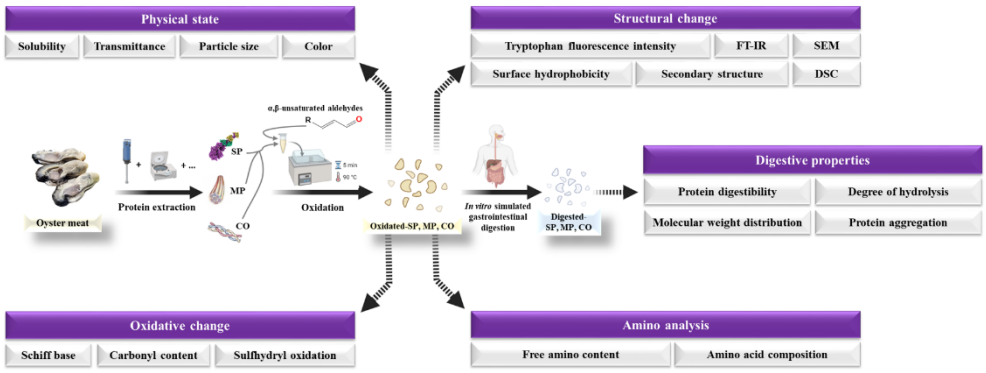

青柳蛤活性肽对小鼠急性酒精性肝损伤的预防作用及机制研究

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摘 要：目的: 以青柳蛤为原料制备活性肽，评价其预防酒精性肝损伤的作用，并阐明潜在机制。以期为解酒护肝功能性产品的开发利用提供参考。方法 酶解法制备青柳蛤肽（MCP），建立小鼠急性酒精性肝损伤模型，从行为学、生化指标、氧化应激、脂代谢、炎症及肠道菌群等角度评估其保护作用。并通过分离纯化和分子对接筛选活性肽段。结果 碱性蛋白酶酶解 12 h 的 MCP 对 ADH 激活率最高且富含小分子肽；MCP 可减轻小鼠醉酒症状、调节 ALT/AST 与 ADH/ALDH 活性，缓解氧化应激、脂质积累、炎症并改善肠道菌群；分离得到的 TLW 和 KLPL 肽段表现出较强 ADH 激活和抗氧化作用；分子对接验证其与 ADH 结合稳定。结论 MCP 可显著缓解 ALD，其机制可能与激活 ADH 活性、抗氧化、调节脂代谢、减轻炎症及改善肠道菌群有关。

关键词：青柳蛤；生物活性肽；酒精性肝损伤；肠道稳态；分子对接

Study on the preventive effect and mechanism of active peptides derived from *Mactra chinenesis* on acute alcoholic liver injury in mice

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Abstract: Objective：To prepare bioactive peptides from the Mactra chinensis and evaluate their preventive effects against alcoholic liver injury (ALD), elucidating potential mechanisms to inform the development of hangover-relief and hepatoprotective functional products. Methods：Mactra chinensis peptides (MCP) were prepared by enzymatic hydrolysis and an acute alcohol-induced liver injury mouse model was established. The protective effects of MCP were assessed on behavioral signs of intoxication, biochemical markers, oxidative stress, lipid metabolism, inflammatory responses, and gut microbiota. Active peptide fractions were isolated and purified, and candidate peptides were screened by molecular docking. Results：MCP produced by alkaline protease hydrolysis for 12 h exhibited the highest alcohol dehydrogenase (ADH) activation and was enriched in low-molecular-weight peptides. MCP alleviated intoxication behaviors, modulated

serum ALT/AST and hepatic ADH/ALDH activities, attenuated oxidative stress, lipid accumulation and inflammatory responses, and improved alcohol-induced gut microbiota dysbiosis. Isolated peptides TLW and KLPL showed strong ADH-activating and antioxidant activities, and molecular docking indicated stable binding to ADH. Conclusion:MCP markedly ameliorates acute ALD, likely via ADH activation, antioxidant activity, regulation of lipid metabolism, anti-inflammatory effects, and restoration of gut homeostasis.

Keywords: Mactra chinensis; bioactive peptides; alcoholic liver injury; gut homeostasis; molecular docking

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不同种类鲈鱼鱼肉品质差异的研究

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摘　要：为研究冷水鲈鱼与淡水鲈鱼鱼肉品质差异，选择冷水鱼锦源鲈鱼与安福鲈鱼和淡水鲈鱼进行取样，分析其营养成分、鲜度、脂肪酸、质地和风味的差异。结果显示： 鱼肉营养成分方面，冷水鱼锦源鲈鱼鱼肉具有较高的蛋白含量（17.50g/100g），冷水鱼锦源鲈鱼与安福鲈鱼鱼肉中脂肪含量显著低于淡水鲈鱼，安福鲈鱼鱼肉中脂肪含量仅为淡水鲈鱼的47.7%。鱼肉质地方面，熟制冷水鱼锦源鲈鱼与安福鲈鱼鱼肉中硬度、 弹性、韧性、粘着性和咀嚼性显著高于淡水鲈鱼；鱼肉营养成分方面，淡水鲈鱼有较低的饱和脂肪酸，较高的多不饱和脂肪酸，冷水鱼锦源鲈鱼有较高的单不饱和脂肪酸；风味方面，GC-IMS 表明了三种鲈鱼鱼肉共检测到包括醛类、醇类、酮类、酯类、烃类以及酚类化合物等 47 种挥发性风味物质，但三种鲈鱼鱼肉之间挥发物类型和浓度存在显著的差异。本研究结果表明，两种冷水鲈鱼具有高蛋白质低脂肪的特点。淡水鲈鱼富含优质脂肪酸。

关键词：HS-GC-IMS；冷水鱼；鲈鱼；品质；挥发性有机化合物

Research on the Quality Differences of Fish Meat among Different Kinds of Sea Bass

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Abstract: To study the differences in meat quality between cold-water perch and freshwater perch, samples of Jin Yuan perch (a cold-water fish), Anfu perch (a cold-water fish), and freshwater perch were collected and analyzed for their nutritional components, freshness, fatty acids, texture, and flavor. The results showed that in terms of nutritional components, the meat of Jin Yuan perch had a higher protein content (17.50g/100g), and the fat content in the meat of Jin Yuan perch and Anfu perch was significantly lower than that of freshwater perch. The fat content in the meat of Anfu perch was only 47.7% of that in freshwater perch. Regarding texture, the hardness, elasticity, toughness, adhesiveness, and chewiness of the cooked meat of Jin Yuan perch and Anfu perch were

significantly higher than those of freshwater perch. In terms of nutritional components, freshwater perch had a lower content of saturated fatty acids and a higher content of polyunsaturated fatty acids, while Jin Yuan perch had a higher content of monounsaturated fatty acids. In terms of flavor, GC-IMS analysis detected 47 volatile flavor substances including aldehydes, alcohols, ketones, esters, hydrocarbons, and phenolic compounds in the meat of the three types of perch. However, there were significant differences in the types and concentrations of volatile substances among the three types of perch. The results of this study indicated that the two cold-water perches had the characteristics of high protein and low fat, while freshwater perch was rich in high-quality fatty acids.

Keywords: HS-GC-IMS; cold-water fish; perch; quality; volatile organic compounds

基于 SPME-GC-MS 和 GC-IMS 多维度分析红酸汤-草鱼块共发酵过程中挥发性风味化合物的变化规律

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摘　要：采用圣女果红酸汤与草鱼协同发酵，以红酸汤风味转化草鱼腥味，开发新型鱼发酵产品。本研究采用电子鼻、HS-SPME-GC-MS 与 GC-IMS 多维技术策略，对红酸汤-草鱼共发酵不同时期（0、2、4、8、12 d）鱼肉的挥发性成分进行定性定量追踪，以阐明其风味演变机制。结果表明：HS-SPME-GC-MS 鉴定出的 160 种挥发性化合物中共有 25 种 OAV＞1 和 54 种 VIP＞1，进一步筛选出 8 种（辛醛、异戊醇、丁香酚和苯甲醛等）作为影响草鱼块特殊风味的香气化合物。GC-IMS 技术共确定了 56 种挥发性风味物质，主要包括醇类、酯类、酮类、醛类、萜烯类、芳香类化合物等。综上，本研究通过监测共发酵过程中香气组分的演变，以确定最佳风味窗口与产品安全性，为发酵鱼的品质控制与工业化生产提供了关键数据与理论参考。

关键词：HS-GC-IMS；HS-SPME-GC-MS；发酵鱼；红酸汤；挥发性有机化合物

Multidimensional Analysis of Volatile Flavor Compound Dynamics During Co-Fermentation of Red Fermented Soup and Grass Carp Chunks Using SPME-GC-MS and GC-IMS

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Abstract: A novel fermented fish product was developed by synergistically fermenting cherry tomato red sour soup with grass carp, utilizing the flavor of the red sour soup to mask the fishy odor of the grass carp. This study employed a multidimensional technological strategy, combining an electronic nose, HS-SPME-GC-MS, and GC-IMS, to qualitatively and quantitatively track volatile components in fish meat at different stages (0, 2, 4, 8, 12 days) of co-fermentation with red sour

soup, elucidating the flavor evolution mechanism. Results indicate that among the 160 volatile compounds identified by HS-SPME-GC-MS, 25 exhibited an OAV greater than 1 and 54 showed a VIP greater than 1. Further screening identified 8 compounds (octanal, amyl alcohol, eugenol, benzaldehyde, etc.) as aroma compounds influencing the distinctive flavor of grass carp chunks. GC-IMS technology identified 56 volatile flavor compounds, primarily comprising alcohols, esters, ketones, aldehydes, terpenes, and aromatic compounds. In summary, this study monitored the evolution of aroma components during co-fermentation to determine the optimal flavor window and product safety, providing critical data and theoretical references for quality control and industrial production of fermented fish.

Keywords: HS-GC-IMS；HS-SPME-GC-MS；Fermented fish; Red Sour soup; Volatile organic compounds

Absorption patterns of fucoidan oligosaccharides from *Kjellmaniella crassifolia* in the Caco-2 monolayer cell model and their pharmacokinetics in mice

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Abstract: In this study, fucoidan oligosaccharides were obtained through acid degradation and Bio Gel column separation. By analyzing the chemical composition and molecular weight, oligosaccharides with smaller molecular weights and simpler monosaccharide compositions were selected for further research. A cell model and pharmacokinetics studies in mice were established to analyze the absorption patterns of the oligosaccharides. The results showed that after acid degradation and column separation, the oligosaccharides SPF1 with a molecular weight range of 1.63×10^4 to 2.14×10^5 Da and the oligosaccharides SPF2 with a molecular weight range of 244.22 to 1545.36 Da were obtained. In cell transport and uptake experiments, the transport of SPF1 and SPF2 was positively correlated with time and negatively correlated with concentration. The transport rates of SPF1 and SPF2 ranged from 20% to 70%, with *Papp* values greater than 1×10^{-5} cm/s. In the pharmacokinetics study, the blood concentration of the oligosaccharides in mice was simulated and analyzed using DAS 2.0, which indicated that the fucoidan oligosaccharides exhibited good absorption characteristics *in vivo* and *in vitro*. Therefore, fucoidan oligosaccharides with smaller molecular weights are more easily absorbed, which provides a theoretical basis for the application of fucoidan oligosaccharides.

Key words: Fucoidan Oligosaccharides; Structural Analysis; Column separation; Bidirectional transmembrane transport

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基于多组学与机器学习分析水产品脂质与蛋白质交互氧化及氧化潜在路径---以风干带鱼为例

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摘要：了解水产品脂质与蛋白质的交互氧化对于水产品加工至关重要。本研究基于多组学与 7 种机器学习模型结合，探讨带鱼风干过程中脂质和蛋白氧化的相互作用机制。应用具有梯度惩罚的 Wasserstein 生成对抗网络（Wasserstein Generative Adversarial Network with Gradient Penalty，WGAN-GP）进行数据增强，解决小样本限制问题。确定了 6 种氧化生物标志物：受体表达增强蛋白 6 样、谷胱甘肽-S 转移酶 1 样、过氧化物酶体生物发生因子 19、蛋白-谷氨酰胺-谷氨酰转移酶 2 样异构体 X2、dMePE（18:4/16:0）和 PE（20:1/18:1）。分析了氧化生物标志物的潜在路径，主要涉及铁死亡和蛋白激酶 A 途径。潜在氧化路径表明，通过谷氨酰转移酶 2 形成的凝胶网络促进脂质-蛋白质相互作用氧化。这项研究为控制水产品中的氧化作用提供了新的分子靶标和理论见解。

关键词：多组学；机器学习；氧化生物标志物；脂质氧化；蛋白质氧化

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A study based on the connection between lipidomics and volatiles to examine the mechanism of lipid oxidation in Antarctic Krill (*Euphausia superba*) during storage after the addition of tea polyphenols

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Abstract : Antarctic krill meal is abundant in unsaturated fatty acids; nevertheless, its vulnerability to oxidation limits its use in functional foods. This study utilized gas chromatography-ion mobility spectrometry to observe alterations in volatile components throughout the storage of krill meal after the addition of TP, while performing qualitative and quantitative lipid analysis by lipidomics. A total of 88 volatile chemical compounds and 4,152 lipid molecules were detected. Chemometric study found 20 volatile organic molecules as distinguishing factors. Compared to the CK-0 d sample, 69 DALs in the CK-30 d sample had strong overexpression with high abundance, while 104 DALs were found at low levels and were markedly downregulated. Following the inclusion of TP, the TP-P group exhibited 108 DALs (75 up-regulated, 33 down-regulated), but the TP-M group comprised only 87 DALs (45 up-regulated, 42 down-regulated). The reduction in the quantity and variety of DALs suggests that the addition of TP exerts an inhibitory effect on lipid oxidative changes, particularly when applied through mincing. KEGG pathway enrichment study indicated that the oxidation of krill meal during storage was promoted by the metabolism of glycerophospholipids and sphingolipids. The incorporation of tea polyphenols impeded glycerophospholipid and sphingolipid metabolism during the storage of krill meal, especially when introduced through mincing.

Key words : Antarctic krill meal, Lipid oxidation, Lipidomics, Volatile compounds

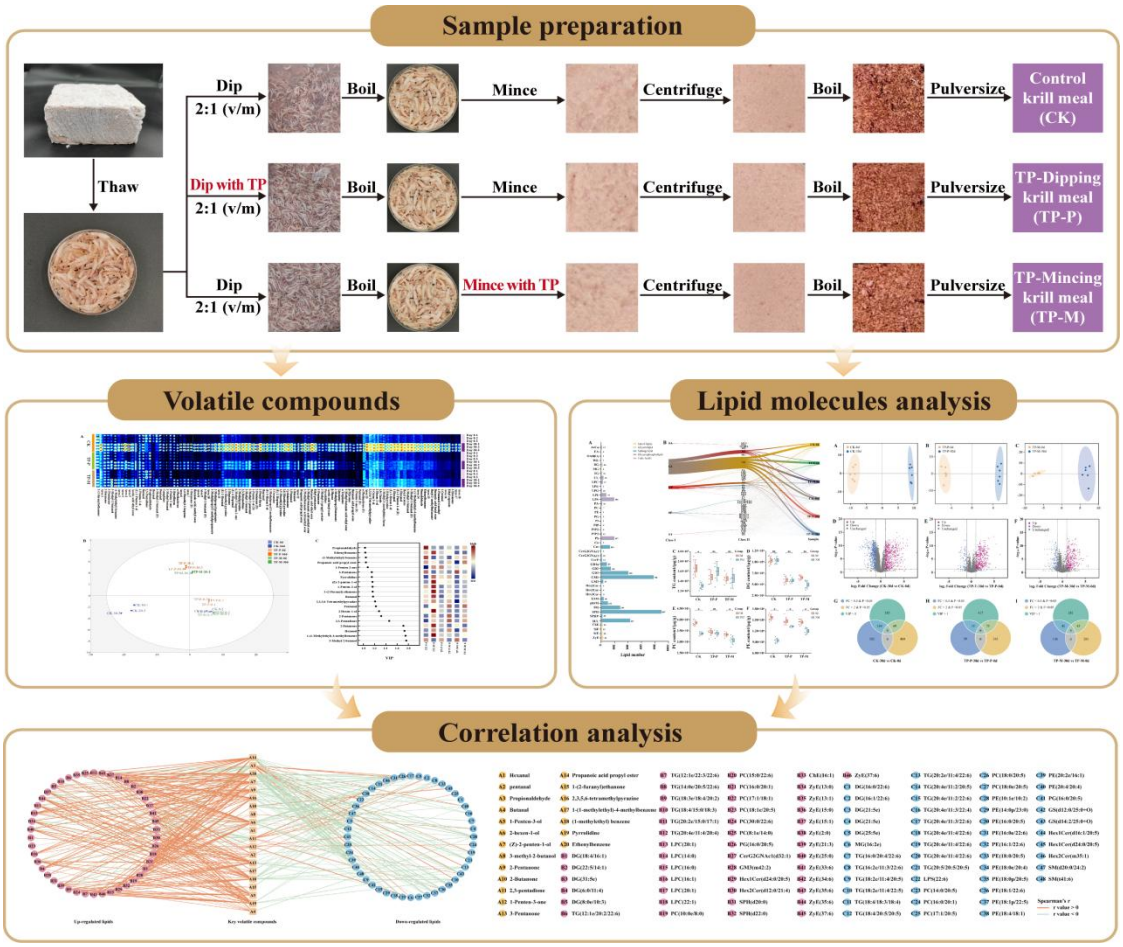

Fig. 1 . Graphic abstract

生态冰温诱导休眠方式太平洋牡蛎营养成分、能量代谢和氧化应激的影响

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摘要：为探究预冷法在无水保存中的作用及温度胁迫对牡蛎氧化损伤与能量代谢的影响，并筛选更优的低温胁迫方法。采用急速降温(AC)、散冰降温(DC)和梯度降温(GC)三种冰温诱导休眠法对活牡蛎进行保存，并通过基础营养成分、代谢状态及氧化应激指标评估不同冷胁迫方式对乳牡蛎的损伤程度。梯度降温保存 10 天的牡蛎存活率、粗蛋白和粗脂肪含量均高于急速降温组和散冰降温组，各组抗氧化酶活性与总胆汁酸（TBA）含量在储存期间持续升高，GC 组糖原消耗量显著高于 AC 组（$P<0.05$），GC 组乳酸升高量显著低于急速和冰层冷却组（$P<0.05$）。结论：梯度降温诱导牡蛎进入生态冰温休眠状态，该方法可降低牡蛎的抗氧化酶活性和脂质过氧化水平，延长牡蛎存活时间，减少物质消耗的能量代谢需求，更有利于牡蛎在无水环境中长期存活。

关键词：太平洋牡蛎；诱导休眠；氧化损伤；能量代谢

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Effects of ecological ice temperature on nutrient composition, energy metabolism and oxidative stress in Pacific oysters

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Abstract :Objective: To investigate the effects of precooling methods of anhydrous preservation and

temperature stress on their oxidative immune system, and energy substance metabolism, and to select a better method of low-temperature stress. Methods: The oysters were preserved alive by three ice temperature-induced dormancy methods, namely, acute cooling, bulk ice cooling, and gradient cooling, respectively, and the degree of damage of different cold stress methods on the milky oyster was investigated by the basic nutrient composition, metabolic status, and oxidative stress indexes. Results: The survival rate, crude protein, and crude fat of oysters preserved by gradient cooling for 10d were higher than those of the acute cooling group and bulk ice cooling group, and the moisture content was not much different, and the bulk ice cooling group was slightly higher than the other two groups. The antioxidant enzyme activity and TBA content of oysters in all groups increased throughout the storage period, and the ice than the other two groups ($P<0.05$); the glycogen consumption of the gradient c -cooling group was significantly higher cooling group was significantly lower than that of the acute and ice-cooling groups ($P<0.05$), and the lactic acid content of oysters in all groups increased, and the gradient cooling group was significantly lower than that of the acute and ice-cooling groups ($P<0.05$). Conclusion: The gradient cooling method induced oysters to enter the ecological ice temperature dormant state and then began to live without water, oysters in this method of antioxidant enzyme activity and lipid peroxidation have been reduced, the survival time of the oyster is longer, the energy metabolism of the material consumed less, and it is more conducive to the oyster's long time without water to survive.

Key words: Crassostrea gigas; Induced dormancy; Oxidative damage; Energy metabolism

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基于 16S rRNA 基因测序和蛋白质组学分析太平洋牡蛎（*Crassostrea gigas*）的保活机理

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摘要：关于休眠状态维持及温度调控对牡蛎品质与存活的生理机制，相关研究仍存在显著认知缺口。本研究以 4℃、15℃、急速冷却（AC）及梯度冷却（GC）为处理组，结合 4D-DIA 蛋白质组学与 16S rRNA 测序技术展开分析。结果显示，15℃与 AC 组中高致病性霍乱弧菌及假交替单胞菌属为优势菌群；GC 组可诱导正向蛋白质组响应，通过差异调控 PKC、LRP5/6、V-ATP 酶及 mTOR 通路中 RAS 等关键蛋白，推动牡蛎向能量节约型低代谢状态转变。KEGG 通路分析表明，终点检测时 AC 组氧化代谢相关酶（如乙酰乳酸合成酶 EC 2.2.1.6、天冬氨酸激酶 EC 2.7.2.4 等）丰度显著高于其他组；GO 功能分类显示，差异表达蛋白主要富集于能量代谢、应激响应、DNA 复制及蛋白质合成通路。综上，GC 可抑制致病菌、降低代谢从而延长牡蛎保质期。

关键词：太平洋牡蛎；低温无水保活；诱导休眠；菌相组成；蛋白组学

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Analyzing the preservation mechanism of the Pacific oyster (*Crassostrea gigas*), based on high-throughput 16S rRNA gene sequencing and proteomics

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Abstract:The physiological mechanisms by which preservation dormancy and temperature affect oyster quality and survival are poorly understood. The current study investigated the mechanisms under four segments: 4°C, 15°C, acute cooling (AC), and gradient cooling (GC). Combined 4D-DIA proteomics and 16S rRNA sequencing depicted that 15°C and AC conditions promoted the supremacy of highly pathogenic Vibrio cholerae and Pseudoalteromonas spp. in contrast, GC associated with advantageous proteomics response, including the differential regulation of key proteins like PKC, LRP5/6, V-ATPase, Rheb, and RAS in the mTOR signaling pathway, indicated a modification towards energy conservation hypo-metabolism. KEGG metabolic pathway analysis indicated significantly higher abundance of enzymes associated with oxidation and metabolism (e.g., acetolactate synthase EC 2.2.1.6, aspartate kinase EC 2.7.2.4, tryptophan synthase EC 4.2.1.20, glutaminase EC 3.5.1.2) in the AC groups compared to other treatments at the endpoint. Gene Ontology (GO) functional classification of differentially expressed proteins indicated their primary involvement in energy metabolism, stress response, DNA replication, and protein synthesis. The study concluded that GC is the dominant preservation method, successfully deterring pathogenic deterioration while encouraging a protective metabolic condition results in prolongs oyster shelf life.

Key words: Crassostrea gigas; Low temperature survival; Inducing dormancy; Microbial community; Proteomics

Acknowledgments: The National Natural Science Foundation of China Project (U22A20542).

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贝类熟制品的加工适宜性与品质特征分析

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摘要：为科学评估贝类熟制品的加工适宜性与品质特征，以蚬子为代表，分析其原料的营养物质含量与关键理化指标，并系统评价其熟制加工后的感官品质。原料蚬子肉具有较高的 pH 值（$p<0.05$）和持水性（WHC, $p<0.05$），在熟制加工中，蒸汽蒸制与水煮是两种主要方式。蒸汽蒸制产品能更好地保留其固有的鲜甜主体风味特征，而水煮制产品则鲜味物质流失较多；蒸汽蒸制产品具有最高的鲜味强度值，且在两种加工方式下，蒸汽蒸制产品的鲜味值均较高（$p<0.05$）；水煮制产品的咸味值较蒸汽蒸制高（$p<0.05$）；蒸汽蒸制产品显著高于水煮制产品（$p<0.05$）；此外，蒸汽蒸制比水煮制产品能更好地保持其肉质韧性（硬度值，$p<0.05$）与弹性，展现出更优的质构特性。

关键词：熟制品；贝类；感官特性

Analysis of Processing Suitability and Quality Characteristics of Cooked Shellfish Products

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Abstract: To scientifically evaluate the processing suitability and quality characteristics of cooked shellfish products, this study used clams as a representative sample to analyze the nutrient content and key physicochemical properties of the raw material, along with a systematic assessment of the sensory qualities after cooking. Raw clam meat exhibited higher pH ($p<0.05$) and water-holding capacity (WHC,$p<0.05$). During cooking, steaming and boiling were the two primary methods employed. Steamed products better preserved the inherent umami and sweet flavor profiles, whereas boiled products showed greater loss of umami compounds. Steamed products achieved the highest umami intensity values, and under both cooking methods, the umami values of steamed products were significantly higher ($p<0.05$). Boiled products had higher saltiness values compared to steamed ones ($p<0.05$). Steamed products also demonstrated a more pronounced sweet aftertaste, with significantly higher sweet aftertaste values than boiled products ($p<0.05$).

Additionally, steaming better maintained the texture toughness (hardness value, $p<0.05$) and elasticity of the products, showcasing superior texture characteristics.

Keywords: Cooked products; Shellfish; Sensory properties

新型结构岩藻寡糖资源挖掘及功能评价

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摘要：岩藻寡糖在早期肠道稳态的建立过程中扮演着关键角色[1]。其中，岩藻糖基化母乳寡糖是当前食品领域的研究热点，然而现有研究多集中于少数几种特定结构的岩藻寡糖[2,3]。本研究开发了一种新的岩藻寡糖制备方法，涵盖了如 Galp-α-(1→2)-Fucp 和 Glcp-β-(1→4)-Fucp 等多种结构。系统探讨了包括海藻来源岩藻寡糖对益生菌株生长与代谢的调控作用，并通过体外模拟发酵体系，评估其对婴儿粪便来源的肠道菌群的影响。在细胞实验中，比较了不同结构的岩藻寡糖对肠上皮细胞紧密连接损伤的保护效果。此外，通过幼鼠实验，进一步研究了这些新型岩藻寡糖对生命早期肠道发育的潜在影响。结果表明，岩藻寡糖能够选择性促进多种益生菌株的生长，尤其是双歧杆菌。单分子实时测序显示，岩藻寡糖增加了婴儿粪便菌群中双歧杆菌和乳杆菌的丰度。岩藻寡糖能够减少脂多糖刺激的 RAW264.7 细胞炎症因子的产生，且提升了 Caco-2 细胞中 Claudin-1 等紧密连接蛋白的表达水平。此外，岩藻寡糖诱导了幼鼠血液和回肠组织中高水平的免疫球蛋白 A。综上所述，新型结构岩藻寡糖能够调控早期肠道健康水平，相关结果为进一步揭示其在调节肠道免疫发育中的作用机制奠定了基础。

关键词：岩藻寡糖；褐藻糖胶；双歧杆菌；肠道菌群；肠道免疫

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高压破碎促进石莼可溶性乳化活性组分释出与不溶性藻体微粒化机制研究

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摘要：海藻产量丰富、成本低廉，且含有多种天然活性分子，是食品工业中广泛用于乳液稳定的原料。本研究依据绿色可持续发展的理念，采用物理手段对石莼藻体进行了可溶性组分和不溶性藻体的全资源开发利用。评估了通过高压均质从石莼中提取出的可溶性界面活性组分作为乳化稳定剂的可行性，以及从可溶性组分中分离出的色素蛋白的功能活性。同时，还探究了石莼不溶性藻体的逐级微粒化机制和消化特性。结果表明，随均质压力从 10MPa 增至 80MPa，界面活性物质被逐渐提取出来。通过膜过滤将其中的多糖和蛋白质等大分子浓缩后得到的浓缩组分（ULER），表现出了更强的乳化性能，而色素蛋白在其中起到了主要的乳化稳定作用。通过优化油体积分数（φ）和 pH 值，发现高内相乳液（φ = 0.7–0.8）在 pH 3–7 时表现出优异的粘弹性和稳定性。外源 Ca^{2+}与 ULER 间的强相互作用也可提升乳液的表观黏度和弹性，但同时也可能会影响乳液的网状结构从而降低其稳定性。此外，随均质压力从 80MPa 增至 160MPa，石莼藻体的纤维结构被破碎得更加彻底。和石莼的可溶性组分相比，不溶性藻体在 pH=6–8 时的乳液表现出了更好的粘弹性和稳定性。通过对 ULER 和不溶性藻体稳定的乳液进行体外消化后，二者的游离脂肪酸（FFA%）释放量和释放速率基本相同，其 FFA%最终释放量可达 54%。总体而言，本研究揭示了高压均质技术将石莼转化为食品工业中有乳化稳定剂的潜力，以及其未来在肠道消化中的应用前景。

关键词：石莼；乳化特性；消化特性；高压均质

应用理性模块置换策略提升 ACE 抑制肽活性

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摘要:食源性血管紧张素转换酶（ACE）抑制肽的活性依赖于序列特定氨基酸组成，本研究旨在应用理性模块替换策略提升 ACE 抑制肽活性。通过数据分析从海参水解物中筛选天然肽 MFPWP，其对 ACE 的半抑制浓度（IC_{50}）值为 10.96 ± 0.48 μM。分子对接和活性测定表明，在 MFPWP 序列中，MF 和 FP 分别是其 ACE 抑制活性的低贡献和高贡献二肽模块。为了替换低贡献模块同时保留高贡献模块，对“XF”组合的二肽模块进行系统评估，结果表明 CF、TF、VF 和 PF 是潜在高贡献模块。基于模块置换获得 CFPWP、TFPWP、VFPWP 和 PFPWP，其 ACE 抑制活性相较原始序列 MFPWP 提高 21.30%-67.07%，且通过调控一氧化氮和内皮素水平发挥细胞降血压功效。本研究证明模块置换是提高功能肽活性的有效策略，并为 ACE 抑制肽序列中的模块效应提供了创新性见解。

关键词：ACE 抑制肽；模块置换；活性提升策略；分子模拟对接；降血压作用

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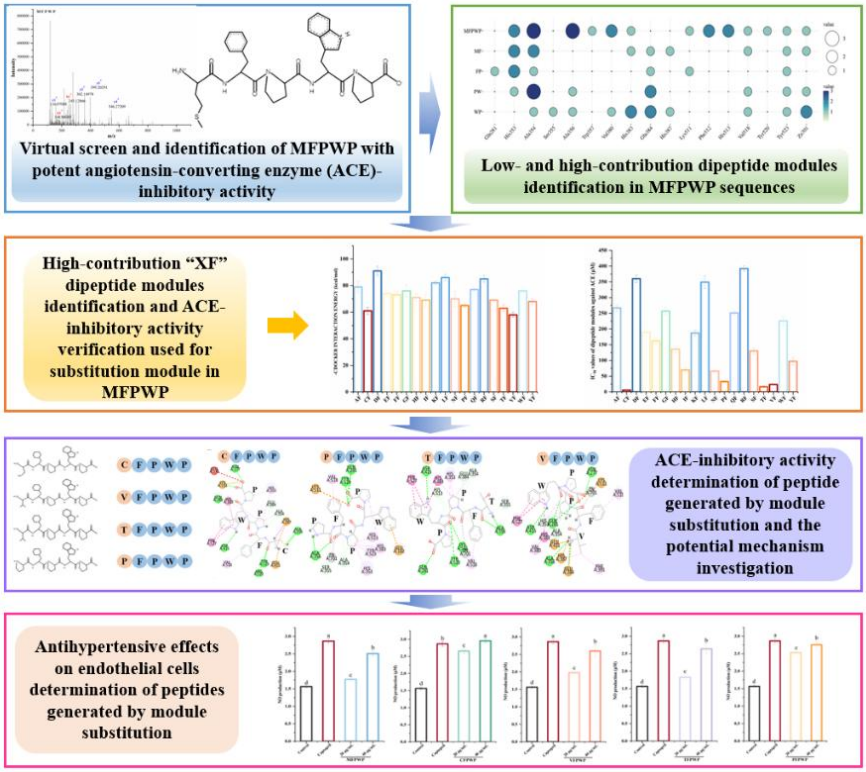
资助项目: 山东省重点研发计划（2022CXGC020414）；山东省海洋养殖创新创业共同体项目（YZ2024002 和 YZ2024004）；青岛市关键技术研发项目（25-1-1-gjgg-53-hy）。


Virtual screen and identification of MFPWP with potent angiotensin-converting enzyme (ACE)-inhibitory activity
Low- and high-contribution dipeptide modules identification in MFPWP sequences
High-contribution "XF" dipeptide modules identification and ACE-inhibitory activity verification used for substitution module in MFPWP
ACE-inhibitory activity determination of peptide generated by module substitution and the potential mechanism investigation
Antihypertensive effects on endothelial cells determination of peptides generated by module substitution

细菌胞外多糖来源岩藻寡糖的益生潜力及其对空肠弯曲杆菌生长与毒力的抑制作用

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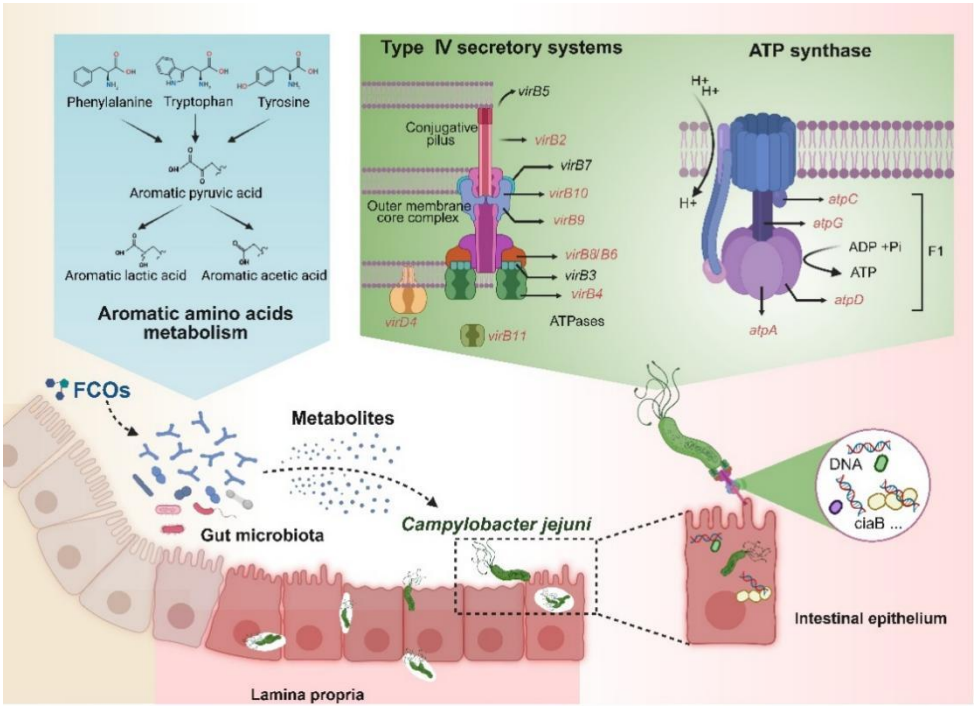
摘要：目的：本研究旨在探究胞外多糖来源岩藻糖基化寡糖（FCOs）对菌群组成和代谢的调控作用及其发酵后衍生的代谢产物对空肠弯曲杆菌生长和毒力的影响。方法：建立酸解-电渗析与乳酸菌发酵工艺制备新型岩藻寡糖（FCOs），通过单菌培养和结肠发酵评价其益生元活性。并利用转录组学和 Caco-2 模型分析菌群发酵 FCOs 对空肠弯曲杆菌生长和毒力的抑制作用。结果：FCOs 促进乳酸菌生长，增加双歧杆菌、副拟杆菌和巨球形菌丰度。菌群发酵 FCOs 后的上清液（F-FCOs）显著富集了芳香族氨基酸代谢物，降低空肠弯曲杆菌的丰度，并下调其 IV 型分泌系统基因的表达。F-FCOs 及其衍生的苯丙氨酸代谢物（苯乙酸，D-3-苯乳酸）显著抑制空肠弯曲菌对 Caco-2 细胞的侵袭，最高抑制率达 44.4%。结论：岩藻寡糖通过促进菌群中益生菌增殖和芳香族氨基酸代谢，发挥益生作用并抑制空肠弯曲菌生长和侵袭毒力。

关键词：岩藻寡糖；单糖脱除；体外发酵；芳香酸，空肠弯曲杆菌；



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辣椒素对南美白对虾肌原纤维蛋白构象影响及虾糜凝胶性质研究

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摘要：了解辣椒素对南美白对虾蛋白结构的影响对水产品加工至关重要。本实验探讨了不同浓度辣椒素对南美白对虾肌原纤维蛋白及虾糜凝胶的影响，通过测定浊度、粒径和 Zeta 电位、拉曼光谱、红外光谱等来表征南美白对虾肌原纤维蛋白的特性。通过蒸煮损失率、持水性、持油率以及微观结构等来表征虾糜的凝胶特性。结果表明，辣椒素的加入破坏了肌原纤维蛋白之间的氢键，添加辣椒素后各组均具有较低的无规则卷曲含量，表明加入辣椒素后保持了更规则和紧凑的蛋白质结构。通过研究加入辣椒素前后虾糜凝胶的变化，发现辣椒素通过增强虾糜凝胶网络的交联，增加虾糜凝胶的持水性，持油性以及白度，且随辣椒素浓度的增加而增加。

关键词：辣椒素；肌原纤维蛋白；蛋白特性；凝胶特性

项目号：国家自然科学基金项目（U23A20263，32502306），浙江省杰出青年项目（LRG25C200001），国家重点研发项目（2023YFD2401500）

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典型交联度鱼糜凝胶冻藏期间滋味变化的潜在机制：基于冰晶、水分迁移和价键作用

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摘要：【目的】冻藏鱼糜制品普遍存在滋味物质流失问题，严重影响其食用品质。【方法】本研究以典型交联度（29.66%和 62.99%）的鱼糜凝胶为对象，基于超高效液相色谱、微计算机断层扫描等技术探讨了其经不同冻结方式处理后在-20℃下冻藏 90 d 后滋味物质的变化规律及潜在机制。【结果】冻藏过程中肌肽、呈味核苷酸（IMP、AMP、GMP）及鲜味氨基酸（Asp、Glu、Thr、Pro 等）均呈下降趋势，而苦味物质（HxR、Hx 等）则不断累积。提高交联度（62.99%）结合液氮喷淋冻结（LF-80℃）可形成致密均一的凝胶网络，从而减少冰晶破坏和水分迁移，有助于保持鲜味物质的含量。氢键、离子键及非特异性结合有助于鲜味物质保留，而疏水相互作用增强则促进苦味物质累积。【结论】冻结方式与交联度通过冰晶效应和水分迁移协同调控鱼糜凝胶滋味，蛋白质构象与分子作用力在风味保持中起关键作用，其中提高交联度结合液氮喷淋快速冻结是延缓风味劣变的有效策略。

关键词：冻藏；鱼糜凝胶；滋味物质；分子间作用力

资助项目：国家自然科学基金面上项目（32172227），河南科技大学教师科研启动金（13480093）

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新型光动力介的绿色食品包装膜的创制及三文鱼保鲜应用研究

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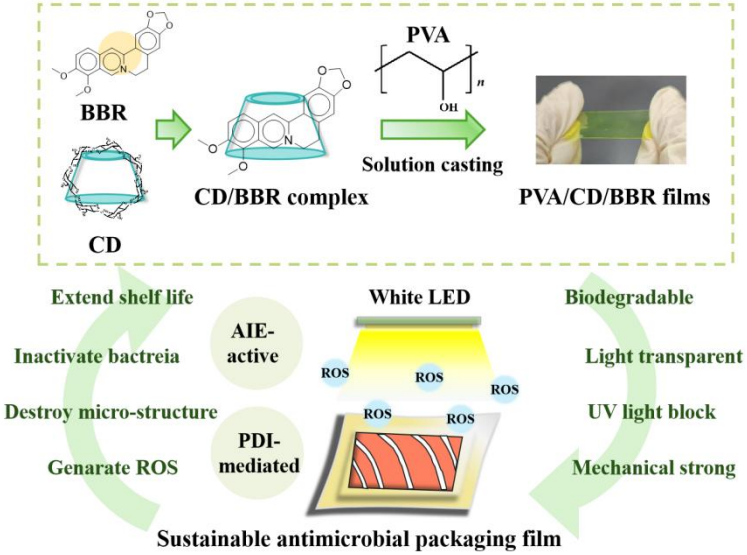
摘要：光动力灭活（PDI）是一种新型保障水产品质量与安全的非热杀菌技术，本研究旨在开发一种 PDI 介导的绿色食品包装膜以保障三文鱼的储存品质。环糊精/盐酸小檗碱包合物（CD/BBR）作为聚集诱导发光（AIE）光敏剂被装载于聚乙烯醇（PVA）中，以制备 PVA/CD/BBR 薄膜。该薄膜具有较高的透光率（~70%）以及优异的生物降解性。此外，由于氢键的形成，PVA/CD/BBR 薄膜表现出良好的机械性能，拉伸强度为 62.53 MPa，断裂伸长率为 69.14%。在白光照射下（14.4 J/cm^2），PVA/CD/BBR 薄膜可产生大量活性氧攻击细菌细胞，显著抑制三文鱼上细菌的增殖（0.92 log CFU/g）。同时，PDI 介导 PVA/CD/BBR 薄膜还可以保持储存期间三文鱼的感官品质和持水能力，有效抑制三文鱼的化学变化，延缓蛋白质降解和脂质氧化，将其货架期延长至少 3 天。

关键词：聚乙烯醇；光动力灭活；聚集诱导发光；小檗碱；抗菌包装薄膜



摘要图：光动力介导聚乙烯醇包装膜的制备及三文鱼保鲜应用

资助项目：上海市农业科技创新项目（T2024108）；国家自然科学基金（32102105）

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褐藻源古罗糖醛酸寡糖经代谢重编程介导巨噬细胞先天免疫训练研究

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摘要：褐藻胶作为海带主要营养成分，是由 β-D-甘露糖醛酸（M）和 α-L-古罗糖醛酸（G）通过 1→4 糖苷键连接构成的酸性线性多糖。古罗糖醛酸寡糖（GOS）是通过酶解法解聚均聚古罗糖醛酸（PG）制备的聚合度 2-8 的寡聚体。巨噬细胞过度活化与功能失调是炎症性及感染性疾病恶化进程的重要因素，本研究发现 GOS 可触发巨噬细胞训练免疫效应，调控巨噬细胞在二次刺激下的免疫应答水平，并增强其对异源物质的吞噬能力及病原微生物的杀伤能力。机制解析表明，GOS 通过特异性激活 mTOR/HIF-1α 信号通路，驱动巨噬细胞代谢重编程发生与先天免疫训练，进而实现固有免疫功能长效增强。该研究为褐藻源寡糖在特殊医学用途食品领域的开发与应用提供了创新性理论支撑。

关键词：褐藻胶；巨噬细胞；训练免疫；代谢重编程。

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负载虾青素的褐藻胶低聚糖纳米胶束的构建及其功能研究

续旭

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摘要：褐藻胶经分级可制得均聚甘露糖醛酸低聚糖（PM）与均聚古罗糖醛酸低聚糖（PG），具备良好的生物活性。虾青素具有改善肠道炎性紊乱的潜力，但因其水溶性和化学稳定性较差，难以正常发挥生物活性。本研究利用胱胺引入二硫键作为“桥梁”，将 PM、PG 分别与硬脂酸桥接，构建两种谷胱甘肽（GSH）响应性褐藻胶低聚糖纳米胶束，用于负载虾青素，靶向肠道并预防肠道炎性损伤。结果表明，两种虾青素纳米胶束具有良好的 GSH 响应性、理化稳定性和生物相容性，能通过锚定结肠炎区域，快速穿过肠道粘液层，被炎症巨噬细胞内吞后在高浓度 GSH 刺激下释放虾青素，有效缓解葡聚糖硫酸钠诱导的肠道稳态失衡小鼠的病理特征，且 PG 纳米胶束缓解模型小鼠组织损伤等病征的效果更显著。本研究为提高疏水性营养物质的口服生物利用度及预防肠道炎性损伤提供了新策略，展现了海藻食品资源在健康产业中的高值化应用潜力。

关键词：褐藻胶低聚糖；纳米胶束；谷胱甘肽（GSH）响应；结肠炎

资助项目：国家重点研发计划课题：水产营养健康食品的功效提升理论与技术（No. 2024YFD2401605）

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基于褐藻胶低聚糖巯基化修饰的益生菌封装与稳态定殖研究

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摘要：益生菌在口服递送过程及病理环境下的低存活率严重制约了其功效发挥。本研究通过对经褐藻胶降解得到的古罗糖醛酸低聚糖（PG）巯基化修饰，构建了一种新型益生菌包覆材料 TPG。研究表明，TPG 具有良好的生物相容性和益生元活性，可实现对包括乳酸乳球菌、大肠杆菌 Nissle1917 等在内多种益生菌的单细胞级高效封装，有效提升其在胃酸、氧化应激以及抗生素联用环境中的存活率。此外，TPG 还可显著增强益生菌在 DSS 诱导结肠炎小鼠的肠内滞留与定殖能力。该研究为开发高效、稳定、菌株适配性广泛的下一代益生菌递送系统提供了新思路，凸显了海洋糖类材料在功能性食品及生物医药领域的应用潜力。

关键词：褐藻胶；低聚糖；益生菌。

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基于双基因探针的新型高灵敏 RAA-TS-DTL 检测牛奶中荧光假单胞菌的研究

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摘要:本研究基于重组酶辅助扩增结合试纸条（RAA-TS），建立了荧光假单胞菌毒力基因 *aprX* 和内控基因 *gyrB* 的双试纸系（DTL）快速检测系统。肉眼观察可在 90 min 内检测出 *gyrB*（50 CFU/mL）和 *aprX*(250 CFU/mL)，包括样品前处理和 RAA 反应及检测步骤。未见与假单胞菌或其他细菌发生交叉反应（n = 19）。*gyrB* 和 *aprX* 对牛奶中荧光杆菌的定量检出限（LOD）分别为 37 CFU/mL 和 233 CFU/mL。与聚合酶链反应-琼脂糖凝胶电泳（PCR-AGE）相比，所建立的 RAA-TS-DTL 系统的灵敏度提高了约 4 倍。此外，与优化后的 PMAxx 样品预处理相结合，可检测牛奶中的荧光假单胞菌。该方法与传统培养法检测 25 份牛奶样品中荧光假单孢菌的一致性为 100%。开发的 RAA-TS-DTL 具有精度高、耗时短的优点，为牛奶中荧光假单胞菌的快速筛选或检测提供了一种新的方法或工具。

关键词：荧光假单胞菌；重组酶辅助扩增；试纸条；PMAxx; *aprX*; *gyrB*

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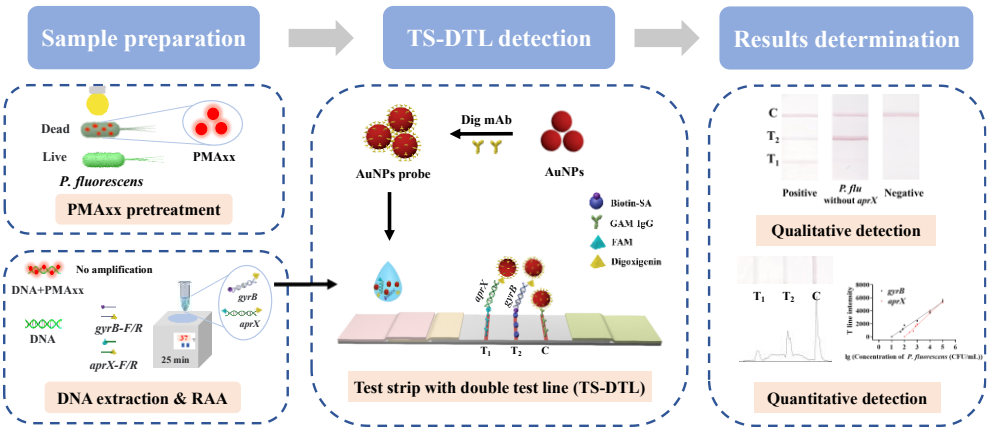

Valorizing fishery byproducts: Anti-colitis effects, gut microbiota modulation, and network pharmacology of snapper scale-derived collagen peptide

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Abstract : This study investigated the preventive effects of snapper scale collagen peptide (SSCP) powder on intestinal inflammatory health, to promote the high-value utilization of processing by-products and to facilitate the development of anti-inflammatory functional bioactive components. Comprehensive characterization confirmed its unique molecular weight distribution and rich peptide composition. In a murine dextran sulfate sodium (DSS)-induced acute colitis model, oral SSCP administration markedly attenuated colitis severity, significantly reduced pro-inflammatory cytokine levels (e.g., IL-1β, iNOS, and TLR4), and effectively enhanced intestinal barrier function by upregulating key proteins (Claudin-3, Muc-3, and Tff-3). 16S rRNA sequencing revealed that SSCP beneficially modulated the gut microbiota structure by decreasing pro-inflammatory taxa (Enterobacteriaceae and Erysipelatoclostridiaceae) while enriching beneficial families (Muribaculaceae) and restoring Akkermansiaceae abnormal levels. Furthermore, network pharmacology analysis predicted interactions between core potential anti-inflammatory peptides in the hydrolysate and colitis-related targets, further predicted its potential mechanism of prevention and protection. This work provides a sustainable strategy for valorizing aquaculture byproducts and supports the potential of fish scale-derived collagen peptides as functional ingredients for preventing intestinal inflammation.

Key words：Collagen; DSS-induced colitis; Network pharmacology; Snapper scale

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Dual Enhancement of Gel Properties and Taste in *Penaeus vannamei* Surimi Gels Using Betaine-Based Natural Deep Eutectic Solvents

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Abstract: Natural deep eutectic solvents (NADESs) have attracted significant interest in food processing owing to their low toxicity, excellent solubilization and tunable functionality. In this study, the potential of three natural deep eutectic solvents (betaine:glycerol, betaine:glucose, and betaine:sorbitol) as dual-functional modifiers for improving the gel properties and taste attributes of *Penaeus vannamei* surimi gel was investigated. The rheological behavior, gel strength, water holding capacity (WHC), microstructure, and protein structural stability were systematically evaluated. The incorporation of NADESs significantly improved the dynamic viscoelasticity of surimi, as evidenced by increased storage and loss moduli, accelerated gelation rates, and the formation of a stronger and more elastic gel network. Additionally, NADES-treated gels showed enhanced WHC and a denser, more homogeneous microstructure. Notably, NADESs helped stabilize the secondary and tertiary structures of myofibrillar proteins by increasing α-helix content and reducing tryptophan solvent exposure. Additionally, NADESs simultaneously improved the textural properties (enhanced hardness and chewiness, retained springiness) and taste profiles (intensified umami, sweetness, and saltiness) of shrimp surimi gels. These results underscore the dual role of betaine-based NADESs in simultaneously improving the textural and sensory qualities of surimi gels, highlighting their potential as sustainable multifunctional additives in aquatic protein processing.

Keywords: Natural deep eutectic solvents, rheological behavior, shrimp surimi, gel properties, flavor

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《许氏平鲉减菌保鲜新技术：超声强化微酸性电解水的应用》

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摘要：本研究旨在优选许氏平鲉的保鲜处理方式，以延长其冷藏货架期并减缓品质劣化。方法上，分别采用微酸性电解水（SAEW，有效氯浓度 40 mg/L）及其与超声的联合处理（US+SAEW，20 kHz, 600 W）对鱼片处理 10 min（4° C），以无菌去离子水处理为对照，于 4° C 冷藏并定期测定微生物、理化及品质指标。结果表明，SAEW 处理可显著抑制微生物生长，使菌落总数降低；US+SAEW 联合处理效果最优，可有效延缓 TVB-N 和 TBA 值上升（第 12 d 时分别为 18.7 mg/100g 和 0.85），抑制生物胺积累（组胺≤45 mg/kg），保持硬度与持水力（65.3%），显著优于对照组和 SAEW 单独处理。结论：US+SAEW 联合处理可将货架期延长至 15 d 以上，通过抑制微生物繁殖、脂肪氧化和生物胺积累，有效维持鱼类品质，是一种适于冷链物流的高效保鲜技术。

关键词：许氏平鲉；微酸性电解水；冷藏货架期；微生物控制

New technology of bacteria reduction and preservation of Sebastes schlegelii : application of ultrasound-enhanced slightly acidic electrolyzed water

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Abstract: The purpose of this study was to optimize the preservation treatment of Sebastes schlegelii, so as to prolong its shelf life and slow down its quality deterioration during cold storage. Fish fillets were treated with slightly acidic electrolyzed water (SAEW, available chlorine concentration 40 mg / L) and its combination with ultrasound (US + SAEW, 20 kHz, 600 W) for 10 min (4 ° C), respectively. The sterile deionized water treatment was used as the control. The fish fillets were refrigerated at 4 ° C and the microbial, physicochemical and quality indicators were measured regularly. The results showed that SAEW treatment could significantly inhibit the growth

of microorganisms and reduce the total number of colonies. The combined treatment of US + SAEW had the best effect, which could effectively delay the increase of TVB-N and TBA values (18.7 mg / 100 g and 0.85 on the 12 th day, respectively), inhibit the accumulation of biogenic amines (histamine ≤ 45 mg / kg), and maintain hardness and water holding capacity (65.3 %), which was significantly better than the control group and SAEW treatment alone. Conclusion : US + SAEW combined treatment can extend the shelf life to more than 15 days, and effectively maintain the quality of fish by inhibiting microbial reproduction, fat oxidation and biogenic amine accumulation. It is an efficient preservation technology suitable for cold chain logistics.

Key words: Sebastes schlegelii ; slightly acidic electrolyzed water ; refrigerated shelf life ; microbial control

添加海藻酸钠改善含有氯化钾部分代品的鲢鱼鱼糜品质的研究：深入了解其凝胶特性和食用感官

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摘要：当今食品行业普遍认同应减少氯化钠的添加量。在此背景下，本研究探讨了不同浓度（0.0%、0.2%、0.4%、0.6%、0.8%）的藻酸钠（SA）对50%氯化钾盐替代鱼糜凝胶特性及感官品质的影响。添加0.8%SA显著增强了含有氯化钾替代品鲢鱼鱼糜凝胶的凝胶强度（2873.74 g），同时降低游离水比例（0.73%），促进蛋白质结构展开与分子间作用力形成，构建出更稳定的凝胶网络。此外，添加SA能有效掩盖KCl盐替代鱼糜的苦味，赋予鱼糜更好的感官品质。综上，KCl与SA的联合应用是改善鱼糜凝胶特性、抑制苦味感知且不影响咸味的有效策略。本研究揭示了 SA 在低钠鱼糜加工中的应用潜力，为开发低钠食品提供了前景广阔的解决方案。

关键词：鱼糜；盐替代品；藻酸钠；凝胶特性

Improved qualities of potassium chloride partially replacing sodium chloride *Hypophthalmichthys molitrix* surimi by adding sodium alginate: Insight into the gel properties and sensory properties

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Abstract : It is the consensus of the food industry today to reduce the amount of sodium chloride added. In this context， the effects of sodium alginate (SA) at different concentrations (0.0 %, 0.2 %, 0.4 %, 0.6 %, 0.8 %) on the gel properties and sensory quality of 50 % KCl salt–substitute fish surimi were investigated. The addition of 0.8 % SA significantly enhanced the gel strength (2873.74 g) of the KCl salt–substitute *Hypophthalmichthys molitrix* surimi gel, while also reducing the

proportion of free water (0.73 %), promoted the unfolding of protein structure and the generation of intermolecular forces, and formed a more stable gel network. Moreover, the addition of SA effectively masked the bitter taste of the KCl salt–substitute surimi gel, imparted a better flavor to the surimi, and significantly improved the sensory quality of the surimi gel. In conclusion, the combined use of KCl and SA is an effective sodium reduction strategy that improves the gel properties of surimi, inhibits the perception of bitterness but does not affect the salty taste. Our findings highlight the potential of SA in the processing of low–sodium surimi and provide a promising approach for the development of sodium–reduced foods.

Key words: Surimi; Salt–substitute; sodium alginate; gel properties

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三元壁材复合凝聚和复合凝胶化载鱼油微胶囊的性质研究

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摘要：本文开发了在 pH 4.0 下牛骨明胶(BBG)-阿拉伯胶(GA)复合凝聚和 BBG-麦芽糊精(MD)复合凝胶化的同时方法来制备鱼油胶囊化凝聚和粉末。增加的 MD/BBG 质量比(0.0-2.0)增加了堆积密度、堆积密度和封装效率。相反，它们降低了粉末尺寸、水分含量、水分活度、表面油含量和负载能力。BBG-GA 复合凝聚延缓了鱼油粉末的热重行为。BBG-MD 复合凝胶延缓和减少鱼油粉末中油的氧化。鱼油粉末可以在胃相中溶解形成乳状液滴，然后在小肠相中消化，以指数形式释放游离脂肪酸。这些结果为了解鱼油粉末的形成机理和性质提供了有益的信息。这也为开发粉状配方食品的油粉提供了一种有用的方法。

关键词：封装效率；鱼油氧化；体外消化；微观结构；ζ电位

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Simultaneous complex coacervation and complex gelation for the encapsulation of fish oil

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Abstract: Herein, a simultaneous method of bovine bone gelatin (BBG)-gum Arabic (GA) complex coacervation and BBG-maltodextrin (MD) complex gelation at pH 4.0 was developed to prepare fish oil-encapsulated coacervates and powders. The increasing MD/BBG mass ratios (0.0–2.0) increased the bulk densities, tapped densities, and encapsulation efficiencies. In contrast, they decreased the powder sizes, moisture contents, water activities, surface oil contents, and loading capacities. BBG-GA complex coacervation delayed the thermogravimetric behaviors of the fish oil powders.BBG-MD complex gelation delayed and reduced oil oxidation in fish oil powders. The fish oil powders could be dissolved in the gastric phase to form emulsion droplets and then be digested in the small intestinal phase to exponentially release free fatty acids.All these results provided beneficial information to understand the formation mechanism and properties of fish oil powders. It also provided a useful method to develop oil powders for powdered formula foods

Key words: Encapsulation efficiency; Fish oil; in vitro digestion; Microstructure; zeta potential

The Effects of Tilapia Fillets at Different Center Temperatures on the *In Vitro* Digestion Characteristics of the Elderly

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Abstract: [Objective] This study investigated the *in vitro* digestion characteristics of tilapia fillets steamed to different center temperatures (60, 70, 80, and 90°C) under elderly gastrointestinal conditions, as well as the influence of both intrinsic (protein physicochemical properties) and extrinsic (texture characteristics) factors; [Methods] Texture properties and protein physicochemical characteristics (solubility, turbidity, surface hydrophobicity, aggregation, TCA-soluble peptides, and SDS-PAGE profiles) of steamed tilapia fillets were determined. The INFOGEST static model was applied to simulate *in vitro* digestion under both control and elderly conditions. Protein digestibility was assessed, while microstructure and infrared spectra were examined before and after digestion; [Results] Results showed a significant reduction in digestibility with increasing temperature, reaching the lowest value at 90°C (78.98%). Texture properties peaked at 70°C, while microstructural and physicochemical analyses indicated protein denaturation, gelation, and re-aggregation, which collectively impaired digestibility. Correlation analysis revealed that texture mainly influenced gastric digestion, whereas protein physicochemical properties determined intestinal digestion; [Conclusion] Overall, center temperature markedly modulates the *in vitro* digestive behavior of tilapia fillets in the elderly, highlighting the need to balance texture and protein properties when developing dietary strategies for this population.

Key words: Tilapia fillet; *In vitro* digestion; Elderly model; Texture; Protein physicochemical properties; Center temperature

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鹅肌肽降尿酸及其修复肝肾损伤的作用机制

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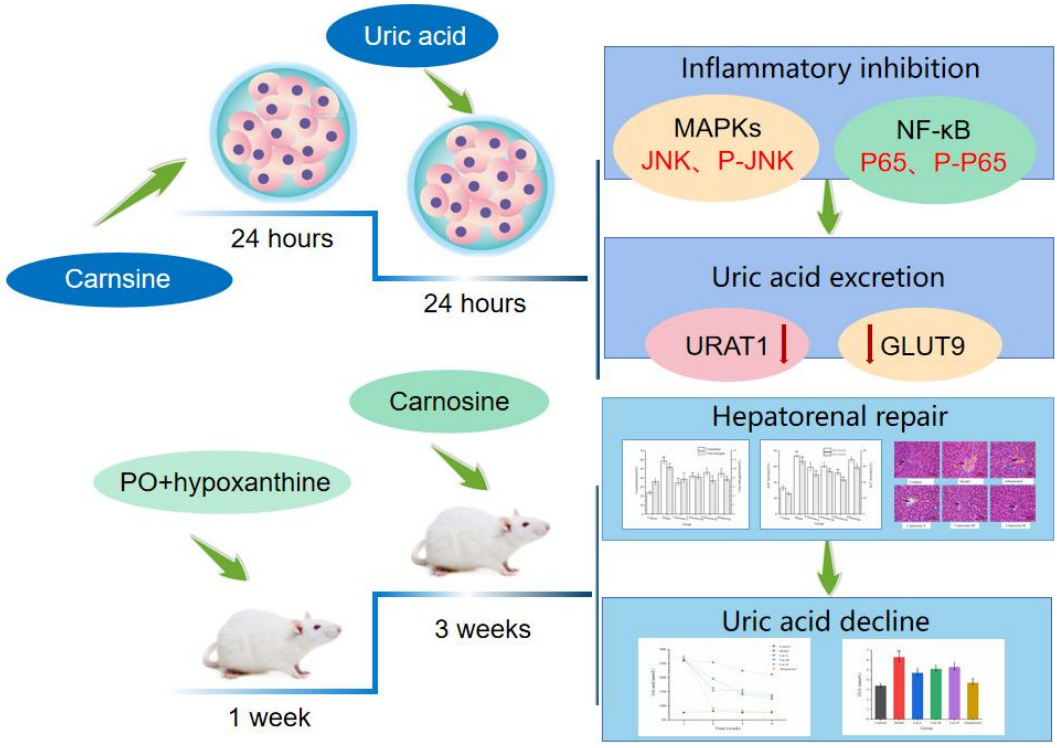
摘要：探究鹅肌肽降尿酸及修复肝肾损伤的作用机制。建立大鼠高尿酸血症模型及 TBHP/尿酸诱导的肝肾细胞损伤模型，通过生化检测、组织病理学分析及 qPCR/Western blot 等技术，评估鹅肌肽对尿酸代谢、氧化应激及炎症通路的影响。鹅肌肽显著降低血尿酸水平，其机制包括：抑制肝脏 XOD 活性以减少尿酸生成；调控肾脏尿酸转运蛋白 URAT1、GLUT9 和 ABCG2 的表达以促进尿酸排泄。特别发现，鹅肌肽通过抑制 NF-κB 和 JNK 炎症信号通路活化，进而下调尿酸重吸收蛋白 URAT1 和 GLUT9 的表达，通过抗炎作用间接促进尿酸排泄。同时，鹅肌肽通过激活 Nrf2 抗氧化通路减轻肝肾氧化损伤。 鹅肌肽通过多靶点调节尿酸生成与排泄，并通过抗氧化和抗炎作用保护肝肾，是一种潜在的治疗高尿酸血症的食源性活性物质。



关键词：鹅肌肽；降尿酸；肝肾损伤；炎症反应；氧化应急

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Mechanisms of Muscle Protein Degradation and Non-volatile Taste Precursor Release in *Eriocheir sinensis* During Under Various Thermal Processing Methods

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Abstract: This study investigated the degradation patterns of muscle proteins and the release characteristics of non-volatile taste precursors in Eriocheir sinensis subjected to various thermal processing methods. The extraction of total protein, SDS-PAGE, protein solubility, surface hydrophobicity, intrinsic fluorescence, and DIA-proteomics were determined. The results demonstrated that thermal processing significantly promoted the accumulation of non-protein nitrogen components and induced irreversible protein degradation. Compared with other groups, the BK group exhibited higher protein solubility ($P<0.05$) and a remarkable increase in proteins with molecular weights below 17 kDa. KEGG enrichment analysis revealed significant involvement of nucleotide metabolism, phenylalanine metabolism, glutathione metabolism, and fatty acid biosynthesis pathways. Protein degradation induced by thermal processing was mainly associated with ATP degradation, amino acid metabolism, glycolysis, and lysosomal pathways, with a total of 11 major differential proteins identified. Notably, alanyl aminopeptidase, glutaminase, AMP dehydrogenase, and succinate dehydrogenase were significantly upregulated following heat processing, potentially contributing to taste variations. Moreover, nucleoside kinase, AMP deaminase, L-serine dehydratase, and cytosolic non-specific dipeptidase were found to facilitate the accumulation of small peptides and enhance umami perception.

Keywords: *Eriocheir sinensis*; Thermal processing; Protein degradation; DIA-proteomic; Taste precursors

酶解协同发酵制备狭鳕鱼骨α-葡萄糖苷酶抑制肽的工艺优化

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摘要：糖尿病作为一种常见的慢性代谢性疾病，已成为严重威胁人类健康的重大公共卫生问题，如何从天然食物中发掘具有血糖调节功能的活性成分具有重要意义。本研究以狭鳕鱼骨泥为原料，采用酶解法协同发酵法制备具有α-葡萄糖苷酶抑制活性的多肽物质。结果显示，以水解度、多肽含量和α-葡萄糖苷酶抑制率为评价指标，比较不同蛋白酶的酶解效果及不同菌株的发酵效果，筛选出最适蛋白酶为木瓜蛋白酶，最适发酵菌株为LpS2和LpF176。通过单因素和响应面优化试验，确定了狭鳕鱼骨泥α-葡萄糖苷酶抑制肽的最佳发酵工艺为复合菌株接种量7.16%，菌株比例为1:1，酶解液添加量为50%，葡萄糖添加量为4%，发酵时间48 h。在此条件下发酵，α-葡萄糖苷酶抑制率为47.04%，与预测值无显著性差异（P＞0.05）。本研究制备的α-葡萄糖苷酶抑制肽具有较高的活性，为狭鳕鱼骨排的高值化利用提供了新的途径，也为开发新型天然α-葡萄糖苷酶抑制肽提供了理论参考。

关键词：狭鳕鱼骨泥；α-葡萄糖苷酶抑制肽；酶解法；发酵法；响应面优化

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Process Optimization of Enzymatic Hydrolysis and Synergistic Fermentation for the Preparation of α-Glucosidase Inhibitory Peptides from Alaska Pollack Bone

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Abstract : As a common chronic metabolic disease, diabetes has become a significant public health issue that seriously threatens human health. It is crucial to explore the active ingredients with blood glucose regulation functions from natural foods. In this study, Alaska Pollack bone puree was utilized to prepare polypeptides with α-glucosidase inhibitory activity through enzymatic hydrolysis and co-fermentation. The results indicated that the degree of hydrolysis, polypeptide content, and α-glucosidase inhibition rate served as evaluation indices to compare the effects of different proteases in enzymatic hydrolysis and the fermentation effects of various strains. The optimal protease identified was papain, while the best fermentation strains were LpS2 and LpF176. Through single-factor and response surface optimization experiments, the ideal fermentation process of α-glucosidase inhibitory peptide from Alaska Pollack bone puree was established as follows: the inoculation amount of the composite strain was 7.16%, the strain ratio was 1:1, the addition amount of enzymatic hydrolysate was 50%, the glucose addition amount was 4%, and the fermentation duration was 48 h. Under these conditions, the α-glucosidase inhibition rate achieved was 47.04%, which was not significantly different from the predicted value ($P>0.05$). The α-glucosidase inhibitory peptide developed in this study demonstrates high activity, providing a new approach for the high-value utilization of Alaska Pollack bone row and offering a theoretical reference for the creation of new natural α-glucosidase inhibitory peptides.

Key words: Alaska Pollack Bone Puree; α-Glucosidase Inhibitory Peptide; Enzymatic Hydrolysis; Fermentation Method; Response Surface Optimization

不同处理阶段对鱼皮（草鱼、罗非鱼）结构及理化特性的影响

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摘要：本研究探讨碱浸与烫漂处理对草鱼和罗非鱼皮特性的影响。结果表明，不同处理阶段显著改变了鱼皮组成，其中灰分和粗蛋白含量下降，水分含量和溶胀率上升（烫漂后达 70%）。质构特性显示烫漂后硬度、咀嚼性和破断力急剧降低。微观结构观察发现胶原纤维网络从有序变为无定形凝胶。蛋白质氧化加剧（巯基下降、羰基上升），罗非鱼皮抗氧化性更强。热分析表明烫漂后胶原完全变性，水分分布显示自由水向不易流动水迁移。脂质氧化分析证实烫漂促进次级氧化产物生成。本研究阐明了加工对鱼皮特性的影响机制，为其高值化利用提供依据。

关键词：鱼皮；碱浸；烫漂；明胶化；微观结构

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Effects of different processing stages on the structure and physicochemical properties of fish skins (grass carp, Nile tilapia)

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Abstract:This study investigated the effects of alkaline soaking and blanching on grass carp and Nile tilapia skins. Results showed significant compositional changes: ash and crude protein decreased while moisture and swelling rate increased (reaching 70% after blanching). Texture analysis revealed a sharp decrease in hardness, chewiness and breaking force. Microscopy showed transformation from ordered collagen fibers to an amorphous gel network. Protein oxidation intensified (decreased sulfhydryl and increased carbonyl groups), with Nile tilapia exhibiting

stronger antioxidant capacity. Thermal analysis confirmed complete collagen denaturation after blanching, and water migration from free to immobilized water was observed. Lipid oxidation analysis indicated blanching promoted secondary oxidation products. This study elucidates the impact of processing on fish skin properties, providing a basis for their value-added utilization.

Keywords: fish skins; alkaline soaking; blanching; gelatinization; microstructure

冷冻与冻藏对四种淡水鱼品质及蛋白质稳定性的影响

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摘要：冷冻是水产品最主要的保藏方式，但冻结与冻藏过程易引起鱼肉品质劣变。本研究以草鱼、黑鱼、鲢鱼和鲴鱼四种淡水鱼背肌为对象，系统比较了未冷冻、冷冻-解冻及冻藏 12 周处理对其品质特性的影响。通过分析蛋白质变化、水分分布、持水性及超微结构的变化，揭示了品质劣变机制。结果表明，冷冻处理显著促进了蛋白质氧化变性与降解，破坏肌肉超微结构，导致持水性降低，其中冻藏阶段的影响显著大于冻结。不同鱼种耐冻性具显著差异：鲢鱼品质劣变最为严重，蛋白质稳定性与持水性最差；而鲴鱼冷冻稳定性最佳。游离氨基酸与脂质的变化亦呈现种间差异。本研究明确了冷冻不同阶段对鱼肉品质的影响及种间特异性机制，为针对性保鲜技术开发提供了理论依据。

关键词：淡水鱼；冷冻；蛋白质氧化；超微结构

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Effects of Freezing and Frozen Storage on Quality and Protein Stability in Four Freshwater Fish Species

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Abstract: Freezing is the most common preservation method for aquatic products, but freezing and frozen storage can easily lead to quality deterioration in fish. This study systematically compared the effects of different freezing treatments — non-frozen, freeze-thawed, and 12-week frozen storage — on the quality characteristics of dorsal muscle from four freshwater fish species: *Ctenopharyngodon idella*, *Channa argus, Aristichthys nobilis* and *Ictalurus punctatus*. By analyzing changes in proteins, water distribution, water-holding capacity, and ultrastructure, the mechanisms of quality deterioration were revealed. The results showed that freezing significantly promoted protein oxidation, denaturation, and degradation, disrupted muscle ultrastructure, and reduced water-holding capacity, with frozen storage having a more substantial impact than initial freezing. Freezing tolerance varied significantly among species: *Aristichthys nobilis* showed the most severe quality deterioration, with the poorest protein stability and water-holding capacity, while *Ictalurus punctatus* exhibited the best freezing stability. Changes in free amino acids and lipids also displayed species-specific differences. This study clarifies the effects of different freezing stages on fish quality and the species-specific mechanisms involved, providing a theoretical basis for developing targeted preservation technologies.

Keywords: freshwater fish; freezing; protein oxidation; ultrastructure;

Pre-drying decontamination of laver seaweed by slightly acidic electrolytic water, ozonated water, and UV light treatment

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Abstract: High microbial counts present on dried laver can be of microbial quality and safety concerns. Previous research indicated that post-drying decontamination has limited effects eliminating surviving microbes on dried laver. Thus, this work explored the efficacy of pre-drying decontamination methods for wet laver, including washing wet laver with slightly acidic electrolytic water (SAEW) or ozonated water (OW) before drying, or treating wet laver sheets with ultraviolet (UV) during early stage drying. The average APC and coliform in untreated wet laver were ~5.69 and 4.34 Log CFU/g. SAEW (100 ppm, 30 min), OW (1 mg/L, 30 min) and UV (5 cm, 30 min) decreased the APC and coliform of laver by 2.56 and 2.59, 2.95 and 2.84, and 1.03 and 1.22 Log CFU/g, respectively. SAEW (100 ppm, 30 min) and OW wash (0.7 mg/L, 30 min) caused visible color changes to wet laver, however the drying process (right after the treatment) mitigated the changes quite significantly. 16S sequencing results showed that OW significantly reduced Flavobacteriaceae in the Bacteroidota phylum, while the SAEW and UV significantly reduced the Bacteroidota and Proteobacteria phyla. The above results showed that decontamination of wet laver before drying or during early drying stage was effective to reduce the APC and coliform loads of dried laver.

Key words: *Porphyra yezoensis*, UV-C, electrolyzed water, ozone, food safety, preservation

电场强度对白鲢鱼糜凝胶性质及蛋白质结构调控机制的影响研究

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摘要：为探索电场对肌原纤维蛋白诱导交联的非热效应，本研究采用不同电场强度（2.0～8.0 V/cm）处理白鲢鱼糜，同时做出欧姆加热匹配传统水浴加热的同步升温曲线，通过测定鱼糜凝胶的质构特性、凝胶强度、持水性和同速率加热下肌原纤维蛋白的粒径、巯基、二级结构等指标，评估不同加热方式对凝胶品质的影响，初步探究电场对蛋白质结构的调控机制。研究结果表明：与水浴加热相比，欧姆加热显著改善凝胶品质，在 6 V/cm 的场强下，鱼糜凝胶强度达到 254.45±36.93 g.cm 最优，α-螺旋占比 14.04%而 β-折叠占比 43.80%，该条件可快速通过凝胶劣化温度带，减少肌原纤维蛋白水解，形成稳定凝胶网络；同速率加热的条件下，欧姆加热的蛋白粒径更小，总巯基含量更低，二级结构中 α-螺旋含量更低而 β-折叠含量更高，这表明欧姆加热通过诱导二硫键的形成，促进表面疏水性，使蛋白结构更加有序，形成的凝胶越精细、致密，凝胶强度也越好，显著提升了鱼糜凝胶品质。

关键词：白鲢鱼糜；欧姆加热；肌原纤维蛋白；凝胶特性；二级结构

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The effect of ohmic heating on the Gel Properties of Silver Carp (Hypophthalmichthys molitrix) Surimi

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Abstract：To investigate the non-thermal effects of electric fields on cross-linking induced in myofibrillar proteins, this study treated silver carp surimi with varying electric field intensities (2.0 – 8.0 V/cm). while simultaneously generating ohmic heating curves matched to conventional water bath heating. By measuring the textural properties, gel strength, water-holding capacity, and indicators such as particle size, sulfhydryl content, and secondary structure at constant heating rates, the impact of different heating methods on gel quality was assessed. This provided preliminary insights into the regulatory mechanisms of electric fields on protein structure. Results indicated that compared to water bath heating, ohmic heating significantly enhanced gel quality. At a field strength of 6 V/cm, the surimi gel strength reached an optimal of 254.45±36.93 g·cm, with α-helix accounting for 14.04% and β-sheet accounting for 43.80%. This condition enabled rapid passage through the gel degradation temperature range, reducing myofibrillar protein hydrolysis and forming a stable gel network. Under conditions of equivalent heating rates, ohmic heating produced smaller protein particle sizes, lower total thiol content, reduced α-helix content, and increased β-sheet content within the secondary structure. This indicated that ohmic heating promotes surface hydrophobicity by inducing disulphide bond formation, thereby enhancing protein structural order. Consequently, the resulting gel exhibitd finer texture, greater density, and superior gel strength, significantly improving the quality of fish paste gel.

Keywords：Silver carp surimi; Ohmic heating; Myofibrillar protein; Gel properties; Secondary structure

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几种典型磷脂脂质组成及其特性解析

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摘要：为实现南美白对虾 (*Penaeus vannamei*) 加工副产物的高值化利用，本研究采用优化后的超声辅助乙醇法提取虾头总脂 (SHO)，并通过丙酮沉淀法富集虾头磷脂 (SHP)。通过对比 SHO、SHP 及市售磷虾磷脂 (AKP)、蛋黄磷脂 (EYP) 和大豆磷脂 (SBP) 的组成与特性，评估 SHP 应用潜力。薄层色谱显示所有磷脂均以磷脂酰胆碱为主，其次为磷脂酰乙醇胺和溶血磷脂酰胆碱。SHO、SHP 与 AKP 含有丰富的多不饱和脂肪酸 (35.98% - 41.62%)，其中 SHP 的 EPA+DHA 含量相较 SHO 显著提升了 37.80%。磷脂乳化特性研究表明 AKP 和 SBP 的乳化能力最优，而 EYP 乳化稳定性最差。AKP 与 SHP 的加速氧化过程伴有明显的颜色变深和异味产生。但 SHP 的过氧化物值和硫代巴比妥酸值增长速率慢于 AKP，氧化稳定性更好。综上，南美白对虾虾头是制备高不饱和脂肪酸磷脂的优质来源，且在功能特性上展现出一定的开发利用优势。

关键词：南美白对虾虾头；磷脂；脂肪酸组成；乳化性；氧化稳定性

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模拟酸鱼系统中群体感应信号分子 2-苯乙醇的浓度效应对戊糖乳植物杆菌风味代谢的影响

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摘要：2-苯乙醇（2-PE）是一种群体感应信号分子，能影响微生物代谢，但其在乳酸菌（LAB）发酵中的作用尚未深入研究。本研究探讨了 2-PE 浓度对模拟酸鱼系统中戊糖乳植物杆菌 1（Lp 1）发酵的影响。通过分析细菌生长、残糖量、有机酸和挥发性风味化合物，并结合代谢组学，结果表明，低到中等浓度的 2-PE 抑制了 Lp 1 的生长和某些代谢功能，而高浓度则诱导了适应性变化，增强了氨基酸代谢，并促进了后期有机酸的积累。值得注意的是，750 μM 组展示了最高水平的醇类、醛类和酮类化合物。进一步分析表明，2-PE 主要影响与氨基酸代谢/合成、三羧酸循环（TCA 循环）和脂肪酸生物合成相关的途径。这些研究结果表明，作为代谢调节因子的 2-PE 可以作为目标分子以增强发酵鱼制品的风味。

关键词：酸鱼发酵；2-苯乙醇；群体感应；风味代谢；戊糖乳植物杆菌 1

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The concentration-dependent impact of quorum-sensing signal molecule 2-phenylethanol on the flavor metabolite profile of *Lactiplantibacillus pentosus* 1 in a simulated sour fish system

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Abstract: 2-Phenylethanol (2-PE) is a quorum-sensing signal molecule–that influences microbial metabolism, but its role in lactic acid bacteria (LAB) fermentation remains underexplored. This study investigates the effect of 2-PE concentrations on *Lactiplantibacillus pentosus* 1 (Lp 1) fermentation in a simulated sour fish system. Analyses of bacterial growth, residual sugar, organic acid, and volatile flavor compounds were combined with metabolomics. Results demonstrated that low to moderate concentrations of 2-PE inhibited Lp 1 growth and certain metabolic functions, while high concentrations induced adaptation, enhanced amino acid metabolism, and promoted organic acid accumulation in the later stages. Notably, the 750 μM group exhibited the highest levels of alcohols, aldehydes, and ketones. Further analysis revealed that 2-PE mainly affects pathways related to amino acid metabolism/synthesis, the TCA cycle, and fatty acid biosynthesis. These findings suggest that 2-PE, as a metabolic regulator, could be targeted to enhance the flavor of fermented fish products.

Key words: sour fish fermentation; 2-phenylethanol; quorum sensing; flavor metabolism; *Lactiplantibacillus pentosus* 1

Effects of postmortem chilling times and subsequent frozen storage durations onmicrostructure and protein properties of tilapia (*Oreochromis niloticus*) fillets

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Abstract: This study aimed to investigate the effects of postmortem chilling times (4 °C: 0, 2, 8, and 12 h) and subsequent frozen storage durations (-20 °C: 0, 1, 2, and 3 months) on the microstructure and protein properties of tilapia fillets. Tilapia fillets with 8 h of chilling (P8) resulted in highest overall acceptability, hardness, chewiness, and shear force. The thawing losses of tilapia fillets with different postmortem chilling times for the same frozen storage duration were ranked as follows: P12 > P0/P2 > P8. With the prolongation of postmortem chilling times and frozen storage periods, the muscle tissue structure was gradually damaged, with the most severe disruption after 12 h of postmortem chilling time. Tilapia fillets pre-chilled for 8 h showed a 17.63% decrease in Ca2+-ATPase activity at 3 months of frozen duration, which was the smallest decrease compared with the other groups. Furthermore, the endogenous fluorescence intensity of P0, P2, P8 and P12 samples decreased by 34.53%, 14.29%, 13.95% and 26.98%, respectively, at the end of frozen storage. Overall, frozen storage durations had a greater effect on the quality of tilapia fillets than postmortem chilling times. In summary, the maximum postmortem chilling time for frozen tilapia fillets is recommended to be 8 h, with significant quality differences when frozen for more than 2 months.

Key words: Tilapia**;** Postmortem chilling time; Frozen storage; Microstructure; Quality deterioration

V 型淀粉-环糊精金属有机框架的制备、表征及其对缢蛏酶解物的风味改良研究

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摘要：为改善缢蛏（*Sinonovacula constricta*）酶解物的整体风味特性，本研究以 V 型淀粉和环糊精（α、β 和 γ-Cyclodextrins，CDs）为原料，结合晶种介导法和蒸汽扩散法制备了一种新型脱腥壁材——V 型淀粉-环糊精金属有机框架（V-CD-MOF）。元素分布情况中钾离子的均匀分布及 X 射线衍射中特征峰的出现证实了 V-CD-MOFs 的成功制备。X 射线光电子能谱表明，添加 V 型淀粉后 V-CD-MOFs 的-OH 相对含量提高了 0.12–1.59%。气相色谱-离子迁移谱结果显示，V-β-CD-MOF 对酯类等芳香物质的吸附率保持在 12.94–56.11%，始终低于 V 型淀粉。气相色谱-质谱联用表明，V-β-CD-MOF 对醛类的脱除率高达 87.59%，并将庚醛等 10 种特征腥味物质完全脱除。综上，V-β-CD-MOF 对腥味分子的高效吸附和对芳香化合物的保留能力使其成为改善缢蛏酶解物整体风味的潜在理想材料，该研究为 MOF 材料的改性和水产品的脱腥应用提供了理论参考。

关键词：V 型淀粉；环糊精金属有机框架；缢蛏酶解物；风味

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V-type starch cyclodextrin metal-organic framework as a encapsulant: Preparation, characterization, and its application in flavor improvement of Razor Clam enzymatic hydrolysate

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Abstract : To improve the overall flavor profile of razor clam (*Sinonovacula constricta*) enzymatic hydrolysate, this study developed a novel deodorizing encapsulant—V-type starch cyclodextrin metal-organic framework (V-CD-MOF). This encapsulant was synthesized using V-type starch and cyclodextrins (α-, β-, and γ-CDs) as raw materials, employing a combination of a seed-mediated method and vapor diffusion technique. The uniform distribution of potassium ions in the elemental distribution and the appearance of characteristic peaks in X-ray diffraction confirmed the successful preparation of V-CD MOFs. X-ray photoelectron spectroscopy analysis revealed that the relative content of -OH in V-CD-MOFs increased by 0.12–1.59% after the addition of V-type starch. Gas chromatography-ion mobility spectrometry suggested that the adsorption rate of V-β-CD-MOF for aromatic compounds, such as esters, was maintained at 12.94–56.11%, consistently lower than that of V-type starch. Gas chromatography-mass spectrometry demonstrated that the removal rate of aldehydes by V-β-CD-MOF was as high as 87.59%, and 10 characteristic fishy substances such as heptanal were completely removed. In conclusion, the efficient adsorption of off-flavor compounds and the remarkable retention of aromatic compounds by V-β-CD-MOF make it a potentially ideal material for improving the overall flavor profile of razor clam enzymatic hydrolyzate. This study provides a theoretical reference for the modification of MOF materials and their application in deodorizing aquatic products.

Key words: V-type starch; Cyclodextrin metal-organic framework; Razor Clam enzymatic hydrolysate; Flavor

复配胶体的优化及其对冷冻虾滑性质的影响

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摘要：本研究以虾滑粘稠度及其制品的硬度作为评价指标，对醋酸酯淀粉、κ-卡拉胶和低酰基结冷胶进行复配优化，通过单因素与正交试验确定最佳配比。接着，考察该优化配方对虾滑制品的质构、水分分布和微观结构等指标的影响，并与未添加复配胶体的对照组以及市售虾滑产品（市售组）进行对比分析。结果表明，复配胶体的最优组合为 8.0%淀粉、3.0%卡拉胶和 0.12%结冷胶。流变性质分析显示，添加复配胶体的实验组虾滑储能模量（G′）和损耗模量（G″）均高于对照组，而加热至 95 ℃时的 G′值低于市售组。实验组虾滑制品的凝胶破断力、硬度和咀嚼性均高于对照组和市售组，而破断距离和弹性则显著降低（$P < 0.05$）。色泽分析表明，实验组虾滑制品的 L^*值（62.51）介于对照组（57.94）和市售组（67.92）之间，而 a^*值、b^*值最高。持水性和低场核磁共振结果显示，实验组与市售组的虾滑制品在持水性和水分分布方面无显著差异（$P<0.05$），但两者均高于对照组。电泳分析显示，实验组虾滑制品在添加复配胶体后，其高分子量聚合物条带和肌球蛋白重链条带浓度明显高于对照组，并且与市售组相近。因此，优化复配醋酸酯淀粉、κ-卡拉胶和低酰基结冷胶可改善虾滑及其制品的品质，为开发符合市场需求的高品质虾滑产品提供技术支持。

关键词：虾滑；淀粉；卡拉胶；结冷胶；凝胶特性

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干热处理对鲍鱼肌肉糖蛋白的理化性质及其消化产物抗氧化活性的影响

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摘要：为了探究干制过程中鲍鱼肌肉糖蛋白（AGP）结构和功能特性的变化，本研究采用硫酸铵盐析法从鲍鱼肌肉中提取 AGP，并在 45 ℃、相对湿度 75%的条件下进行干热处理。采用紫外光谱、荧光光谱及圆二色谱等技术，分析 AGP 在干热处理过程中的褐变行为和结构变化。通过体外模拟胃肠道消化制备 AGP 消化产物（AGP-D），并评价其体内外抗氧化活性。结果表明，制备的 AGP 以 β-折叠（48.31%）为主，其糖链部分含有 O-糖苷键与吡喃糖型 β-糖苷键。经干热处理后，AGP 的褐变程度随处理时间延长逐渐加深，颜色参数 L^*值逐渐下降，a^*、b^*及 ΔE 值均显著上升（$P < 0.05$）。结构分析显示，α-螺旋含量降至 5.94%，β-折叠增至 50.19%，内源荧光强度显著降低。体外抗氧化实验结果显示，随干热时间延长，AGP-D 对 DPPH、ABTS 和 DMPD 自由基清除活性的 IC_{50} 值分别降至 3.11、0.31 和 0.92 mg/mL。在秀丽隐杆线虫模型中，与对照组相比，饲喂 2 mg/mL AGP-D 的线虫体长由 157.39 μm 显著增加至 251.88 μm，吞咽频率也明显提高。在热应激与氧化应激条件下，线虫的平均寿命分别延长至 7.51 h 和 5.30 h。AGP-D 饲喂处理使线虫体内活性氧水平降至对照组的 29.13%，同时提升了谷胱甘肽含量、超氧化物歧化酶和过氧化氢酶的活性，以及总抗氧化能力。综上所述，干热处理不仅可改变 AGP 的结构特性，还可增强其消化产物的体外自由基清除能力和体内抗氧化保护作用。本研究结果可为干制过程中鲍鱼肌肉结构和营养功能变化的机制研究提供理论依据。

关键词：鲍鱼；糖蛋白；干热反应；抗氧化活性；秀丽隐杆线虫

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大豆分离蛋白-表没食子儿茶素没食子酸酯-壳寡糖复合 Pickering 乳液表征

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摘要：蛋白-多酚/蛋白-寡糖复合可用于构建出稳定的 Pickering 乳液体系。然而，关于蛋白-多酚-寡糖复合 Pickering 乳液的稳定机制尚不清楚。本研究制备了大豆分离蛋白（Soybean isolate protein，SPI）-表没食子儿茶素没食子酸酯（Epigallocatechin gallate，EGCG）-壳寡糖（Chitosan oligosaccharide，COS）复合物（SECs），旨在揭示 SECs 协同稳定 Pickering 乳液（SECPEs）油水界面的稳定机制。傅里叶红外光谱显示 SECs 在 3277.09 cm^{-1} 处的峰变宽且峰位蓝移，表明 EGCG 和 COS 通过氢键作用与 SPI 相互作用。SECs 的接触角降低至 80.88 ± 1.28°，具有良好的两亲性。扫描电子显微镜表明 COS 与 SPI、EGCG 主要通过静电吸附作用。随着油水比（1:9-6:4，v/v）和浓度（1%-5%，w/v）的增加，SECPEs 的乳析指数和稳定性指数减小，相分离现象降低。SECPEs 的粒径与油水比成正相关，与 SCEs 浓度成负相关。油水比 6:4 和 SECs 浓度 4%时，SECPEs 稳定性显著提升，且 pH 8 下 SECPEs 的聚集和絮凝受到抑制，更有利于在油水界面形成密集的网络结构抑制乳析。以上结果表明蛋白-多酚-寡糖三元复合物具有作为新型皮克林稳定颗粒的潜力。

关键词：大豆分离蛋白；表没食子儿茶素没食子酸酯；壳寡糖；Pickering 乳液；稳定性

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Characteristics of Pickering emulsions using soy protein isolate-epigallocatechin gallate-chitooligosaccharide complexes

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Abstract: Protein-polyphenol or protein-oligosaccharide complexes have been demonstrated to stabilize Pickering emulsions effectively. However, the stabilization mechanisms underlying Pickering emulsions stabilized by protein-polyphenol-oligosaccharide complexes remain poorly understood. In this study, soy protein is4olate (SPI)-epigallocatechin gallate (EGCG)-chitooligosaccharide (COS) complexes (SECs) were prepared to explain the stabilization mechanism of SECs in synergistically stabilizing the oil-water interface of Pickering emulsions (SECPEs). Fourier transform infrared spectroscopy revealed a blue shift and broadening peak of the SECs at 3277.09 cm^{-1}. This indicated that EGCG and COS interacted with SPI through hydrogen bonding. In addition, the contact angle of SECs decreased to 80.88 ± 1.28° with good amphiphilicity. Scanning electron microscope revealed the interaction of EGCG and COS with SPI through electrostatic adsorption. As the oil-water ratios (1:9-6:4, v/v) and SEC concentrations (1%-5%, w/v) increased, the creaming index and stability index of SECPEs declined to reduce phase separation. The size of SECPEs was positively correlated with the oil-water ratios and negatively correlated with the SEC concentrations. The stability of SECPEs was significantly enhanced at an oil-water ratio of 6:4 (v/v) and SECs concentration of 4% (w/v). Furthermore, the aggregation and flocculation of SECPEs were inhibited at pH 8, promoting the formation of a dense network structure to suppress creaming. These findings indicate that the potential of protein-polyphenol-oligosaccharide ternary complexes have the potential as novel Pickering stable particles.

Key words: Soy protein isolate; Epigallocatechin gallate; Chitooligosaccharide; Pickering emulsions; Stability

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pH、离子强度及 TGase 对鳙鱼肌球蛋白皮克林乳液稳定性的三重调控研究

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摘要：肌球蛋白稳定 Pickering 乳液容易受到多种因素影响，本研究探讨了 pH 值、离子强度和转谷氨酰胺酶(TGase)对大头鱼肌球蛋白稳定 Pickering 乳液（Pickering emulsion gel solely using myosin from bighead carp，BCMPEs）的物理化学性质、微观结构和稳定性的影响。在中性条件下，BCMPEs 的粒径更小，絮凝程度更低，这有利于提高 Pickering 乳液的稳定性。在离子强度为 600 mmol/L 时，肌球蛋白颗粒能很好地吸附在油水界面，使乳液液滴均匀分散，粒径小且絮凝程度低。此外，在高离子强度下，由于乳液液滴的絮凝增加，BCMPEs 的粘度和储能模量更高，同时添加 TGase 会导致乳液凝胶化。当 TGase 活性为 15 U/g 时，乳液凝胶中结合水和固定水的总含量最高，从而提高了其持水能力，形成的三维网络结构增强了 BCMPEs 的凝胶强度和 TPA 特性。因此，适宜的 pH 和离子强度以及 TGase 能够提高 BCMPEs 的稳定性，为 鱼蛋白基 Pickering 乳液凝胶的设计和制备提供了理论依据。

关键词：鳙鱼；肌球蛋白；转谷氨酰胺酶；Pickering 乳液；稳定性

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Stability of Pickering emulsions using myosin from bighead carp: Effect of pH, ionic strength and TG enzyme

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Abstract: The impact of pH, ionic strength, and TG enzyme on the physicochemical properties, microstructure, and stability of Pickering emulsions stabilized by bighead carp myosin (BCMPEs) was investigated. This study provides a new method for preparing Pickering emulsions with excellent performance. Under neutral conditions, BCMPEs exhibit smaller particle size and lower flocculation degree, which is beneficial for improving the stability of Pickering emulsions. At an ionic strength of 600 mmol/L, myosin particles can adsorb well at the oil-water interface, resulting in uniform dispersion of emulsion droplets with small particle size and low flocculation degree. Furthermore, BCMPEs exhibit higher viscosity and storage modulus due to increased flocculation of emulsion droplets under high ionic strength. Finally, the addition of TG enzyme leads to gelation of the emulsion. When the TG enzyme activity is 15 U/g, the total content of bound water and immobilized water in the emulsion gel is highest, leading to increased water holding capacity. The excellent 3D network structure enhances gel strength and TPA characteristics of BCMPEs. In conclusion, appropriate pH and ionic strength can enhance the stability of BCMPEs and the utilization of TG enzymes provides a theoretical basis for the design and preparation of Pickering emulsion gels.

Key words: Bighead carp Myosin Transglutaminase Pickering emulsion; Stability

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卡拉胶-普鲁兰多糖纤维膜对菲律宾蛤仔酶解物腥味物质的吸附机制研究

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摘要：为改良菲律宾蛤仔（*Ruditapes philippinarum*）酶解物的不良风味，本研究以 κ、λ 和 ι 三种卡拉胶（Carrageenan, Car）和普鲁兰多糖（Pullulan, PUL）为原料，利用静电纺丝技术制备纳米基纤维膜。X-射线光电子能谱中 S_{2p} 的存在表明卡拉胶与 PUL 成功混合制备出纳米纤维膜，脱腥后 O/C 的下降意味着酶解物中的风味化合物被纳米纤维膜有效吸附。气相色谱-离子迁移谱结果显示，κ、λ 和 ι-Car-PUL 纳米纤维膜对关键性腥味物质的总脱除率分别为 17.84%、25.55%和 29.20%。经多糖基纳米纤维膜吸附后关键腥味物质己醛和二甲基二硫醚的峰强度分别从 429.93、4893.03 降低至 103.68、1067.61。κ-Car-PUL 具有最高的疏水性（31.13°）和抗拉伸强度（4.33 MPa）。本研究为多糖基纳米纤维膜材料在水产品风味改良中提供了绿色环保的新途径。

关键词：静电纺丝；卡拉胶；菲律宾蛤仔酶解物；吸附

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Off-odor adsorption mechanism of carrageenan/pullulan nanofiber membranes for enzymatic hydrolysate of clam (*Ruditapes philippinarum*)

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Abstract: To mitigate the undesirable flavor of clam (*Ruditapes philippinarum)* enzymatic

hydrolysate, this study utilized electrospinning technology to prepare nanofiber membranes from three types of κ, λ, and ι-carrageenan (κ, λ, and ι-Car) and pullulan polysaccharide (PUL). The presence of S_{2p} in the X-ray photoelectron spectrum indicated successful co-preparation of nanofiber membranes from car and PUL. The decrease in O/C after deodorization signified that flavor compounds in the enzymatic hydrolysate were effectively adsorbed by the nanofiber membranes. Gas chromatography-ion mobility spectrometry results indicated that κ-, λ-, and ι-Car-PUL nanofiber membranes exhibited total removal efficiencies of 17.84%, 25.55%, and 29.20%, respectively, for key fishy odor compounds. After adsorption by the polysaccharide-based nanofiber membranes, the peak intensities of the key fishy odor compounds hexanal and dimethyl disulfide decreased from 429.93 and 4893.03 to 103.68 and 1067.61, respectively. κ-Car-PUL exhibited the highest hydrophobicity (31.13°) and tensile strength (4.33 MPa). This study provides an environmentally friendly approach for improving the flavor of aquatic products using polysaccharide-based nanofiber membranes materials.

Key words: Electrospin; Carrageenan; *Ruditapes philippinarum* enzymatic hydrolysate; Adsorption

柔性 V 型淀粉对牡蛎肽二元特征腥味物质的固相吸附作用机制研究

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摘要：食品风味通常与消费者的接受度相关，而水产品中异味气体的结合与相互作用机制在食品工业中发挥着重要作用。本研究利用柔性 V 型淀粉对牡蛎肽二元腥味体系（庚醛/1-辛烯-3-醇=4:0, 3:1, 2:2, 1:3 和 0:4, w/w）进行固相吸附。结果显示，1-辛烯-3-醇复合物（H/O=0:4）的包埋率和负载率均高于庚醛复合物（H/O=4:0），表明 1-辛烯-3-醇具有比庚醛更强的淀粉结合性能。在 1-辛烯-3-醇（H/O=3:1）的促进下，庚醛和淀粉之间的相互作用增强，产生协同效应，使得复合物对庚醛的包埋率和负载率分别从 2.55%和 2.53%（H/O=4:0）增加至 2.77%和 3.51%。分子动力学模拟结果表明，1-辛烯-3-醇的加入增加了庚醛与淀粉的结合自由能和氢键数量，促进了庚醛与淀粉的结合，证实了其协同复合作用。V 型淀粉与二元腥味体系的协同作用为水产品中风味的定向调控与脱腥技术的开发提供理论依据。

关键词：V 型淀粉；牡蛎肽；二元腥味体系；吸附作用；分子动力学模拟

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The synergistic adsorption mechanism of V-type starch on the binary characteristic odor compounds of oyster peptides

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Abstract: Flavor is usually related to consumer acceptance, and the combination encapsulation and interaction mechanisms of off-odors in aquatic products play an important role in the food industry. The flexible V-type starch was utilized to adsorb binary off-odor compounds in oyster peptides at varying ratios (heptanal and 1-octen-3-ol=4:0, 3:1, 2:2, 1:3 and 0:4, w/w) in a solid environment. The results revealed that both the encapusltion rate and loading rate of the 1-octen-3-ol complex (H/O=0:4) were higher than those of the heptanal complex (H/O=4:0), suggesting that 1-octen-3-ol exhibits a stronger starch-binding capacity than heptanal. Facilitated by 1-octen-3-ol (H/O=3:1), the interaction between heptanal and starch is strengthened, leading to a synergistic effect. As a result, the encapusltion and loading rates of the complexes material for heptanal rise from 2.55% and 2.53% (H/O=4:0) to 2.77% and 3.51%, respectively. Molecular dynamics simulation results demonstrated that the incorporation of 1-octen-3-ol enhances the binding free energy and the number of hydrogen bonds between heptanal and starch, thereby facilitating their binding and confirming its synergistic complexation effect. The synergistic interaction between V-type starch and the binary fishy odor system offers a theoretical foundation for the precise flavor regulation and the advancement of deodorization techniques in aquatic products.

Key words: V-type starch; Oyster peptide; Binary off-odor system; Adsorption; Molecular dynamic simulation

卡拉胶膜网络结构和理化性质的温度调控机制研究

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摘要：本研究通过探究凝胶化温度与干燥温度对卡拉胶膜网络结构及理化性质的影响，揭示其温度调控机制。将 95 ℃ 加热溶解的 κ-卡拉胶溶液分别放在-20 ℃、0 ℃、10 ℃ 和 20 ℃ 下凝胶化处理 60 min，随后放在 40 ℃ 下干燥，制备得到凝胶化-低温干燥卡拉胶膜；作为对比，将加热溶解后的卡拉胶溶液直接于 60 ℃ 和 80 ℃ 下干燥，制得高温干燥卡拉胶膜。电子显微镜观察表明，经 10 ℃ 凝胶化处理的低温干燥卡拉胶膜具有高度有序的网络结构，且膜表面光滑平整；而经 60 ℃ 和 80 ℃ 高温直接干燥的膜中则出现大量聚集物，并伴有表面盐析现象。理化性质测定结果显示，经 10 ℃ 凝胶化处理的低温干燥卡拉胶膜的抗拉伸强度（81.66 MPa）、熔融转变温度（146.10 ℃）和溶胀率（3974.25%）均最高；而 80 ℃ 直接干燥膜的断裂伸长率（32.40%）显著高于其他组。研究结果表明，适当的凝胶化处理结合低温干燥有助于卡拉胶形成有序三维网络结构，从而改善膜性能，而高温干燥则阻碍网络结构形成。本研究为卡拉胶膜的结构调控与性能优化提供了理论依据。

关键词：κ-卡拉胶膜；凝胶化温度；干燥温度；结构调控

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Molecular dynamic simulation elucidates temperature- and pH-dependent film-forming mechanisms of soybean β-conglycinin and glycinin

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Abstract: The effects of temperature (25–95 °C) and pH (7.0–9.0) on the film-forming mechanisms of soybean β-conglycinin (7S) and glycinin (11S) were investigated using molecular dynamics (MD) simulations and experimental validation. All MD simulations achieved equilibrium within 50 ns.

The elevated temperatures and lower pH conditions reduced the center-of-mass distance and the radius-of-gyration (Rg) between 7S and 11S, while increasing hydrogen bond formation and binding free energy. Solvent-accessible surface area decreased with temperature, while root-mean-square fluctuation remained stable at pH 7.0 but increased with temperature at pH 9.0. The 7S-11S films prepared at higher temperatures exhibited enhanced tensile strength and higher proportion of hydrophobic interactions. With increasing temperature of the 7S-11S solution, the elongation at break increased at pH 7.0, but initially increased and then decreased at pH 9.0. Fourier transform infrared spectra revealed that hydrogen bonds and β-sheet structures increased with increasing temperature. In conclusion, heating the film-forming solution at pH 7.0 promoted 7S-11S molecular interactions, thereby improving the mechanical properties.

Key words: Soybean glycinin; Interaction; Molecular dynamics simulation; Protein films; pH; Temperature

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琼胶寡糖对冻藏南美白对虾肌肉品质特性的影响

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摘要：目的：考察琼胶寡糖对冻藏南美白对虾肌肉品质特性的影响。方法：将新鲜南美白对虾分别浸泡在蒸馏水、1.5%和3.0%琼胶寡糖、1.5%和3.0%三聚磷酸钠溶液中，冻藏0、20、40、60、80和100 d，分别测定其解冻损失率、蒸煮损失率、pH值、L^*值、水分活度、水分含量、质构、肌原纤维蛋白含量、Ca^{2+}-ATPase活性、羰基含量、各化学键含量、活性巯基和总巯基含量等指标。结果表明，随着冻藏时间增加，南美白对虾蒸煮损失率、解冻损失率、L^*值、羰基和疏水键含量增加；弹性、咀嚼性、水分活度、水分含量、肌原纤维蛋白、离子键、氢键、活性巯基和总巯基含量降低；pH值呈先下降再上升趋势。其中，琼胶寡糖和三聚磷酸钠组各个指标的检测结果均优于蒸馏水组，以高浓度效果更佳。结论：琼胶寡糖能显著改善冻藏南美白对虾肌肉品质特性。本研究为新型无磷抗冻剂的开发与应用提供思路和理论支撑。

关键词：南美白对虾；琼胶寡糖；品质特性；肌原纤维蛋白

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基于漂洗工艺优化的鲟鱼糜溶胶冻藏稳定性研究

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摘要：以西杂鲟鱼【 西伯利亚鲟（Acipenser baeri）与施氏鲟（Acipenser schrenckii）的杂交品种】为原料制备鱼糜溶胶，探究不同漂洗工艺（漂洗次数 0、1、2、3 次及三级逆流漂洗）对鲟鱼糜溶胶冻藏稳定性的影响。对不同漂洗工艺处理的样品，测定其冻藏期间持水力、凝胶强度、质构特性、蛋白组成、总巯基含量、羰基含量、Ca^{2+}-ATPase 活性、TBARs 值、挥发性风味物质等指标，综合评价其品质变化。实验结果表明，漂洗工艺通过减少诱导蛋白变性、脂质氧化及异味产生的因子，可有效抑制冻藏过程中鱼糜溶胶的品质劣化，较好地保持其原有的质构特性与风味稳定性。与传统漂洗工艺相比，三级逆流漂洗工艺在有效提高样品冻藏稳定性的同时可显著减少耗水量，具有重要的应用推广价值。

关键词：鲟鱼；鱼糜溶胶；漂洗；逆流漂洗；冻藏稳定性

基金项目：江苏现代农业产业技术体系（JATS [2023] 464）

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雨生红球藻渣抗氧化肽制备及功能活性探究

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摘要:雨生红球藻渣是提取虾青素后的副产物，富含蛋白质等营养物质，尚未得到充分利用。本研究旨在以雨生红球藻渣为原料，酶法制备新型抗氧化肽，并对其稳定性、肽序列以及体内活性进行解析。结果表明，中性蛋白酶为最佳蛋白酶，且确定了最优酶解条件。分子量低于 5 kDa 的肽段表现出更好的抗氧化活性和良好的 pH、热以及耐胃肠道消化稳定性。基于 LC-MS/MS、分子对接和体外活性验证，筛选出三种具有高抗氧化活性的新型肽。动物研究表明，雨生红球藻渣抗氧化肽能显著改善衰老小鼠肝损伤，提高免疫低下小鼠免疫力，并缓解雷公藤甲素诱导的雄性小鼠生殖障碍。我们的研究结果为雨生红球藻渣高价值利用以及新型抗氧化活性肽的开发提供了理论依据。

关键词：雨生红球藻渣；抗氧化肽；肝损伤；免疫力；生殖

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Preparation of antioxidant peptides from *Haematococcus pluvialis* residue and exploration of the functional activities

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Abstract: *Haematococcus pluvialis* (*H. pluvialis*) residue is a by-product of astaxanthin extraction and has not been sufficiently utilized. Herein, we aimed to prepare novel antioxidative peptides from *H. pluvialis* residue by enzymatic hydrolysis and evaluate the stability, peptides sequence and *in vivo* activities. The results indicated that neutral protease was the best protease and the optimal enzymatic conditions was determined. Peptides fractions with molecular weights below 5 kDa showed better antioxidant activity and excellent pH, thermal and gastrointestinal digestion stability. Three novel

peptides with high antioxidant activity were screened based on LC-MS/MS, molecular docking and *in vitro* activity validation. Animal studies indicated that the antioxidative peptides from *H. pluvialis* residue improved liver injury in aging mice, enhanced the immunity of mice with immunodeficiency, and alleviated triptolide induced reproductive demage in male mice. Our findings provide theoretical basis for the high-value utilization of *H. pluvialis* residue and exploitation of novel antioxidant peptides.

Key words: *Haematococcus pluvialis* residue; antioxidant peptides; liver injury; immunity; reproduction

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褐藻胶-多酚复合物的提取分离纯化、结构表征及其体外抗氧化活性的研究

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摘要：褐藻胶-多酚复合物具有多种生物活性，酚糖复合物具有重要的研究意义。本研究以海带为原料，采用复合酶法提取褐藻胶-多酚复合物，通过单因素实验和响应面分析法优化提取工艺，并利用大孔树脂 NKA-9 对粗提物进行分离纯化，进一步对所得组分进行结构表征与体外抗氧化活性分析。结果表明，最优提取工艺条件为：纤维素酶添加量 3.32%，果胶酶添加量 2.14%，木瓜蛋白酶添加量 0.92%，料液比 1:70.66，时间 6 h，pH 5.5，温度 55 ℃。在此条件下，酚含量为 1177.70±6.14 mg PE/100 g DW，糖含量为 95.06±0.44%，提取率为 18.91±0.34%，复合物提取效果良好。粗提物经大孔树脂 NKA-9 纯化后得到两个组分 AP-1 和 AP-2，其中 AP-1 的酚含量和提取率较高，分别为 1279.31±38.83 mg PE/100g DW，25.57±1.65%；AP-2 糖含量较高，为 71.09±1.55%。光谱分析显示，样品在 280 nm 处无蛋白特征吸收峰，且在 1256 cm^{-1} 处均出现 C-O-C 伸缩振动特征峰。体外抗氧化实验表明，粗提物对羟基自由基清除率最高，达 86.93%；AP-1 在超氧阴离子清除（44.40%）和铁离子还原能力（0.072 mmol Fe^{2+}/mL）方面表现较好。本研究为褐藻胶-多酚复合物在功能食品的应用提供了理论依据。

关键词：褐藻胶-多酚复合物；提取工艺；响应面；结构表征；抗氧化活性

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Research on extraction, separation and purification, structural characterization and in vitro antioxidant activity of Alginate-polyphenol conjugates

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Abstarct: Alginate-polyphenol conjugates exhibit diverse biological activities, and such phenol-polysaccharide complexes are recognized to be of significant research interest. In this study, *Saccharina japonica* was used as the raw material for extracting alginate-polyphenol conjugates through a complex enzymatic method. The extraction process was optimized using single-factor experiments and response surface methodology (RSM). The crude extract was subsequently separated and purified with macroporous resin NKA-9, followed by structural characterization and in vitro antioxidant activity analysis of the resulting fractions.The optimal extraction conditions were determined as follows: cellulase addition 3.32%, pectinase addition 2.14%, papain addition 0.92%, solid-to-liquid ratio 1:70.66, duration 6 h, pH 5.5, and 55℃. Under these conditions, the phenolic content reached 1177.70±6.14 mg PE/100 g DW, the sugar content was 95.06±0.44%, and the extraction yield was 18.91±0.34%, indicating efficient extraction of the conjugates. After purification with NKA-9 resin, two fractions AP-1 and AP-2 were obtained. AP-1 showed higher phenolic content and extraction yield, measuring 1279.31±38.83 mg PE/100 g DW and 25.57±1.65%, respectively, while AP-2 exhibited a higher sugar content of 71.09±1.55%. Spectral analysis revealed no characteristic protein absorption peak at 280 nm, but a distinct C-O-C stretching vibration peak was observed at 1256 cm^{-1}. In vitro antioxidant assays indicated that the crude extract possessed the highest hydroxyl radical scavenging activity at 86.93%. Meanwhile, AP-1 demonstrated superior superoxide anion radical scavenging capacity (44.40%) and ferric reducing antioxidant power (0.072 mmol Fe^{2+}/mL). This study provides a theoretical foundation for the application of alginate-polyphenol conjugates in functional foods.

Keywords:alginate-polyphenol conjugates; extraction methods; response surface; antioxidant activity; structure characterization

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超高压牡蛎开壳机理研究

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摘要：目前，牡蛎开壳主要采用人工开壳采肉的方式，生产效率低，产品破损率高，制约了牡蛎的精深加工产业发展。本研究应用超高压技术进行牡蛎开壳研究，探究超高压处理对牡蛎开壳效果及其肌原纤维蛋白结构与性质的影响。结果表明，随着超高压压力的上升，牡蛎开壳率也随之提高，在 250 MPa 时牡蛎开壳率可达 90%以上；对超高压牡蛎理化性质进行检测，结果表明，肌原纤维蛋白含量、总巯基和 Ca^{2+}-ATPase 活性显著下降，羰基含量和表面疏水性显著上升，蛋白质氧化变性和结构破坏加剧，尤其在 350 MPa 时变化最为显著。因此，超高压处理可通过破坏蛋白质结构和分子间作用力促进牡蛎开壳，这也为超高压在牡蛎开壳应用提供了理论基础。

关键词：超高压；牡蛎；肌原纤维蛋白；蛋白质结构；开壳机理

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大黄鱼鲜味肽的制备及呈味特性研究

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摘要：【目的】为解决大黄鱼加工碎鱼骨肉等副产物利用率低、资源浪费及环境压力等问题，并响应食品工业对天然鲜味物质日益增长的需求，本研究旨在从大黄鱼碎鱼骨肉中提取和鉴定具有高价值的新型鲜味肽，并系统评价其呈味特性和应用潜力。【方法】以大黄鱼加工副产物为原料，以水解度与鲜味强度为考核指标，通过单因素实验和响应面法优化筛选最佳酶解参数；采用膜分离技术对酶解产物进行分级纯化，利用 LC-MS/MS 进行肽段序列鉴定，构建多肽库，并通过计算机虚拟筛选（包括可溶性、毒性和呈味活性预测）及分子对接技术靶向筛选潜在鲜味肽；最后通过固相合成获得候选鲜味肽，并借助感官评价、电子舌分析、滋味轮廓评价及添加实验，系统评估其呈味特征、增鲜效果及在减盐模型中的应用表现。【结果】风味蛋白酶为最适酶，最优酶解条件为：加酶量 1611 U/g、料液比 1:10(g/mL)、pH 8.1、温度 48 ℃、时间 5 h，该条件下鲜味强度达 14.79±0.03，水解度为 42.61±0.36%；经过超滤膜分离获得的组分 UF1（<1 kDa）鲜味最强、苦味最低，风味品质显著优于其他组分（P<0.01）；从中鉴定出 1448 条肽段，经虚拟筛选获得 41 条潜在鲜味肽，进一步通过分子对接筛选出结合得分最高的 5 条肽段；固相合成 5 条鲜味肽（代号分别为 1M 肽、2V 肽、3W 肽、4S 肽、5G 肽），其鲜味阈值介于 0.107~1.055 mmol/L 之间，单均低于 MSG（1.6 mmol/L），增鲜阈值范围为 0.127~2.743 mmol/l；其中三条肽段对 MSG 具显著增鲜效果（14.22﹣29.84%），2V 肽的增鲜效果最佳；在减盐 12.5%模型中，5 条肽均能提升咸味与鲜味强度，S4 肽的增咸率和增鲜率分别为 60.29%和 33.23%，效果最为突出。【结论】本研究成功从大黄鱼加工副产物中提取并鉴定出多条具有高鲜味强度的活性肽，其中部分肽段具备显著增鲜和增咸潜力，不仅为水产品副产物高值化利用提供了可行路径，也为开发天然风味增强剂和低盐健康食品提供了理论依据与技术支撑。

关键词：大黄鱼；鲜味肽；分离纯化；呈味特性

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Effects of Drying Techniques on the Volatile Flavor Profile of Triploid Fujian oysters *Crassostrea angulata*

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Abstract: Oysters are nutrient-rich and flavor-distinctive, yet highly perishable. Drying extends shelf life and enriches flavor, however, its precise role in shaping the characteristic flavor of dried oysters remains poorly understood. This study systematically evaluated the effects of four drying techniques—sun drying (SD), vacuum drying (VD), hot-air drying (HAD), and far-infrared assisted hot-air drying (FIRHAD)—on the flavor formation of triploid Fujian oysters (*Crassostrea angulata*). Headspace solid-phase microextraction gas chromatography-mass spectrometry (HS-SPME-GC-MS), lipid oxidation indices (POV, TBARS, TOTOX), and fatty acid profiling, in combination with odor activity value (OAV) quantification and partial least squares–discriminant analysis (PLS-DA) multivariate statistics, were employed to unveil the mechanism of dried oyster characteristic flavor formation. The results showed that drying markedly accelerated lipid oxidation and the Maillard reaction, generating key volatile compounds including aldehydes, ketones, and alcohols. Concentrations of key odorants (OAV ≥ 1) increased significantly, notably (E,E)-2,4-heptadienal (nutty), 1-octen-3-ol (mushroom-like), and 2-undecanone (fresh, green). In addition, FIRHAD exhibited the most intense aroma profile, albeit with higher degree of lipid oxidation. These findings provide a robust theoretical foundation for optimizing drying technologies and developing high-quality dried oyster products.

Key words: Dried oyster; Triploid *Crassostrea angulata*; Drying techniques; Lipid oxidation; Volatile flavor profile

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In-situ NIR monitoring of acid value during enzymatic deacidification of squid oil

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Abstract: Squid oil is rich in ω-3 fatty acids (EPA+DHA ≥ 20 %), but high acid value makes it prone to oxidative deterioration. Conventional alkali refining causes substantial neutral-oil losses and environmental pollution, whereas enzymatic deacidification is eco-friendly; however, the absence of real-time acid value feedback results in prolonged reaction, over-deacidification or residual acidity above specification. In this study, squid oil with high acid value was processed with an in-house optimised Lipozyme 435-ethanol esterification system, whereas the near-infrared spectra (4800–10000 cm^{-1}) of oil samples were collected in situ. After six preprocessing algorithms (SG, MSC, etc.) combined with successive projections algorithm (SPA) variable selection, an NIR-PLS models for acid value was established. The MSC full-spectrum model performed the best, with Rc^2 and $Rp^2 \geq 0.99$, RMSEP of 0.68, demonstrating high accuracy and stability. This strategy provides a real-time, non-destructive and on-line quality-control solution for the green refining of marine oils.

Key words: NIR spectroscopy; enzymatic deacidification; squid oil; acid value; in-line monitoring

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Virtual screening and evaluation of bioactive peptides from *Haliotis discus hannai* as potential HMGCR inhibitors for hyperlipidemia treatment

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Abstract: Hyperlipidemia remains a major disease threatening global public health. The morbidity and mortality associated with cardiovascular diseases have been increasing. The inhibition of 3-Hydroxy-3-methylglutaryl-coenzyme A reductase (HMGCR), a key enzyme in the cholesterol synthesis pathway, can effectively reduce cholesterol levels. In this study, the most suitable protease for preparing HMGCR inhibitory peptides was screened using the evaluation indexes of peptide yield and HMGCR inhibition rate. Peptide sequences with molecular weights < 1 kDa were identified, and peptide fragments were docked with HMGCR for virtual screening. The inhibitory effects of these peptides on HMGCR activity were evaluated *in vitro* using a high-fat Hep-G2 cell model. The screened peptides possessed significant HMGCR inhibitory activity and reduced cholesterol micelle solubility and total cholesterol and triglyceride levels in hyperlipidemic Hep-G2 cells. This study provides novel insights into developing natural drugs for hyperlipidemia; moreover, the results will facilitate the functional application of marine bioactive peptides.

Keywords: Hyperlipidemia, 3-Hydroxy-3-methylglutaryl-coenzyme A reductase, Virtual Screening,Bioactive Peptides, *Haliotis discus hannai*

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超声波对半干盐渍仿刺参复水特性影响研究

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摘要：海参因其营养价值高备受关注，但干海参传统复水工艺耗时长、效率低，制约了海参的规模化生产。本项目应用超声波辅助开展海参复水工艺研究，通过 Box-Behnken 中心组合设计，以超声功率、温度和时间为参数，建立二次多项式回归模型优化半干盐渍仿刺参复水工艺，研究复水过程水分迁移规律及微观结构变化。结果表明，超声波辅助复水各因素对复水效果的影响程度依次为超声功率＞作用时间＞处理温度；最佳工艺为超声波功率 400 W、温度 50 ℃，复水处理时间 83 min，复水时间缩短至 72 h，复水比达 2.103，与模型预测值误差小于 5%；超声波的空化效应促使半干盐渍仿刺参形成空间网络结构，显著提升吸水率。研究表明，超声波处理能够加快海参的水发时间，提升海参水发效率，为海参复水工艺优化提供理论依据。

关键词：半干盐渍仿刺参；复水特性；超声波辅助；预测模型

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Preparation of Takifugu Flavidus Small Molecular Peptides and Screening of Anti-fatigue Peptides and Molecular Docking Studies

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Abstract :[Objective] The study aimed to prepare potential anti-fatigue small molecular peptides from *Takifugu flavidus* testis. [Methods] The optimal process parameters were determined based on the degree of hydrolysis by single-factor and response surface methodology. To isolate specific peptides, ultrafiltration was employed, and the antioxidant properties of various peptide fractions were assessed and analyzed for their anti-fatigue activity in vitro. The best activity of the components was identified by using LC-MS/MS mass spectrometry through peptide sequencing, virtual screening, and molecular docking to explore the potential anti-fatigue activity of peptides. [Results] Results indicated that the ideal conditions for peptide formation involved an enzymolysis temperature of 54.15 ℃, an enzymolysis period of 4.12 h, an enzyme dosage of 10216.38 U/g, a liquid - material ratio of 13.99 : 1 (mL : g) and the degree of hydrolysis was 38.059 %. Ultrafiltration revealed that peptides with molecular weights below 1 kDa exhibited substantial antioxidant activity demonstrated by their DPPH, OH^-, and superoxide anion radical scavenging rates, with IC_{50} values of 8.941 mg/mL, 12.15 mg/mL and 7.578 mg/mL, respectively. Among the 1510 peptide sequences analyzed, 4 active pentapeptides (1D hexapeptide, 2D hexapeptide, 3F hexapeptide and 4F heptapeptide) were identified, which formed a stable complex with LDH, CK, and Nrf2 protein through hydrogen bonds and hydrophobic interactions. [Conclusion] This study provides a theoretical foundation for the development of high-quality, low-bitterness, walnut-derived antioxidant peptides. The study optimized the preparation process of speptides from Takifugu flavidus testis and screened potential anti-fatigue small molecular peptides, which provided a theoretical foundation for the development of high-value anti-fatigue peptides derived from Takifugu flavidus.

Key words: Takifugu flavidus testes; papain; anti-fatigue; small molecular peptides; molecular docking

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暗纹东方鲀（*Takifugu fasciatus*）鱼皮促胶原生成肽的筛选及其作用机制

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摘要：目的：鱼源胶原肽具有延缓皮肤衰老和增加皮肤胶原蛋白含量功效，本研究以暗纹东方鲀（*Takifugu fasciatus*）鱼皮为原料筛选出促胶原合成多肽并探究其抗衰机制。**方法：**本研究采用生物酶酶解获得暗纹东方鲀鱼皮胶原肽，通过 I 型胶原蛋白 ELISA 测定筛选对细胞胶原蛋白合成具有最佳促进作用的胶原肽，利用 UVB 辐照 L929 细胞模型，以 ROS、β-半乳糖苷酶染色实验评价鱼皮胶原肽的抗光老化功效。通过斑马鱼尾鳍实验，从体内水平验证鱼皮胶原肽对 UVB 辐照斑马鱼尾部修复情况。通过探究多肽修复 L929 细胞胶原生成信号通路相关蛋白表达分析其抗皱机制。**结果：**经碱性蛋白酶酶解胶原肽可显著促进 UVB 诱导 L929 细胞 I 型胶原的含量，并显著清除细胞内 ROS，有效减少细胞内β-半乳糖苷酶含量，缓解 UVB 引起的 L929 细胞衰老；Western blotting 结果显示胶原肽可显著上调 TGF-β/Smad 信号通路中 TGF-β、Smad4 蛋白表达；体内实验证明胶原肽对 UVB 辐射后的斑马鱼尾鳍均具有显著修复能力，修复率最高达 18.79%。**结论：**本研究揭示了暗纹东方鲀鱼皮胶原肽具有促进细胞胶原生成以及抗光老化功效，为后续促胶原再生序列及其作用机制的阐明提供理论基础，为河鲀源胶原多肽在抗光老化化妆品及功能性食品行业中潜在应用价值提供技术支撑，对实现河鲀的高值化利用具有产业化意义。

关键词：暗纹东方鲀；胶原多肽；促胶原生成；成纤维细胞；斑马鱼

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Screening and Mechanism of Collagen-Promoting Peptides Derived from *Takifugu fasciatus* Fish Skin

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Abstract :**Objective:** Given the efficacy of fish-derived collagen peptides in delaying skin aging and enhancing collagen content, this study aimed to screen for collagen-synthesis-promoting peptides from *Takifugu fasciatus* skin and elucidate their anti-aging mechanisms. **Methods:** Collagen peptides were obtained via enzymatic hydrolysis of *T. fasciatus* skin. The optimal peptide fraction for stimulating cellular collagen synthesis was identified using a Type I collagen ELISA assay. An UVB-irradiated L929 cell model was employed to evaluate the photoprotective effects of these peptides through ROS detection and β-galactosidase staining. In vivo validation was conducted via zebrafish caudal fin experiments to assess tail repair post-UVB exposure. Western blotting analyzed protein expression in collagen-generating signaling pathways to uncover anti-wrinkle mechanisms. **Results:** Alkaline protease-hydrolyzed peptides significantly increased Type I collagen levels in UVB-induced L929 cells, reduced intracellular ROS, and decreased β-galactosidase activity, mitigating cellular senescence. Western blot revealed upregulated TGF-β/Smad pathway proteins (TGF-β, Smad4). In vivo, peptide treatment achieved up to 18.79% repair efficiency in UVB-damaged zebrafish fins. **Conclusion:** *T. fasciatus* skin-derived collagen peptides demonstrate pro-collagenogenic and photoaging-resistant properties. This study provides theoretical insights into collagen-regenerating sequences and technical support for their application in anti-photoaging cosmetics and functional foods, advancing high-value utilization of pufferfish resources.

Key words: *Takifugu fasciatus*; collagen peptide; collagen-synthesis-promoting; fibroblasts; zebrafish

重组海带夹心薄片脆的加工工艺优化

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摘要：为了促进海带这一重要的经济藻类的利用，本研究利用海带中多糖褐藻胶的凝胶特性对海带进行打碎重组，开发一种新型海带重组食品—夹心薄片脆。以感官评分、质构和风味为指标，通过单因素和正交优化试验，比较不同加工工艺对重组海带夹心薄片脆的影响。结果表明，重组海带夹心薄片脆产品的最佳加工工艺条件为料液比1：3、研磨时间5 min、涂膜厚度35 g和烤箱130℃烘烤5 min，辅料配方为大豆蛋白添加量0.4%、麦芽糊精0.4%、碳酸氢钠0.8%和面粉添加量0.9%，调味配方为盐添加量0.3%、糖添加量4%和酱油添加量0.3%、麦芽糖浆1.2%和白芝麻0.5%。该条件下制备的重组海带夹心薄片产品口感酥脆，感官品质良好，腥味较低具有较好的烘烤风味。

关键词：海带；重组食品；薄片脆；加工工艺

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疣吻沙蚕（*Tylorrhynchus heterochaetus*）抗凝血肽的提取及其抗凝活性研究

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摘要：目的：沙蚕体内含有多种不同机制的天然抗血栓活性成分，疣吻沙蚕作我国南方主要养殖品种，其抗血栓活性成分研究仍为空白。本研究以疣吻沙蚕（*Tylorrhynchus heterochaetus*）为原料，深入挖掘疣吻沙蚕抗凝血肽并验证其抗凝功效。**方法：**本研究定向酶解和膜分离获得疣吻沙蚕抗凝血活性肽（T. heterochaetus anticoagulant peptide，THAP），优化最佳提取工艺条件，并通过兔血和贫血小板血浆实验从体外水平验证抗凝活性。**结果：**通过滴定实验可以得知风味蛋白酶酶解沙蚕酶解液具有显著抗凝活力，以抗凝活力为指标，通过单因素实验、正交实验得到了最优工艺条件为酶解温度 50.87 ℃，pH 7.46，加酶量 5000 U/g，料液比 1:41.5，酶解时间 5h。利用超滤获得不同分子量疣吻沙蚕抗凝肽，其中 THAP-H（＞5000da）具有最强的抗凝活性。凝血四项实验表明沙蚕抗凝肽可能通过干扰凝血因子Ⅱ、Ⅴ、Ⅶ和Ⅹ或直接抑制凝血酶达到抗凝的作用。**结论：**本研究明确了 THAP 最佳提取工艺，并初步探究其抗凝活性及机制，为深度发掘疣吻沙蚕潜在抗血栓应用价值及其高质化规模化开发提供理论依据。

关键词：疣吻沙蚕；抗凝血肽；抗凝活性

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Extraction and Anticoagulant Activity Study of Peptides from *Tylorrhynchus heterochaetus*

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Abstract: Objective: Polychaete worms harbor diverse natural antithrombotic components with distinct mechanisms. Despite being a major cultivated species in southern China, the thrombogenic activity of *Tylorrhynchus heterochaetus* remains unexplored. This study aimed to identify and validate anticoagulant peptides from this species. **Methods:** Directed enzymatic hydrolysis combined with membrane separation was employed to isolate T. heterochaetus anticoagulant peptide (THAP). Optimal extraction conditions were optimized via single-factor experiments and orthogonal array design, followed by in vitro validation using rabbit blood and platelet-poor plasma assays. **Results:** Flavorzyme-mediated hydrolysis yielded significant anticoagulant activity. The optimized parameters included hydrolysis at 50.87° C, pH 7.46, enzyme dosage of 5000 U/g, solid-liquid ratio of 1:41.5, and 5 h duration. Ultrafiltration fractionated peptides by molecular weight, with THAP-H (>5000 Da) exhibiting the strongest anticoagulant efficacy. Coagulation profile analysis suggested interference with coagulation factors II, V, VII, X, or direct thrombin inhibition. **Conclusion:** This study establishes the optimal THAP extraction protocol, elucidates its anticoagulant mechanism, and provides a theoretical foundation for exploring the therapeutic potential and large-scale development of T. heterochaetus-derived antithrombotic resources.

Key words: *Tylorrhynchus heterochaetus*; anticoagulant peptide; anticoagulant activity

花胶加工过程中 SEM 产生的机理机制研究

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摘要：花胶（FM）是鱼鳔的干制品，是我国的传统滋补产品。前期研究结果表明，花胶经漂白处理后，氨基脲(SEM)含量显著增加，影响了其食用安全性。本研究以巴沙鱼（*Pangasius bocourti*）鱼鳔（BFM）为原料，研究在不同 H_2O_2 处理条件下 SEM 的产生规律以及对胶原蛋白理化性质的影响，并结合非靶向代谢组学探究 SEM 的产生机理。结果表明：H_2O_2 的浓度、浸泡温度和时间与 BFM 中 SEM 的产生量呈正相关，在酸性条件下（pH 值<7）SEM 产生量较低，随着 pH 值的升高，花胶中 SEM 含量显著增加；H_2O_2 处理使 BFM 呈现紧密排列的纤维网状结构，质构特性显著提高；胶原蛋白的 α 链和三级结构被破坏，胶原蛋白含量降低。非靶向代谢组学分别在正负离子模式下筛选到 571 和 361 个差异代谢物，KEGG 富集结果显示差异代谢物主要富集在脂肪酸氧化、氨基酸代谢相关通路，涉及丙酮酸代谢、不饱和脂肪酸的生物合成以及组氨酸、甘氨酸、精氨酸等氨基酸的代谢，表明 H_2O_2 处理对 BFM 中的脂质、氨基酸等具有氧化应激作用。验证实验证明部分氨基酸可经 H_2O_2 氧化代谢产生 SEM。本研究提出了花胶加工过程中 SEM 产生的机理机制，可以为花胶的安全生产提供理论依据。

关键词：花胶；漂白；氨基脲；非靶向代谢组学

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Plasma exosomes as modulators of tetrodotoxin distribution in *Takifugu bimaculatus*: Implications for safety in pufferfish-based food products

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Abstract: The objective of this study was to investigate the potential role of exosome-mediated microRNA regulation in the transport and bioaccumulation of tetrodotoxin (TTX) in *Takifugu bimaculatus*, specifically the skin, liver, and ovary. An oral TTX exposure model was established to analyze the temporal distribution of TTX in key tissues. Transcriptome sequencing was performed on plasma exosomes collected within 4 hours after TTX administration, followed by qPCR validation to identify differentially expressed microRNAs. Functional enrichment analyses, including Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) pathways, were conducted to explore the biological roles of target genes of these microRNAs. Tissue-specific expression profiling was further employed to identify genes associated with TTX accumulation. A total of 10 differentially expressed microRNAs were identified in plasma exosomes following TTX exposure. Functional enrichment analysis indicated that the target genes of these microRNAs are primarily involved in energy metabolism, biofilm assembly, and transmembrane transport. Tissue-specific profiling revealed multiple target genes correlated with TTX accumulation, highlighting key pathways implicated in toxin enrichment. The results suggest that *T. bimaculatus* utilizes an exosome-mediated microRNA regulatory network to coordinate an “exosome-membrane transport” system for TTX transport and accumulation. This study offers novel insights into the molecular mechanisms of TTX transport and enrichment and provides important theoretical foundations for enhancing food safety risk control through monitoring and regulation of toxin levels in puffer fish.

Keywords: Tetrodotoxin; *Takifugu bimaculatus*; Exosome; microRNA; Food safety

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三疣梭子蟹原肌球蛋白分离纯化方法优化

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摘要：目的：原肌球蛋白(tropomyosin，TM)是三疣梭子蟹(*Portunus trituberculatus*)中最主要的过敏原，可引发严重的食品安全问题，TM 的分离纯化对于系统准确地鉴定和控制过敏具有重要的意义。因此，本研究以三疣梭子蟹为研究对象，优化 TM 分离纯化的方法。方法：分析提取液 A 和提取液 B 的抽提时间及次数、不同脱脂试剂、硫酸铵浓度对 TM 纯度的影响。结果：提取液 A 瞬时抽提 30 min 重复 3 次、提取液 B 过夜抽提、正丁醇脱脂和硫酸铵饱和度 50%时，可有效分离纯化 TM，回收率达 11.47%。质谱鉴定该蛋白的 uniprot 数据库登录号为 ABS12234.1，确定该蛋白为三疣梭子蟹原肌球蛋白，相对分子量为 32.8 kDa。结论：该方法缩短提取时间，且 TM 纯度较高，适用于实验室少量制备。

关键词：三疣梭子蟹; 原肌球蛋白; 分离纯化

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干燥方式对鮰鱼鱼鳔理化特性及风味品质的影响

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摘要：鱼鳔富含胶原蛋白且脂肪含量低，是一类营养价值高的滋补食品，多作为干制品进行销售。为探究鱼鳔的高质、高效干制方法，研究了自然晾晒（ND）、热风干燥（HD）、液氮冷冻干燥（FD）对鮰鱼鱼鳔理化特性和品质的影响。通过测定水分状态、复水率、质构、微观结构等指标，明确干制鱼鳔理化特性；采用 GC-IMS、电子舌测定，阐明不同干燥过程下鱼鳔风味物质的演变规律，综合表述干燥对鮰鱼鱼鳔的品质调控作用。结果表明，FD 鱼鳔表面呈乳白色，含水率均低于 6%，形成了疏松多孔的结构；ND 和 HD 鱼鳔外观呈黄色半透明，含水率大于 12%，微观结构的坍塌减弱了干燥中后期的速率；对干燥动力学模型进行回归拟合，验证了 Page 模型可用于描述不同干燥过程中的水分变化过程。FD 有效保留了鱼鳔胶原蛋白成分，其含量为 0.79 g/g，高于 ND 和 HD 组；FD 鱼鳔复水率高、复水速率高，且复水后质构柔软，具有较佳的食用口感。相比于 ND、HD 组，FD 鱼鳔具有更高浓度的 3-甲基丁醛、3-甲基-2-丁烯醛、甲基异丁基酮等风味物质，保持了鱼鳔的特征风味。因此，FD 处理为鮰鱼鱼鳔的高质量干燥提供了新的思路，具有较强的应用前景。

关键词：鱼鳔；干燥特性；复水特性；胶原蛋白；风味物质

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The effects of drying methods on the physicochemical characteristics and flavor quality of fish swim bladder from Chinese longsnout catfish

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Abstract: Fish swim bladder (FSB) is rich in collagen and low in fat, making it a type of tonic food with high nutritional value. FSBs are mostly sold as dried products. To explore high-quality and

efficient drying methods for FSBs, this study investigated the effects of natural drying (ND), hot air drying (HD), and liquid nitrogen freezing with freeze-drying (FD) on the physicochemical characteristics and quality of FSBs from Chinese longsnout catfish. The physicochemical properties of dried FSBs were obtained by determining moisture state, rehydration rate, texture, and microstructure. Gas Chromatography-Ion Mobility Spectrometry (GC-IMS) and E-tongue were used to clarify the evolution of flavor compounds in FSBs during different drying processes. The regulatory effect of the drying process on the quality of FSBs was comprehensively described. The results showed that the surface of FD FSBs was milky white, with a moisture content below 6%, forming a loose and porous structure. ND and HD FSBs appeared yellow and translucent, with a moisture content higher than 12%, and the collapse of their microstructure reduced the drying rate in the middle and late stages of the drying process. Regression fitting of the drying kinetic models verified that the Page model could be used to describe the moisture change process during different drying methods. The collagen content of FD FSBs was 0.79 g/g, which was higher than that of the ND and HD groups. In addition, FD FSBs showed a high rehydration rate and fast rehydration speed. After rehydration, FD FSBs had a soft texture and better mouth-feel. Compared with the ND and HD groups, FD FSBs retained more characteristic flavor substances such as 3-methylbutanal, 3-methyl-2-butenal, and methyl isobutyl ketone. Therefore, FD treatment provides a new approach for the high-quality drying of FSBs from Chinese longsnout catfish, and it has promising application prospects.

Keywords: Fish swim bladder; Drying properties; Rehydration properties; Collagen; Flavor compounds

海参糖蛋白改善糖尿病前期糖代谢的作用与机制研究

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摘要：

目的：糖尿病前期是延缓糖尿病发展的关键干预窗口。海洋源糖蛋白因其生物活性多样且安全性高而成为研究热点。本研究旨在探究从海参副产物中提取的糖蛋白（SCGP）改善糖尿病前期血糖水平的具体分子机制。

方法：本研究通过高脂高糖饮食诱导建立糖尿病前期小鼠模型。在造模成功后，对小鼠进行 SCGP 灌胃干预，通过检测空腹血糖、口服糖耐量等指标评价其降糖效果；并采用分子生物学技术，分析 SCGP 对肝脏和肠道组织中关键信号通路及糖代谢相关蛋白表达的影响。

结果：SCGP 干预能显著降低糖尿病前期小鼠的空腹血糖和餐后血糖水平，使其口服糖耐量恢复正常，并有效增强胰岛素敏感性。机制研究表明，SCGP 可协同调控 INSR/PI3K/AKT 与 PLCβ2/PKCα/SGLT1-GLUT2 信号通路，从葡萄糖利用和肠道局部糖吸收转运两方面共同改善糖尿病前期糖代谢紊乱。

结论：本研究证实了 SCGP 具有缓解糖尿病前期发展的显著潜力，其作用是通过多靶点协同调控肝脏和肠道的糖代谢机制实现的。该研究丰富了海参高值化综合利用与功能性食品开发的理论基础，为辅助降血糖功能海洋源新型功能食品的开发提供理论依据和数据支撑。

关键词：海参副产物；糖蛋白；糖尿病前期；血糖水平

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大豆分离蛋白-单宁酸杂化颗粒稳定的鲢鱼油 Pickering 乳液体系构建及稳定性分析

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摘要：如何制备具有高品质的鱼油 Pickering 乳液是推动鱼油基产品多样化的重要前提。本文以鲢鱼鱼油为油相，基于大豆分离蛋白（SPI）与单宁酸（TA）的共价复合杂化颗粒，联合均质-超声制备了具有高稳定性的 Pickering 乳液，考察了颗粒浓度（1%-5%，w/w）、油相体积分数（20%-60%，v/v）对 Pickering 乳液的理化特性的影响。结果表明，随杂化颗粒浓度自 1%递增至 5%，所制备乳液滴的平均粒径呈现缩减趋势，液滴的聚集效应显著减弱；当鲢鱼油体积分数增至 0.5 时，观察到乳液滴平均粒径呈现出显著增长的趋势，达到 1.72 μm。乳液流变行为表现为剪切稀化，随着剪切速率的增加，乳液表观黏度逐渐降低；在线性黏弹区范围内，各组乳液的储能模量（G′）均高于损耗模量（G″），表现出较好的固体弹性特性。综合上述发现，当油相体积分数为 0.5、颗粒浓度为 4%时，乳液具有最好的乳化稳定性，其数值高达 97.62%，储藏 35 d 后乳液外观无明显变化，乳液滴粒径随储藏时间的增加略有增大，乳液稳定性较好。本研究可为鱼油基功能性乳液的制备及后续产品应用提供了参考。

关键词：单宁酸；大豆分离蛋白；Pickering 乳液；乳化特性；稳定性

Construction and stability analysis of silver carp oil based-Pickering emulsion system stabilized by soy protein isolate-tannic acid hybrid particles

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Abstract: How to prepare fish oil Pickering emulsions with high quality is an important prerequisite

for promoting the diversification of fish oil-based products. Therefore, in this study, silver carp fish oil was used as the oil phase. Based on covalent composite hybrid particles of soy protein isolate (SPI) and tannic acid (TA), Pickering emulsions with high stability were prepared by combined homogenization-ultrasonication method. The effects of particle concentration (1%-5%, w/w) and oil phase volume fraction (20%-60%, v/v) on the physicochemical properties of the Pickering emulsions were investigated. The results showed that as the concentration of hybrid particles increased from 1% to 5%, the average particle size of the prepared emulsion droplets showed a decreasing trend, and the aggregation effect of the droplets was significantly weakened. When the volume fraction of silver carp oil increased to 0.5, the average particle size of the emulsion droplets showed a significant increasing trend, reaching 1.72 μm. The rheological behavior of the emulsion showed shear thinning, and as the shear rate increased, the apparent viscosity of the emulsion gradually decreased. Within the linear viscoelastic region, the storage modulus (G′) of each emulsion group was higher than the loss modulus (G″), showing good solid elastic characteristics. Based on the above findings, when the oil phase volume fraction was 0.5 and the particle concentration was 4%, the emulsion had the best emulsification stability, with a value as high as 97.62%. After 35 days of storage, the appearance of the emulsion showed no significant change, and the droplet size of the emulsion slightly increased with increasing storage time, indicating good overall stability of the emulsion. This study can provide a reference for the preparation of fish oil-based functional emulsions and their subsequent product applications.

Key words: Tannic acid; soy protein isolate; Pickering emulsion; emulsifying properties; stability

不同蛋白基 Pickering 乳液的稳定性比较

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摘 要： 固体颗粒的特性直接影响 Pickering 乳液的稳定性及其产品的品质。本文以大豆油为油相，选取牛皮明胶（CG）、鱼鳞明胶（FG）、乳清分离蛋白（WPI）、大豆分离蛋白（SPI）及豌豆蛋白（PPI）作为固体颗粒，构建了不同蛋白质稳定的 Pickering 乳液体系。系统评价了上述蛋白基乳液在常温贮藏、加热处理及不同 pH 条件下的稳定性，并对其粒径分布、Zeta 电位、乳化活力指数（EAI）、乳化稳定指数（ESI）、乳化相体积分数（EPVF）、稳定性指数（SI）以及微观结构进行了综合分析。结果表明，在常温贮藏过程中，乳液随时间的延长逐渐出现分层现象，贮藏至第 14 天时，仅 CG 与 FG 组保持稳定状态，其余各组均发生不同程度相分离；至第 28 天时，CG 组仍未出现分层，其 SI 值仍维持在 100%。此外，CG 组的 EAI 最高，达 27.89 ± 0.42 m^2/g，ESI 为 98.92 ± 0.8%。粒径分析也证明贮藏期内 CG 组乳液滴粒径始终保持最小且变化幅度较小。微观结构观察进一步证实，贮藏 28 天后，CG 组乳液结构仍保持均匀，而其它蛋白组则出现液滴聚集、分布不均及尺寸增大等现象。在加热与 pH 稳定性方面，综合粒径、Zeta 电位及显微镜图像分析，CG 组也表现出最优的稳定性。本研究为基于蛋白质的 Pickering 乳液构建提供了理论参考，尤其在活性成分的包埋与递送系统开发方面具有应用潜力，推动其在功能性食品配方中的应用。

关键词： Pickering 乳液；蛋白质颗粒；稳定性；微观结构

Comparative study on the stability of protein-based Pickering emulsions

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Abstract: The properties of solid particles significantly influence the stability of Pickering emulsions and the quality of resultant products. In this study, soybean oil was employed as the oil phase, and several protein types—calfskin gelatin (CG), fish scale gelatin (FG), whey protein isolate (WPI), soy protein isolate (SPI), and pea protein isolate (PPI)—were selected as solid stabilizers to

construct protein-based Pickering emulsion systems. The stability of these emulsions was systematically evaluated under ambient storage, thermal treatment, and varying pH conditions. Comprehensive assessments included particle size distribution, zeta potential, emulsifying activity index (EAI), emulsifying stability index (ESI), emulsified phase volume fraction (EPVF), stability index (SI), and microstructure. The results revealed that the emulsions exhibited gradual phase separation during ambient storage. By day 14, only the CG and FG groups remained stable, all other groups exhibited varying degrees of phase separation. After 28 days, the CG group still did not exhibit any phase separation, with an SI value remaining at 100%. Furthermore, the CG group demonstrated the highest EAI (27.89 ± 0.42 m^2/g) and an ESI of 98.92 ± 0.8%. Particle size analysis indicated that the CG group maintained the smallest and most consistent droplet size throughout storage. Microscopic observation further confirmed that the microstructure of the CG group remained uniform after 28 days, while other protein-stabilized emulsions exhibited droplet aggregation, inhomogeneous distribution, and increased droplet size. The CG group also showed superior thermal and pH stability based on integrated analysis of particle size, zeta potential, and microscopic images. This study provides valuable insights into the development of protein-stabilized Pickering emulsions and suggests their potential for encapsulating and delivering active ingredients, promoting applications in functional food formulations.

Keywords: Pickering emulsion; protein particles; stability; microstructure

乳化鱼糜凝胶：形成机制及冻融稳定性的多维度调控

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摘要：乳化鱼糜凝胶质地嫩滑、口感多汁、风味独特，备受消费者青睐。其本质是脂质作为填料颗粒分散在大分子蛋白凝胶中，然而乳化过程中脂质的复杂界面结构导致乳化鱼糜凝胶的形成机制缺乏理论阐释；另外，该类制品在冷冻储藏和解冻过程中极易发生水分流失、质地塌陷等品质劣变，这已成为制约其产业化发展和品质调控的关键瓶颈。因此，本综述首先深入解析了乳化鱼糜凝胶的形成机制，即以油水两相界面颗粒-鱼糜蛋白相互作用为主导的“乳化界面膜理论”和以鱼糜凝胶三维网络结构束缚脂质颗粒的“物理包埋理论”。进一步揭示了冻融循环中冰晶生长和蛋白质冷冻变性导致的乳化凝胶水分流失及微观结构破坏的本质原因，并系统总结了提升乳化鱼糜凝胶冻融稳定性的多维度调控策略，包括应用新型冷冻工艺定制冰晶形貌、添加不同类型的抗冻剂、增加保水能力的亲水胶体、设计乳液滴的界面结构、基于外源性配料强化基质网络结构等。本综述对于提升乳化鱼糜凝胶品质稳定性具有重要意义，有望为构建高稳定性的新型乳化凝胶食品体系提供理论支撑。

关键词：乳化鱼糜凝胶；形成机制；界面结构；皮克林乳液；冻融稳定性

Emulsified Surimi Gels: Formation Mechanisms and Multidimensional Regulation of Freeze-Thawing Stability

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Abstract: Emulsified surimi gels are highly favored by consumers for their tender texture, juicy mouthfeel, and unique flavor. These gels are essentially composite systems where lipid droplets act

as filler particles dispersed within a macromolecular protein gel matrix. However, due to the complex interfacial structures formed during emulsification, a systematic theoretical elucidation of their formation mechanism is still lacking. Furthermore, these products are prone to significant quality deterioration during freeze-thawing (FT) cycles, such as water loss and texture collapse, which has become a critical bottleneck restricting their industrial development and quality control. Therefore, this review first provides an in-depth analysis of the formation mechanisms of emulsified surimi gels, which are primarily governed by the "interfacial film theory" centered on the interactions between fish myofibrillar proteins and oil-water interface particles, and the "physical entrapment theory" based on the confinement of lipid droplets by the three-dimensional surimi gel networks. Subsequently, the review reveals the fundamental reasons for moisture loss and microstructure damage of emulsified gels caused by ice crystal growth and protein cryo-denaturation during FT cycles. It systematically summarizes multidimensional regulation strategies for enhancing the FT stability of emulsified surimi gels. These include customizing ice crystal morphology through novel freezing technologies, adding various types of cryoprotectants, utilizing hydrocolloids to improve water-holding capacity, designing the interfacial structure of emulsion droplets, and reinforcing the matrix networks with exogenous ingredients. This review is of great significance for improving the quality stability of emulsified surimi gels and is expected to provide theoretical support for the development of highly stable, novel emulsified gel food systems.

Key words: emulsified surimi gels; formation mechanisms; interface structure; Pickering emulsion; freeze-thawing stability

牡蛎源 ADH 激活肽筛选及其预防 ALD 作用机制研究

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摘要：【目的】从香港牡蛎（*Crassostrea hongkongensis*）和太平洋牡蛎（*Crassostrea gigas*）中筛选具有乙醇脱氢酶（ADH）激活活性的多肽，明确其对酒精性肝损伤（ALD）的预防效果及潜在分子机制，为天然保肝活性物质研发提供支撑。**【方法】**采用“酶解制备-肽组学分析”（香港牡蛎）/“计算机模拟水解-生物信息学预测”（太平洋牡蛎）结合分子对接筛选 ADH 激活肽，并通过体外 ADH 活性实验与表面等离子体共振（SPR）技术验证其结合活性，再经乙醇诱导的 HepG2 细胞损伤和小鼠肝损伤模型探究多肽对肝脏的保护作用。**【结果】**从香港牡蛎和太平洋牡蛎中分别筛选出 3 种、6 种 ADH 激活肽，其中 LQPPR 活性最优。LQPPR 显著提高 ADH 活性、改善乙醇损伤 HepG2 细胞活力，升高 SOD、GSH 水平，降低 MDA 及胞外 ALT、AST；动物试验结果显示：LQPPR 降低小鼠血清 ALT、AST，改善肝组织病理，增强 ADH、ALDH 活性，抑制 CYP2E1 表达以减 ROS、MDA，还可改善线粒体功能（调节 ATP 与 NADH/NAD+），下调 Bax、细胞色素 c 及 Cleaved-caspase-3 以抑制凋亡。**【结论】**牡蛎肽（如 LQPPR）通过调节酒精代谢，改善线粒体能量代谢，抑制凋亡多途径发挥肝保护作用，为开发天然 ALD 保护剂及功能性食品开发提供依据。

关键词：酒精性肝病；牡蛎；ADH 激活肽；氧化应激；凋亡

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Screening and Mechanistic Investigation of Oyster-Derived ADH-activating Peptide in Preventing Alcoholic Liver Injury

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Abstract: [Objective] To screen peptides with alcohol dehydrogenase (ADH)-activating activity from *Crassostrea hongkongensis* (Hong Kong oyster) and *Crassostrea gigas* (Pacific oyster), clarify their preventive effects on alcoholic liver disease (ALD) and underlying molecular mechanisms, and provide support for the development of natural hepatoprotective active substances. **[Methods]** For *C. hongkongensis*, the "enzymatic hydrolysis-peptidomics analysis" strategy was adopted; for *C. gigas*, the "in silico enzymatic hydrolysis-bioinformatics prediction" approach was used, both combined with molecular docking to screen ADH-activating peptides. The binding activity of the peptides was verified via *in vitro* ADH activity assays and Surface Plasmon Resonance (SPR) technology. Additionally, ethanol-induced HepG2 cell injury and mouse liver injury models were established to investigate the hepatoprotective effects of the peptides. **[Results]** Three and six ADH-activating peptides were screened from *C. hongkongensis* and *C. gigas*, respectively, among which the peptide LQPPR exhibited the strongest activity. *In vitro* experiments showed that LQPPR significantly increased ADH activity and the viability of HepG2 cells damaged by ethanol, elevated the levels of superoxide dismutase (SOD) and glutathione (GSH), and reduced the content of malondialdehyde (MDA) as well as the extracellular levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST). Animal experiment results demonstrated that LQPPR decreased serum ALT and AST levels in mice, ameliorated liver tissue pathology, enhanced the activities of ADH and aldehyde dehydrogenase (ALDH), inhibited the expression of cytochrome P450 2E1 (CYP2E1) to reduce reactive oxygen species (ROS) and MDA production, improved mitochondrial function (by regulating ATP content and NADH/NAD^+ ratio), and down-regulated the expression of Bax, Cytochrome c, and Cleaved-caspase-3 to inhibit apoptosis. **[Conclusion]** Oyster-derived peptides (e.g., LQPPR) exert hepatoprotective effects through multiple pathways, including regulating alcohol metabolism, improving mitochondrial energy metabolism, and inhibiting apoptosis. This study provides a basis for the development of natural ALD protectants and functional foods.

Key words: Alcoholic Liver Disease; Oyster; ADH-activating peptide; Oxidative Stress; Apoptosis

可溶性南极磷虾蛋白的抗冻活性及其对保加利亚乳杆菌的低温保护作用

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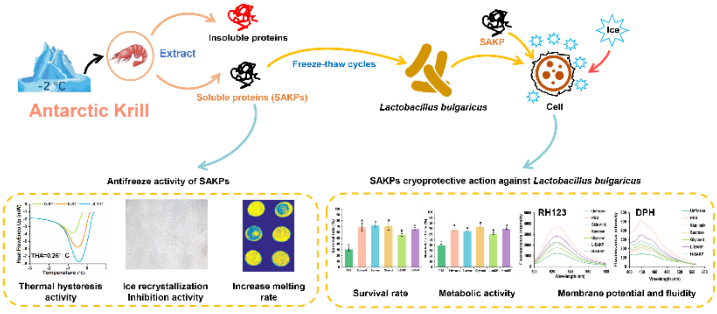
摘要： 抗冻蛋白（AFPs）作为天然抗冻剂，具有在食品工业中替代合成添加剂的潜力。本研究探讨了可溶性南极磷虾蛋白（SAKP）的抗冻活性及其对保加利亚乳杆菌的保护作用。结果表明，SAKP 主要由分子量在 5-20 kDa 的蛋白质组成，富含抗冻相关的氨基酸，如酪氨酸（27.04%）、谷氨酸（16.59%）和天冬氨酸（10.50%）。SAKP 表现出适中的热滞后现象（0.26°C），并在-12°C 至-14°C 的冻融循环中有效抑制冰晶重结晶。值得注意的是，SAKP 的融化特性与蔗糖、脱脂牛奶和甘油等商业抗冻剂相似。使用冻融损伤的保加利亚乳杆菌模型研究发现，SAKP 显著减轻了冰晶对细胞膜的损伤，促进了细菌生长和生理功能。本研究证明南极磷虾蛋白在食品工业中作为天然抗冻剂的潜力。

关键词：南极磷虾；抗冻蛋白；冻融循环；冷冻食品

图形摘要：



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Self-gel and flavor formation mechanisms of silver carp surimi during natural fermentation based on correlation networks and metabolic pathways

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Abstract: High-quality freshwater fish surimi products are limited by poor gel and flavor. In this study, the fermentation was used to improve the gel and flavor of silver carp surimi. The richness and evenness of microbial community decreased significantly during the natural fermentation of silver carp surimi. The spoilage microorganisms such as *Acinetobacter*, *Moraxella*, *Streptococcus*, *Pseudomonas*, and *Soonwooa* were markedly inhibited, while the LAB mainly *Lactococcus* and *Lactobacillus* rapidly dominated after fermentation for 24 h with the relative abundance of 64.5% and 26.9%, respectively. The natural fermentation could induce the self-gel formation of silver carp surimi with the significant increase of gel strength, hardness, and chewiness at 24 h. The whiteness of surimi increased markedly, while the pH decreased significantly during fermentation. After detection by SPME-GC-MS and UHPLC-MS/MS, there were a total of 39 core volatile metabolites (OAV > 1) and 42 non-volatile metabolites ($p < 0.05$, $|\log2FC| > 1$, and VIP > 1), most of which were significantly enhanced after fermentation. The time-dimension correlation revealed that the acidification of Lactococcus and Lactobacillus induced the self-gel without heating. The significant increase of Lactococcus and Lactobacillus contributed to the improvement of flavor metabolites. Metabolic pathways suggested that the oxidation of fatty acids, especially oleic acid, linoleic acid, linolenic acid, arachidonic acid, and DHA played the main role in the formation of volatile flavor metabolites in the fermented silver carp surimi, followed by the metabolisms of glucose and amino acids, while the free amino acids and peptides contributed to the taste formation. The LAB including

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Lactococcus and Lactobacillus can be isolated as starters to further improve the flavor and safety of silver carp surimi in the future.

Key words: Silver carp surimi; Microbial community; Physical property; Volatile metabolites; Non-volatile metabolites

裹粉牡蛎食品配料与工艺优化

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摘要：以牡蛎为原料，明确牡蛎调理食品专用配料与去腥工艺。选取了 12 种不同的粉料进行裹粉油炸，通过感官评价筛选出 F-9、F-8、F-12 三种粉料及 FS-3、FS-5、FS-6 三种浆料，结合电子鼻、电子舌、质构等分析，发现 F-9 组在色度、质构及电子鼻检测中表现最优。进一步通过感官评价、脂质氧化、气相色谱-质谱联用仪（Gas Chromatography-Mass Spectrometry，GC-MS）、游离氨基酸等分析发现生姜（8g）或紫苏（4g）为适宜去腥剂添加量。与空白组对比发现，生姜组和紫苏组的硫代巴比妥酸值（Thiobarbituric Acid Reactive Substance，TBARS）显著降低；风味分析共检出 66 种挥发性物质，包括烯烃类、醛类、醇类，鲜味氨基酸含量高于空白组，苦味氨基酸含量低于空白组；空白组甜味氨基酸含量较高，但存在明显腥味。综上所述，F-9（唐扬粉）为最优裹粉配料，生姜（8g）或紫苏（4g）为适宜去腥剂添加量，可为牡蛎调理食品的工业化开发提供技术参考。

关键字：牡蛎；裹粉；游离氨基酸；感官

Optimization of Ingredients and Processing Technology for Battered Oysters

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Abstract: Using oysters as the raw material, the specific ingredients and de-odorizing techniques for oyster conditioning food were clarified. Twelve different powdered materials were selected for battering and deep-frying, and through sensory evaluation, three powdered materials (F-9, F-8, F-12) and three slurry materials (FS-3, FS-5, FS-6) were screened. Combined with analyses from an electronic nose, electronic tongue, and texture evaluation, it was found that the F-9 group performed the best in terms of color, texture, and electronic nose detection. Further analyses, including sensory

evaluation, lipid oxidation, Gas Chromatography-Mass Spectrometry (GC-MS), and free amino acids, indicated that suitable amounts of ginger (8g) or perilla (4g) could be added as de-odorizing agents. Compared to the blank group, the thiobarbituric acid reactive substance (TBARS) levels in the ginger and perilla groups were significantly reduced; a total of 66 volatile substances were detected in flavor analysis, including alkenes, aldehydes, and alcohols, with the umami amino acid content higher and the bitter amino acid content lower than those in the blank group. The blank group had a higher content of sweet amino acids but with a noticeable fishy taste. In summary, F-9 (Tempura flour) is the optimal batter ingredient, and ginger (8g) or perilla (4g) is suitable as a de-odorizing agent, which can provide technical references for the industrial development of oyster conditioning food.

Keywords: oyster; batter; free amino acids; sensory

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克氏原螯虾高温杀菌过程品质变化的研究

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摘要：本研究以小龙虾为考察对象，针对其在高温杀菌后感官劣变、营养价值降低（色泽变暗、产生异味、虾肉肌肉结构被破坏等）的问题，探究小龙虾杀菌过程中的品质变化，以期为优化小龙虾杀菌工艺提供参考。本研究设置七个组别，分别为 CK 组（不进行任何处理的空白组），100℃-0min，115℃-0min，121℃-0min，121℃-10min，121℃-20min，121℃-30min。测定的指标有感官评鉴，色度，电子鼻，电子舌，氨基酸，GC-MS，质构，水分。结果表明：不同温度和杀菌时间后的虾肉的感官都有差异，肌肉形态和体表颜色在 121℃-10min 出现劣变，风味在温度上升至 115℃发生改变。延长杀菌时间对虾肉的形态及质构特性及组织都遭到破坏，水分减少。色度指标中亮度 L*明显降低，红度 a*上升，黄度 b*上升至 23.4±1.887 下降至 17.98±0.11，氧化程度下降。电子鼻检测，经过高温处理后虾产生对硫化物敏感的物质。氨基酸主要是鲜味物质上升，长时间的杀菌会导致氨基酸总量下降，挥发性成分中三甲胺的含量由 115℃-0min 组从 7.232±6.741ug/kg 增加到 28.826±10.397ug/kg，随着杀菌温度上升和时间的延长逐渐升高，挥发性物质种类增多，出现呋喃，噻吩等美拉德产物。

关键字：高温杀菌；小龙虾；游离氨基酸；GC-MS；品质研究

Research on the quality changes of the high-temperature sterilization process of Ker's original shrimp

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Abstract: This study takes crayfish as the object of investigation. In view of the problems of sensory deterioration and reduced nutritional value (darkening of color, odor, destruction of shrimp muscle structure, etc.) after high-temperature sterilization, it explores the qualit y changes of crayfish in the process of sterilization, in order to provide reference for opti

mizing the sterilization process of crayfish. This study set up seven groups, namely CK group (blank group without any processing), 100℃-0min, 115℃-0min, 121℃-0min, 121℃-10 min, 121℃-20min, 121℃-30min. The indicators of measurement include sensory evaluation, chromaticity, electronic nose, electronic tongue, amino acids, GC-MS, mass composition, and moisture. The results show that the senses of shrimp meat after different temperatures and sterilization times are different. The muscle morphology and body surface color deteriorate at 121℃-10min, and the flavor changes when the temperature rises to 115℃. Prolonging the sterilization time has destroyed the morphology, texture and tissue of shrimp meat, and the moisture is reduced. In the chromaticity index, the brightness L* is significantly reduced, the redness a* is increased, the yellowness b* rises to 23.4±1.887 and decreases to 17.98±0.11, and the degree of oxidation decreases. Electronic nasal detection, after high-temperature treatment, shrimps produce substances sensitive to sulfides. Amino acids are mainly fresh-flavored substances. Long-term sterilization will lead to a decrease in the total amount of amino acids. The content of trimethylamine in volatile components increased from 7.232±6.741ug/kg to 28.826±10.397ug/kg from 115℃-0min. With the increase of sterilization temperature With the extension of time, the types of volatile substances gradually increase, and the appearance of furan, thiophene and other Maillard products.

Keywords: High-temperature sterilization; crayfish; free amino acids; GC-MS; quality research

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油脂的介导对美拉德反应的影响

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摘要：为了解决小龙虾在杀菌过程中发生褐变的问题，本研究以小龙虾肝胰腺为研究对象，基于小龙虾肝胰腺中的还原糖和 17 种氨基酸含量，构建氨基酸-还原糖美拉德反应体系，筛选出褐变最为显著的组合；基于此，研究油脂-美拉德反应体系在热杀菌过程中对美拉德反应各阶段产物的影响。研究结果显示，赖氨酸-核糖组合反应性最强，褐变度最高，为 3.885。在热杀菌过程中，尤其当温度从 100℃升高至 121℃时，美拉德反应剧烈发生，溶液颜色显著加深，其中赖氨酸-核糖组合的 L*亮度值从 97.63 急剧下降至 41.83。此外，油脂的加入会加重美拉德反应，生成更多的 α-二羰基化合物（α-dicarbonyl compounds，α-DCs）和 5-羟甲基糠醛（ 5-Hydroxymethylfurfural，5-HMF）等中间产物，进而导致糖基化终末产物和类黑素等终产物增多，这表明脂质氧化参与美拉德反应的进程也是导致肝胰腺褐变的重要原因。为改善即食小龙虾褐变现象、提高产品的质量和市场竞争力提供理论依据。

关键词：美拉德反应；褐变；氨基酸-还原糖体系

The mediating effect of lipids on the Maillard reaction

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Abstract: To address the browning issue of crayfish during the sterilization process, this study took crayfish hepatopancreas as the research object. Based on the contents of reducing sugars and 17 kinds of amino acids in crayfish hepatopancreas, an amino acid-reducing sugar Maillard reaction system was constructed, and the combination with the most significant browning was screened out. On this basis, the effect of the oil-Maillard reaction system on the products of each stage of the Maillard reaction during thermal sterilization was studied.The results showed that the lysine-ribose

combination had the strongest reactivity and the highest browning degree, reaching 3.885. During thermal sterilization, especially when the temperature increased from 100℃ to 121℃, the Maillard reaction occurred violently, and the color of the solution deepened significantly. Among them, the L* brightness value of the lysine-ribose combination dropped sharply from 97.63 to 41.83. In addition, the addition of oil intensified the Maillard reaction and promoted the generation of more intermediate products such as α-dicarbonyl compounds (α-DCs) and 5-Hydroxymethylfurfural (5-HMF), which in turn led to an increase in end products including advanced glycation end products (AGEs) and melanoidins. This indicates that the involvement of lipid oxidation in the Maillard reaction process is also an important factor causing the browning of hepatopancreas.This study provides a theoretical basis for improving the browning phenomenon of ready-to-eat crayfish and enhancing the product quality and market competitiveness.

Keywords: Maillard reaction, browning, amino acid-reducing sugar system

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Mechanism of Off-Flavor Formation in Thermally Sterilized Procambarus clarkii: Insights from Molecular Sensory Science, Flavoromics, and Multivariate Statistical Analysis

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Abstract :[Objective]Thermal sterilization of Procambarus clarkii generates off-odors that impair its sensory quality. This study aims to identify key off-odor compounds and elucidate the pathways underlying odor intensification during thermal oxidation; [Methods]Using flavoromics and sensomics, key volatile off-odor compounds were qualitatively and quantitatively analyzed; [Results]Based on odor activity values (OAV), 20, 21, and 22 characteristic compounds were identified in samples sterilized at 100°C, 115°C, and 121°C, respectively, primarily exhibiting fatty, overcooked, fishy, and grassy odors. Odor recombination and omission models were constructed for these compounds—including 8 aldehydes, 9 alcohols, 2 ketones, and 4 heterocyclics. The 121°C treatment produced stronger off-odors while retaining some odor characteristics from the other two groups; [Conclusion]Key off-odor compounds were heptanal, (Z)-4-heptenal, 2-octanone, 2-pentylfuran, 1-penten-3-ol, 1-pentanol, 1-hexanol, and isoamyl alcohol.

Key words: Crayfish; Thermal sterilization; Off-flavor

菌酶发酵增强刺参肽风味及新型抗氧化肽的鉴定研究

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摘要：本研究通过单因素实验与响应面法（RSM）优化了菌酶协同发酵（BECF）工艺参数，并采用气相色谱-离子迁移谱（GC-IMS）、自动氨基酸分析仪及液相色谱-串联质谱（LC-MS/MS）等技术，系统分析了发酵产物的挥发性风味物质、氨基酸组成及肽段序列。通过DPPH、ABTS 和羟基自由基清除实验评估了 10 种肽的抗氧化活性。结果表明，刺参体壁的最佳 BECF 条件为：接种量 2.3%、30℃发酵 31 h、酶添加量 463 U/g、50℃酶解 4 h。GC-IMS 分析显示，与对照组相比，发酵产物中具有刺激性气味的醛类物质显著减少（p<0.05），而贡献芳香风味的醇类、酮类和酯类含量分别提升 23.6%、18.9%和 34.2%。自动氨基酸分析表明，AJM 的必需氨基酸含量较 AJBW 提高 5.8%。LC-MS/MS 共鉴定出 808 个高置信度（置信度>95%）的海参肽段，其中肽段 LFW 与 LFPW 的抗氧化活性最强（IC50 分别为 0.12 mM 和 0.15 mM）。分子对接研究表明，这两种肽与自由基受体存在显著氢键相互作用（结合能<-7.5 kcal/mol）。结论表明，BECF 工艺能有效改善刺参肽的风味特性并提升其抗氧化活性，为海参高值化利用提供了理论依据。

关键词：刺参；发酵；酶解；工艺优化；气相色谱离子迁移光谱抗氧化肽

Enhancement of *Apostichopus japonicus* peptide flavor through bacterial and enzyme co-fermentation (BECF) and the identification of novel antioxidant peptides in the fermented product

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Abstract: In this study, we optimized the BECF process parameters by single-factor experiments and response surface methodology (RSM). Additionally, various analytical techniques were employed to determine the volatile flavor compounds, amino acid composition, and peptide sequences of the fermented product. The antioxidant activities of 10 peptides were evaluated via free radical scavenging assays. The results indicated that the optimal BECF conditions for *Apostichopus japonicus* body wall (AJBW) were as follows: 2.3% bacterial inoculum, fermentation for 31 h at 30℃, 463 U/g enzyme dosage, and enzymatic hydrolysis at 50℃ for 4 h. Gas chromatography-ion mobility spectrometry analysis revealed a significant reduction in aldehydes, which impart a pungent odor, in the co-fermented product as compared to the control. While the content of alcohols, ketones, and esters, which contribute to aromatic flavors, was significantly increased. The content of essential amino acids in AJM, as analyzed through an automatic amino acid analyzer, was slightly higher compared to that in AJBW. Liquid chromatography-tandem mass spectrometry identified a total of 808 sea cucumber peptide fragments with high confidence. DPPH, ABTS, and hydroxyl radical scavenging assays revealed that peptides LFW and LFPW exhibited the strongest antioxidant activities. Molecular docking studies showed significant hydrogen-bonding interactions. In conclusion, BECF is an effective strategy for enhancing the flavor of *A. japonicus* peptide.

Key words: *Apostichopus japonicus*; Fermentation; Enzymolysis; Process optimization; Gas chromatography-ion migration spectros; Antioxidant peptide

冻许氏平鲉鱼片复合无磷保水剂的配方优化及保水效果研究

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摘　要：目的：本文旨在开发一款绿色高效的复合无磷保水剂配方，以提升冷冻许氏平鲉鱼片的保水性。方法：以浸泡增重率、解冻损失率和蒸煮失重率为保水性评价指标，在单因素实验的基础上采用正交加权实验法得到最佳复合无磷保水剂配方。并对经最佳复合无磷保水剂配方处理的鱼片进行保水效果、质构特性、微观结构及感官品质分析。结果：复合无磷保水剂最佳配方组合为：2.5%碳酸氢钠、2.0%柠檬酸钠、1.5%海藻糖。经该复合无磷保水剂处理后，许氏平鲉鱼片的浸泡增重率从 5.49%增加至 19.33%，解冻损失率和蒸煮损失率分别降低至 1.28%、14.05%，在质构方面与经 3.0%复合磷酸盐保水剂（焦磷酸钠：三聚磷酸钠：六偏磷酸钠=2:2:1）处理过的鱼片效果相当；同时，该配方有助于维持鱼片肌纤维的完整性，减少解冻后肌纤维结构的破坏；且能有效改善鱼片感官品质，避免了磷酸盐处理带来的感官负面影响。本研究开发的无磷复合保水剂配方证实了其替代传统磷酸盐的可行性，该成果为拓展无磷保水技术剂在许氏平鲉鱼制品加工领域的产业化应用提供了理论依据。

关键词：许氏平鲉；冷冻鱼片；无磷保水剂；保水性；质构；微观结构

Research on Formula Optimization and Water Retention Effect of Composite Phosphorus-Free Water Retention Agent for Frozen *Sebastes schlegelii* Fillets

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Abstract: Objective: This study aims to develop a green and efficient formula for a composite phosphorus-free water retention agent to enhance the water-holding capacity of frozen Sebastes schlegelii fillets. Methods: The optimal ratio was derived from the optimization method of orthogonal experiments based on one-way experiments, using the soaking weight gain rate, thawing loss rate, and cooking loss rate as evaluation indices of water retention. This approach allowed for the determination of the optimal compound phosphorus-free water retaining agent formula. The water retention effect, texture characteristics, microstructure, and sensory quality of the fish fillets treated with the optimal compound non-phosphorus water retaining agent formula were analyzed. Results: The results indicated that the optimal combination of the formula consisted of 2.5% sodium bicarbonate, 2.0% sodium citrate, and 1.5% alginate. Following treatment with this compound non-phosphate water retention agent, the soaking weight gain rate of Sebastes schlegelii fillets increased to 19.33%, while the thawing loss rate and cooking loss rate decreased to 1.28% and 14.05%, respectively. These results were comparable to those of fillets treated with the compound phosphate water retention agent in terms of texture and structure. Microstructural analysis revealed that this formula helped maintain the integrity of the muscle fibers in the fillets, reducing the destruction of muscle fibers after thawing, while also effectively improving sensory quality and mitigating the negative sensory impacts associated with phosphate treatment. The composite phosphorus-free water retention agent formula developed in this study has demonstrated its feasibility as a replacement for traditional phosphates. This achievement provides a theoretical basis for the industrial application expansion of phosphorus-free water retention technology in the processing of *Sebastes schlegelii* products.

Key words: *Sebastes schlegelii;* frozen fish fillets; phosphorus-free water retention agent; water retention; texture; microstructure

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Alkaline Amino Acids for Salt Reduction in Surimi: A Review

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Abstract: Surimi products are popular due to their high protein and low fat content. However, traditional processing methods rely on high concentrations of salt (2%-3%) to maintain texture and stability, contributing to excessive sodium intake. As global health trends advance, developing green and low-salt technologies while maintaining product quality has become a research focus. Alkaline amino acids regulate protein conformation and intermolecular interactions through charge shielding, hydrogen bond topology, metal chelation and hydration, so as to compensate for the defects of solubility, gelity and emulsification stability in low salt system. This article systematically reviews the mechanisms and applications of alkaline amino acids in reducing salt and maintaining quality in surimi. Research indicates that alkaline amino acids regulate the conformational changes of myofibrillar proteins through electrostatic shielding, hydrogen bond topology construction, and metal chelation, significantly improving gel strength, water retention, and emulsion stability in low-salt systems, with results comparable to those in high-salt systems. Future research should optimize addition strategies using computational simulations technologies and establish a multi-dimensional evaluation system to promote industrial application. This review provides a theoretical basis for the green processing and functional enhancement of surimi products, with significant academic and industrial value.

Key words: alkaline amino acids; surimi products; salt reduction; quality preservation; myofibrillar protein

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Plasma activated water (PAW) - gelatin coatings: moderate oxidation of gelatin and controlled release of PAW for preservation of snakehead (*Channa argus*) fillets

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Abstract: Plasma-activated water (PAW) was utilized to dissolve gelatin for the preparation of antibacterial coatings aimed to preserve snakeheads (*Channa argus*) fillets at 4 ºC. PAW significantly enhanced the transparency and viscosity of the gelatin solutions. Specifically, PAW treated for 10 min (PAW10) induced the densest network structure of gelatins with decreased α-helix and increased β-sheet. The antibacterial activity against Escherichia coli and Pseudomonas aeruginosa was enhanced dependently on the preparation time of PAW ($P < 0.05$). Furthermore, PAW-gelatin coatings decelerated the release of H2O2, which favored to reduce the total viable count (TVC) and total volatile base nitrogen (TVB-N) during the storage of fillets ($P < 0.05$) and extended the shelf life from 6 days to 9 days. Essentially, G-PAW10 reduced the crude protease activity of fillets from 102.25 nkat/mL to 7.16 nkat/mL ($P < 0.05$), suggesting the suppression in protein degradation and autolysis. Consequently, the muscle fibres of FG-PAW10 remained intact, smooth and tightly packed, with the shear force increasing from 230.36 g in the control to 839.67 g and the poriness of tissue structures decreasing from 44.97% to 31.58% ($P < 0.05$), indicating effective structural preservation.

Key words: Plasma-activated water; gelatin; H_2O_2; autolysis; tissue structures

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不同加工方式对鲟鱼卵质变为鲟鱼子酱的影响机制研究：聚焦于膜磷脂和膜蛋白质

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摘要：这项新颖的研究重点聚焦在鲟鱼子酱膜磷脂（PLs）和膜蛋白质上，探讨了“搓卵”和“拌盐”两种加工方式是如何将鱼卵品质提升变为鱼子酱的。结果表明，拌盐增加了膜 PLs 中的磷脂酰胆碱（PC）浓度，而 DHA、亚麻酸和亚油酸水平降低。经过物理搓卵及拌盐混合后，膜 PLs 的拉曼光谱在 1300、1450 和 1655 cm−1 处均有所下降，表明翻转运动自由度和 C=C 伸缩振动强度降低。盐与磷脂链间的排斥形成的疏水环境导致氢键结构增加，引起膜蛋白的构象变化和 α 螺旋、β 折叠的增加。同时，物理搓卵导致了膜蛋白质化学键被暂时破坏，同时膜上结缔组织的剔除减轻了鱼子酱的异味并改善了其组织状况。盐的加入引起渗透压释放更多的脂质，从而增加膜厚度和内部孔径，使鱼子酱具有弹性和饱满度。因此，这项工作丰富了鱼子酱品质加工及改善的理论基础。

关键词：鱼子酱；加工；物理性质；风味；品质变化

Mechanisms underlying the influence of different processing methods on the qualitative transformation of fish roe into caviar: focusing on membrane phospholipids and proteins

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Abstract: This novel study explored how “roe rubbing” and “salt mixing” qualitatively transform fish roe into caviar, focusing on membrane phospholipids (PLs) and proteins. Salt mixing increased phosphatidylcholine (PC) concentration in membrane PLs, while DHA, linolenic acid, and linoleic acid levels decreased. After roe rubbing and salt mixing, Raman spectra of membrane PLs decreased

at 1300, 1450, and 1655 cm^{-1}, indicating decreased torsional freedom of motion and C—C telescopic vibration intensity. The hydrophobic environment formed by salt and interchain repulsion led to hydrogen bonding network, causing conformational changes in membrane proteins and increases in α-helix, β-sheet composition. Roe rubbing induced temporary disruption of protein chemical bonds, while eliminating contaminants mitigated off-flavors and improved the tissue condition. Salt caused osmotic pressure to release more lipids, which increased membrane thickness and consistent internal pore size, giving caviar elasticity and fullness. This work enhanced theoretical direction for caviar processing quality.

Key words: Caviar; Processing; Physical properties; Flavor; Quality transformation

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整合非靶向代谢组学和脂质组学，揭示热风干制牡蛎风味发展的分子机制

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摘要：在牡蛎干制进程中，会生成挥发性风味化合物，诸如醛类、酮类、醇类、酯类化合物等。既往研究显示，脂质是挥发性风味化合物的关键前体。然而，干制牡蛎风味形成的机理仍尚不明确。本研究旨在探究牡蛎在热风干制（HAD）过程（0、4、8 和 12 小时）中挥发性风味物质与前体物之间的变化规律及其潜在关联。运用气相色谱—质谱联用（GC - MS）和超高效液相色谱—串联质谱（UPLC - MS/MS）技术，鉴定出 68 种挥发性风味物质、842 种脂质组分以及 641 种代谢产物。研究结果表明，伴随干制时间的延长，挥发性风味物质的含量相应增加，且主要生成于干制后期。从机制层面分析，脂质氧化诱导产生的脂肪醛类物质是牡蛎干挥发性风味化合物的主要构成结构。KEGG 代谢通路分析显示，牡蛎干制过程中的代谢途径主要为氨基酸代谢和生物合成。脂质氧化为形成基本风味框架提供前体分子，如醛和酮；美拉德反应构建杂环主链，赋予独特的杂环香气；氨基酸代谢填充含硫或氮基团的三维级联。这些过程最终在牡蛎干中构建起复杂的风味网络。

关键词：香港牡蛎；热风干燥；挥发性风味化合物；脂质氧化；脂质组学；非靶向代谢组学。

Integrated untargeted metabolomics and lipidomics to reveal molecular mechanisms underlying flavor development in hot-air-dried oysters

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Abstract: During the drying process of oysters, volatile flavor compounds such as aldehydes, ketones, alcohols, and esters are produced. Previous studies have shown that lipids are important precursors of these volatile flavor compounds. However, the mechanism of flavor formation in dried oysters remains unclear. This study aims to investigate the changes and potential relationships between volatile flavor substances and their precursors during hot-air drying (HAD) of oysters (at 0, 4, 8, and 12 h). Using GC-MS and UPLC-MS/MS, 68 volatile flavor compounds, 842 lipid components, and 641 metabolites were identified. The results revealed that the content of volatile flavor substances increased with drying time, primarily forming in the later stages of drying. Mechanistically, lipid oxidation-induced fatty aldehydes constitute the main structural components of volatile flavor compounds in dried oysters. KEGG analysis indicated that the primary metabolic pathways during oyster drying were amino acid metabolism and biosynthesis. Lipid oxidation supplies precursor molecules that form the basic flavor framework, such as aldehydes and ketones; the Maillard reaction constructs heterocyclic backbones, thereby imparting characteristic heterocyclic aromas; and amino acid metabolism fills in three-dimensional cascades containing sulfur or nitrogen groups. These processes contribute to the formation of the complex flavor network in dried oysters.

Key words: *Crassostrea hongkongensis*; Hot-air drying; Volatile flavor compounds; Lipid oxidation; Lipidomics; Untargeted metabolomics.

牡蛎蛋白的温度依赖性凝胶化：结构见解和凝胶网络形成机制

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摘要：本研究通过监测不同加热温度（70–90 ℃）条件下牡蛎蛋白（OP）聚集行为、构象、分子间相互作用、水分分布及微观结构的变化，系统研究了温度对OP凝胶特性的影响规律。结果表明，随着温度升高，OP 聚集程度增强，表现为粒径增大和浊度上升，同时溶解度和 Zeta 电位绝对值下降。原子力显微镜表明，适度加热有利于有序线性聚集体形成。较高温度会引起构象变化，β-折叠含量在 80℃达到峰值，同时荧光强度显著降低。此外，宏观凝胶性能表现出温度依赖性变化，在 80℃时性能最佳，而过度加热会导致其劣化。分子间相互作用和微观结构的分析表明，适当的加热可以通过调节分子间作用力来促进分子聚集，从而建立理想的三维网络结构，提高凝胶品质。该研究为热诱导 OP 凝胶化机制提供了新见解，对开发高品质牡蛎蛋白凝胶制品具有指导意义。

关键词：牡蛎蛋白；凝胶特性；蛋白质聚集；分子间相互作用； 微观结构

Temperature-dependent gelation of oyster protein: Structural insights and network formation mechanisms

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Abstract: This study systematically investigated the effects of different heating temperatures (70–90 ℃) on the gel properties of OP by examining changes in aggregation behavior, conformational transitions, intermolecular interactions, water distribution, and microstructure. The results demonstrated that OP aggregation increased continuously with temperature, as evidenced by increased particle size and turbidity, accompanied by decreased solubility and absolute zeta potential. Atomic force microscopy revealed that moderate heating promoted orderly linear aggregate formation. Higher temperatures induced conformational changes, with β-sheet content peaking at 80 ℃ alongside a significant decrease in fluorescence intensity. Furthermore, the macroscopic gel properties (water holding capacity, gel strength, and textural properties) exhibited temperature-dependent variations, with the optimum performance observed at 80 ℃, while excessive heating led to gel deterioration. Analysis of intermolecular interactions and microstructure demonstrated that appropriate heating promoted molecular aggregation by regulating intermolecular interactions, thereby establishing an ideal three-dimensional network that enhanced gel quality. These findings provide novel insights into heat-induced OP gelation and guide the development of high-quality oyster protein-based gel products.

Keywords: Oyster protein; Gel properties; Protein aggregation; Intermolecular interactions; Microstructure

草鱼片贮藏期间腥味加重的脂质酶促氧化机制解析

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摘要：调理鱼制品在冷藏保鲜过程中会因脂质酶促氧化而引发腥异味加重等品质劣化问题。目前关于酶促氧化反应的作用底物形态（游离态/酯化态脂肪酸）、关键限速酶及其协同机制等问题仍存在学术争议，且关于预制草鱼片冷藏期间腥味加重的酶促氧化途径仍未探明。基于此，本研究以草鱼片为研究对象，明确了草鱼片冷藏过程中形成的关键腥味物质为己醛、(Z)-4-庚烯醛、(E,E)-2,4-癸二烯醛、1-辛烯-3-醇等，相关脂质前体物为 LPC（18:2）和 LPC（20:4），关键内源酶为脂肪氧合酶（LOX）、磷脂酶（PLA）和氢过氧化物裂解酶（HPL）；进而构建“主要脂质底物-相关作用酶（LOX/PLA/HPL）模拟体系，分析各类酶对关键腥味物质形成的作用效果和反应速率，阐明了草鱼片冷藏过程中腥味加重的酶促氧化途径，为靶向抑制调理鱼片贮藏过程中的腥味形成、开发调理鱼制品的精准去腥技术提供理论依据。

关键词：草鱼；腥味物质；脂质底物；关键内源酶；酶促氧化途径

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Analysis of the Lipid Enzymatic Oxidation Mechanism Underlying the Worsening of Fishy Odor in Grass Carp Fillets during Storage

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Abstract: Prepared fish products often undergo quality deterioration, such as the intensification of off-odors, due to lipid enzymatic oxidation during refrigerated storage. However, academic debate persists regarding key aspects of this enzymatic oxidation, including the reactive substrate form (free vs. esterified fatty acids), the key rate-limiting enzymes, and their synergistic mechanisms. Furthermore, the specific enzymatic oxidation pathway responsible for the worsening fishy odor in prepared grass carp fillets during refrigeration remains unclear. Addressing this, our study identified hexanal, (Z)-4-heptenal, (E,E)-2,4-decadienal, and 1-octen-3-ol as the key odorants formed in grass carp fillets during cold storage. Their related lipid precursors were identified as LPC(18:2) and LPC(20:4), and the key endogenous enzymes involved were lipoxygenase (LOX), phospholipase A2 (PLA), and hydroperoxide lyase (HPL). Subsequently, a simulated system incorporating the main lipid substrates and the relevant enzymes (LOX/PLA/HPL) was established. By analyzing the contribution and reaction rates of each enzyme toward the formation of the key odorants, this study elucidated the enzymatic oxidation pathway leading to the intensification of the fishy odor in grass carp fillets during refrigeration. The findings provide a theoretical basis for targeted inhibition of fishy odor formation in prepared fish fillets during storage and for developing precise deodorization techniques for prepared fish products.

Keywords: Grass carp; Fishy odor compounds; Lipid substrates; Key endogenous enzymes; Enzymatic oxidation pathway

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Self-gel and flavor formation mechanisms of silver carp surimi during natural fermentation based on correlation networks and metabolic pathways

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Abstract: High-quality freshwater fish surimi products are limited by poor gel and flavor. In this study, the fermentation was used to improve the gel and flavor of silver carp surimi. The richness and evenness of microbial community decreased significantly during the natural fermentation of silver carp surimi. The spoilage microorganisms such as *Acinetobacter*, *Moraxella*, *Streptococcus*, *Pseudomonas*, and *Soonwooa* were markedly inhibited, while the LAB mainly *Lactococcus* and *Lactobacillus* rapidly dominated after fermentation for 24 h with the relative abundance of 64.5% and 26.9%, respectively. The natural fermentation could induce the self-gel formation of silver carp surimi with the significant increase of gel strength, hardness, and chewiness at 24 h. The whiteness of surimi increased markedly, while the pH decreased significantly during fermentation. After detection by SPME-GC-MS and UHPLC-MS/MS, there were a total of 39 core volatile metabolites (OAV > 1) and 42 non-volatile metabolites ($p < 0.05$, $|\log_2 FC| > 1$, and VIP > 1), most of which were significantly enhanced after fermentation. The time-dimension correlation revealed that the acidification of *Lactococcus* and *Lactobacillus* induced the self-gel without heating. The significant increase of *Lactococcus* and *Lactobacillus* contributed to the improvement of flavor metabolites. Metabolic pathways suggested that the oxidation of fatty acids, especially oleic acid, linoleic acid, linolenic acid, arachidonic acid, and DHA played the main role in the formation of volatile flavor metabolites in the fermented silver carp surimi, followed by the metabolisms of glucose and amino acids, while the free amino acids and peptides contributed to the taste formation. The LAB including

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Lactococcus and *Lactobacillus* can be isolated as starters to further improve the flavor and safety of silver carp surimi in the future.

Key words: Silver carp surimi; Microbial community; Physical property; Volatile metabolites; Non-volatile metabolites

氢气复合气调包装对冷藏南美白对虾品质劣变的影响及协同保鲜效应研究

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摘要：研究探讨了不同浓度氢气（H_2）与二氧化碳（CO_2）复合气调包装对 4℃冷藏南美白对虾保鲜效果的协同作用。实验设置了两种 CO_2 浓度（50%和 75%），每种浓度下分别添加 4 个 H_2 梯度（0%、0.05%、0.5%、1.5%），平衡气体为 N_2，并以空气包装作为对照。在 12 天的贮藏期内，定期测定菌落总数、挥发性盐基氮、pH、汁液损失率、感官评分、蛋白质与脂肪氧化指标、*K* 值及多酚氧化酶活性等。结果表明，H_2 能有效延缓对虾品质劣变。75% CO_2 /1.5% H_2组合在抑制脂肪和蛋白质氧化、降低多酚氧化酶活性方面效果最佳；而 75% CO_2 /0.5% H_2组合在控制菌落总数和挥发性盐基氮上升、降低汁液损失、维持较高感官评分方面表现更优。这说明，尽管高浓度 H_2 抗氧化能力强，但中等浓度 H_2 与高浓度 CO_2 配合，能在抑制微生物腐败和维持感官品质方面取得更好平衡，实现综合保鲜优势。研究揭示了 H_2 的作用具有浓度特异性，不同浓度通过不同机制影响保鲜效果，为 H_2 在水产品气调保鲜中的应用提供了理论依据。

关键词：南美白对虾；气调包装；氢气；二氧化碳；协同保鲜

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辣椒素对南美白对虾肌原纤维蛋白构象影响及虾糜凝胶性质研究

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摘要：了解辣椒素对南美白对虾蛋白结构的影响对水产品加工至关重要。本实验探讨了不同浓度辣椒素对南美白对虾肌原纤维蛋白及虾糜凝胶的影响，通过测定浊度、粒径和 Zeta 电位、拉曼光谱、红外光谱等来表征南美白对虾肌原纤维蛋白的特性。通过蒸煮损失率、持水性、持油率以及微观结构等来表征虾糜的凝胶特性。结果表明，辣椒素的加入破坏了肌原纤维蛋白之间的氢键，添加辣椒素后各组均具有较低的无规则卷曲含量，表明加入辣椒素后保持了更规则和紧凑的蛋白质结构。通过研究加入辣椒素前后虾糜凝胶的变化，发现辣椒素通过增强虾糜凝胶网络的交联，增加虾糜凝胶的持水性，持油性以及白度，且随辣椒素浓度的增加而增加。

关键词：辣椒素；肌原纤维蛋白；蛋白特性；凝胶特性

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新型姜黄素衍生物的光动力灭活保鲜应用

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摘要：为提高姜黄素（Cur）的水溶性和光动力灭活（PDI）保鲜性能，合成了氨基聚乙二醇胺（mPEG-NH_2）修饰的新型姜黄素衍生物（mPEG-NH-Cur，图 1）。结果表明，mPEG-NH-Cur 具有极高的水溶性，饱和溶解度为 6.71 mg/mL，是姜黄素的 15 倍。理论计算表明，引入 PEG 显著增强了 mPEG-NH-Cur 与水之间的氢键、静电相互作用和范德华力，同时降低了其激发态能级差。这些效应使其在水溶液中的稳定性增强、抗聚集能力提高，从而显著提高了其单线态氧（$^1O_2$）生成能力。在 PDI 保鲜实验中，与对照组相比，在 4℃下储存 8 d 后，用 mPEG-NH-Cur 处理的南美白对虾虾仁（*Litopenaeus vannamei*）的感官接受度最高。此外，mPEG-NH-Cur 介导的 PDI 作用对总挥发性盐基氮（TVB-N）、pH、硫代巴比妥酸（TBA）和菌落总数（TVC）的抑制效果显著高于对照组。因此，mPEG-NH-Cur 使虾仁冷藏保质期延长至 8 d。研究成果为姜黄素及其衍生物介导的光动力灭活保鲜应用奠定了重要基础。

关键词：姜黄素；光动力灭活；分子工程；单线态氧；货架期

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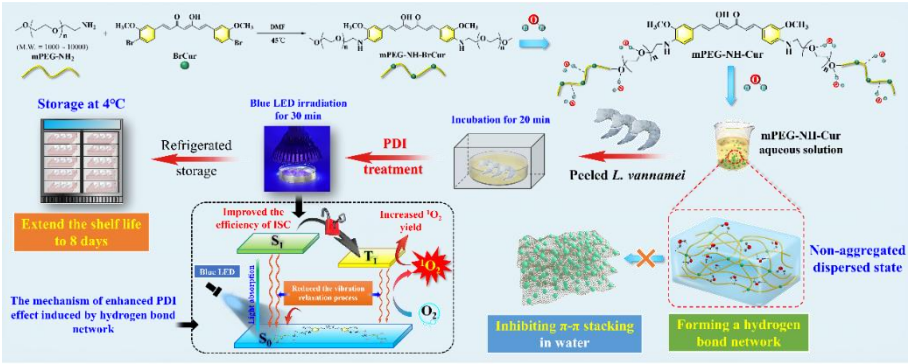

图 1 mPEG-NH-Cur 介导的虾仁光动力灭活保鲜应用

Sous vide 对南美白对虾肌原纤维蛋白结合两种风味化合物（琥珀酸与 1-辛烯-3-醇）能力的影响

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摘要：本研究采用光谱学与分子对接技术，探究不同真空低温蒸煮（Sous vide，SV）加工组合下南美白对虾肌原纤维蛋白（MP）与琥珀酸、1-辛烯-3-醇的结合力、吸附作用及蛋白构象变化。结果显示，与新鲜组相比，无论是否添加风味物质，SV 处理组 MP 均呈表面疏水性增强、粒径增大的趋势，且趋势因风味物质种类而异，表明 SV 加工与风味物质种类均影响 MP 构象。SV 加工过程中，分子间作用力由离子键、氢键主导转为疏水相互作用主导。光谱结果证实，SV 加工中虾 MP 主要发生集聚；MP 与琥珀酸间存在氢键和静电相互作用，与 1-辛烯-3-醇间存在氢键；新鲜 MP 对琥珀酸吸附强于 1-辛烯-3-醇，该吸附关系随 SV 加工逆转。且随加热程度增加，热处理对 MP 构象变化的影响大于风味物质种类。分子对接明确，赖氨酸、苯丙氨酸是 MP 与两种风味物质的主要结合位点。本研究为 SV 加工中改善南美白对虾风味提供理论依据。

关键词：南美白对虾；肌原纤维蛋白；真空低温烹调；分子对接；风味吸附特性

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沙丁鱼脂质氧化程度对果蝇生长及肠道微生物影响研究

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摘要：探究80℃下沙丁鱼油氧化过程品质变化及不同氧化程度沙丁鱼油对果蝇理化指标影响研究。将新鲜沙丁鱼油80℃氧化10d，测定氧化沙丁鱼油理化指标变化，结合相关标准选择酸价为氧化程度建立依据，研究不同氧化程度沙丁鱼油对生理指标以及肠道微生物的影响。氧化 10 d 后，沙丁鱼油理化指标出现显著变化，酸价不断上升，多不饱和脂肪酸的含量显著下降。氧化程度和喂养时间对果蝇寿命、嗅觉记忆和抗冷应激能力等均有显著影响。果蝇肠道微生物 16S rRNA 分析表明，随着鱼油氧化程度的加深，果蝇肠道微生物群落结构发生显著变化。高温氧化降低了沙丁鱼油品质，氧化鱼油严重破坏了果蝇肠道微生物平衡。本研究为油脂氧化对果蝇生理指标及肠道微生物影响提供了一定依据。

关键词：沙丁鱼油；果蝇；肠道微生物；16S rRNA；氧化程度

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基于多组学与机器学习分析水产品脂质与蛋白质交互氧化及氧化潜在路径---以风干带鱼为例

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摘要：了解水产品脂质与蛋白质的交互氧化对于水产品加工至关重要。本研究基于多组学与 7 种机器学习模型结合，探讨带鱼风干过程中脂质和蛋白氧化的相互作用机制。应用具有梯度惩罚的 Wasserstein 生成对抗网络（Wasserstein Generative Adversarial Network with Gradient Penalty，WGAN-GP）进行数据增强，解决小样本限制问题。确定了 6 种氧化生物标志物：受体表达增强蛋白 6 样、谷胱甘肽-S 转移酶 1 样、过氧化物酶体生物发生因子 19、蛋白-谷氨酰胺-谷氨酰转移酶 2 样异构体 X2、dMePE（18:4/16:0）和 PE（20:1/18:1）。分析了氧化生物标志物的潜在路径，主要涉及铁死亡和蛋白激酶 A 途径。潜在氧化路径表明，通过谷氨酰转移酶 2 形成的凝胶网络促进脂质-蛋白质相互作用氧化。这项研究为控制水产品中的氧化作用提供了新的分子靶标和理论见解。

关键词：多组学；机器学习；氧化生物标志物；脂质氧化；蛋白质氧化

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牡蛎肽对地塞米松诱导骨质疏松大鼠的改善作用及机制研究

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摘要：牡蛎作为一种传统的药食同源性物质，其抗骨质疏松活性在近年来受到愈发关注。为了进一步明确牡蛎改善骨质疏松的关键活性物质，建立了地塞米松（Dexamethasone，DEX）诱导大鼠骨质疏松模型以评估牡蛎肽（Oyster peptides, OP），并通过病理切片、微型 CT、血清生化与组学等多项指标评估了 OP 对骨质疏松的改善作用。结果发现，OP 具有介于阿仑膦酸钠与骨疏康颗粒之间的抗骨质疏松作用，可通过 Runx2 和 OPG 途径促进骨微结构重组，减少 DEX 诱导的骨质流失。进一步的组学研究发现其关键信号通路为 ECM-受体互作和 PI3K/Akt 信号通路，针对其关键靶点整合素 α5β1、αvβ3 和 EGFR 的分子对接确定 OP 的分子活性主要来源于其中的 11-20 肽。综上，这些结果表明 OP 作为一种新的骨质疏松治疗佐剂的巨大潜力。

关键词：骨质疏松；地塞米松；牡蛎肽；骨形成；骨吸收

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文蛤免疫调节肽的稳定递送系统：糖基化蛋白纳米颗粒的制备与表征

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摘要：【目的】为提高文蛤免疫调节肽（QLNWD）的口服利用度，本研究旨在构建基于牛血清白蛋白-葡聚糖偶联物（BSA-DX）的糖蛋白纳米颗粒（GBA NPs），以增强其在功能性食药品中的应用潜力。【方法】设计了两种包封策略：在 BSA-DX 加热自组装前包封肽（pre-loading NPs），或自组装后吸附肽（post-loading NPs）。通过理化表征、胶体稳定性以及巨噬细胞摄取实验，探讨肽在不同时序下参与纳米系统自组装的行为差异。【结果】成功制备了稳定的 GBA NPs（110.84 nm）。包封 QLNWD 后，两种 NPs 粒径均减小（pre-loading NPs: 105.51 nm；post-loading NPs: 94.27 nm）。其中，pre-loading NPs 表现出更高的包封率（87.74%），而 post-loading NPs 与 QLNWD 的共定位能力更强（R = 0.95）。两种 NPs 均能显著提升 QLNWD 的生物可及性（pre: 47.5%; post: 42.7%），并有效促进巨噬细胞对其的摄取。【结论】GBA NPs，特别是 pre-loading NPs，展现出作为海洋肽基纳米递送系统的优势。

关键词：海洋免疫调节肽；文蛤；美拉德反应；糖蛋白纳米颗粒；稳定性

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A stable delivery system for Meretrix meretrix derived immunomodulatory peptide: fabrication and characterization of glycosylated protein nanoparticle

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Abstract :[Objective] To improve the oral bioavailability of *Meretrix meretrix* immunomodulatory peptide (QLNWD), this study aimed to develop glycoprotein nanoparticles (GBA NPs) based on a bovine serum albumin-dextran conjugate (BSA-DX) to enhance its potential for application in functional foods and pharmaceuticals; [Methods] Two encapsulation strategies were designed: pre-loading the peptide into nanoparticles prior to BSA-DX thermal self-assembly, or post-loading after self-assembly. Through comprehensive physical and chemical characterization, colloidal stability assessments, and macrophage uptake experiments, this study systematically examined the influence of loading timing on peptide behavior during the self-assembly process of the nanosystem; [Results] Stable GBA NPs with a size of 110.84 nm were successfully prepared. After encapsulation of QLNWD, the particle size of both nanoparticle formulations decreased (pre-loading NPs: 105.51 nm; post-loading NPs: 94.27 nm). The pre-loading NPs exhibited higher encapsulation efficiency (87.74%), whereas the post-loading NPs demonstrated stronger co-localization with QLNWD (R = 0.95). Both formulations significantly enhanced the bioaccessibility of QLNWD (pre-loading: 47.5%; post-loading: 42.7%) and effectively promoted macrophage uptake; [Conclusion] GBA NPs, particularly the pre-loading formulation, demonstrate distinct advantages as nano-delivery systems for marine peptides.

Key words: Marine immunomodulatory peptide; *Meretrix meretrix*; Maillard reaction; glycosylated protein nanoparticle; stabilization

茶多酚对小龙虾腥味物质和肌肉品质的影响

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摘要：目的 小龙虾（*Procambarus clarkii*）富含蛋白、多不饱和脂肪酸、维生素以及矿物质等营养成分，具有降低人体胆固醇、提高机体免疫力等保健功能，深受消费者的喜爱。然而，小龙虾因其腥味物质的存在，降低了消费者对小龙虾产品的接受度，限制了小龙虾加工产业的发展。目前的脱腥方法存在化学试剂残留，影响产品理化性质和产生其它异味等缺点。天然植物提取物脱腥因其安全、有效受到越来越多的关注。本研究以小龙虾为实验原料，研究天然植物提取物茶多酚（Tea polyphenols, TP）对小龙虾虾头、虾尾肉在贮藏期间腥味物质的影响，初步探索小龙虾虾尾肉腥味抑制机制，并研究脱腥处理对贮藏期间小龙虾虾尾肉品质、蛋白质降解及脂质氧化的影响。旨在提供一种安全、高效的脱腥方法，为小龙虾脱腥方法的选择和加工产业的发展提供一定的理论参考。

方法 1、分析不同浓度 TP 处理对小龙虾虾头、虾尾肉的脱腥作用。以不同浓度的天然植物提取物茶多酚（TP0.1%、TP0.5%、TP1.0%）浸泡为处理组，以无菌水浸泡处理为对照组（CK），设置实验贮藏期为 6 d。通过感官腥味值评价、电子鼻分析评估脱腥效果。2、分析不同浓度 TP 处理对小龙虾虾尾肉腥味抑制机制研究和品质的影响。研究随着贮藏时间的延长，CK 组和处理组虾尾肉挥发性盐基氮（Total volatile basic nitrogen, TVB-N）、菌落总数（Total viable count, TVC）、硫代巴比妥酸值（Thiobarbituric acid, TBA）、pH、色泽和蒸煮损失率。3、分析不同浓度 TP 处理对小龙虾虾尾肉蛋白质和脂质的影响。以羰基、巯基、TCA-溶解肽、氨基酸态氮、十二烷基硫酸钠聚丙烯酰胺凝胶电泳（Sodium dodecyl sulfate polyacrylamide gel electrophoresis, SDS-PAGE）和过氧化值、酸价、羰基值、双烯值等指标研究对虾尾肉蛋白质、脂质的影响。

结果 1、小龙虾虾头、虾尾肉腥味值随着贮藏时间的增加而逐渐加重。在贮藏期间，TP1.0%组腥味值显著低于其它组。电子鼻雷达图显示，在贮藏末期 TP1.0%组虾头、虾尾肉氮氧化合物、芳香族化合物、硫化物和醛醇类物质显著减少。电子鼻主成分分析显示，贮藏至第 6 d 时脱腥前后虾头、虾尾肉挥发性气味彼此分开无重叠，其中 TP1.0%组与 CK 组距离最远。通过顶空固相微萃取-气相色谱-质谱联用（Headspace solid phase microextraction-gas chromatography-mass spectroscopy, HS-SPME-GC-MS）技术分析发现，经脱腥处理后贮藏至第 6 d 时，与 CK 组相比，TP1.0%组醛类、醇类挥发性物质均显著下降。经检测虾头的腥味物质为壬醛、1-辛烯-3-醇、(E,E)-2,4-壬二烯醛和(E,E)-2,4-癸二烯醛，虾尾肉的腥味物质为壬醛、癸醛和(E,E)-2,4-癸二烯醛。TP1.0%组虾头、虾尾肉的总腥味物质脱除率分别可达到 71.18%和 56.43%，脱除效果显著高于其它组。2、随着贮藏时间的延长，CK 组和处理组虾尾肉挥发性盐基氮（Total volatile basic nitrogen, TVB-N）、菌落总数（Total viable

count,TVC）、硫代巴比妥酸值（Thiobarbituric acid,TBA）显著增加，pH 呈现先下降后上升的趋势；亮度 L*和持水力逐渐降低，红度 a*、黄度 b*和蒸煮损失率则逐渐增加。与 CK 组相比，不同浓度 TP 处理均能有效抑制 TVB-N、TVC、TBA 的增加，延缓 pH 先降后升的趋势；不同浓度 TP 处理的 L*低于 CK 组，a*高于 CK 组，b*无显著性差异；还能显著延缓虾尾肉硬度、咀嚼性和弹性的降低，减少持水力的损失并抑制蒸煮损失率的增加，其中 TP1.0%处理效果显著（P<0.05）。结合腥味物质变化规律的分析，TP 主要通过抑制蛋白质水解、脂质氧化和微生物繁殖，达到抑制虾尾肉腥味物质产生的目的。电子舌主成分分析显示，贮藏至第 6 d 时，TP1.0%组与 CK 组滋味差异最大。3、随着贮藏时间的延长，处理组和 CK 组虾尾肉巯基含量显著降低，其它指标均显著增加。与 CK 组相比，TP 处理能明显抑制羰基、TCA-溶解肽、氨基酸态氮、过氧化值、酸价、羰基值、双烯值的增加，减少巯基的流失，且随着浓度的增加抑制效果越好，其中 TP1.0%处理效果显著（P< 0.05）。贮藏至第 6 d 时，通过 SDS-PAGE 条带发现 TP1.0%肌球蛋白重链条带比其它处理组较窄，肌球蛋白轻链条带较浅；而 CK 组肌球蛋白重链、肌动蛋白条带变宽；扫描电镜结果显示 TP1.0%处理虾尾肉肌肉纤维表面比 CK 组光滑，蛋白纤维之间的空隙也比较小。

结论 1、TP 处理有效降低了虾头、虾尾肉中的腥味物质，其中氮氧化合物、芳香族化合物、硫化物及醛醇类物质的传感器响应值显著降低，其中在 TP1.0%组尤为明显。贮藏第 6 d 时处理组挥发性物质组成发生显著变化，虾头、虾尾肉 CK 组和所有处理组的挥发性物质分别增加至 54 种、66 种，脱腥处理后醛类、醇类物质的相对含量显著下降（P< 0.05），同时鉴定出关键腥味标志物——虾头中以(E,E)-2,4-癸二烯醛为主要贡献物质，而虾尾中癸醛为特征性腥味物质。2、TP1.0%组通过延缓蛋白质水解、微生物繁殖速度和脂质氧化来抑制虾尾肉贮藏期间腥味物质的产生，TP 在稳定虾尾肉品质方面有一定的积极作用，但会影响小龙虾肉原来的色泽。3、TP 能显著抑制蛋白质降解和变性以及脂质氧化作用，能延缓蛋白质降解。

关键词： 小龙虾；腥味物质；茶多酚；肌肉品质；气相色谱-质谱法

即食脆肠腐败菌的溯源及安全控制

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摘　要：为探究即食脆肠腐败变质的原因，采用传统培养方法对即食脆肠加工车间、设备、操作人员手部、原材料、半成品及成品进行采样检测，分析即食脆肠加工过程中易受污染的环节。运用高通量测序技术（high-throughput sequencing，HTS）剖析即食脆肠加工过程中菌群的变化情况，并追溯优势腐败菌的来源。结果表明：消杀后生产车间的空气沉降菌落均未检出；预处理台面和解冻推车内壁的残留菌量较高；生产结束时，部分设备表面及操作人员手部存在清洁不彻底问题。预煮后即食脆肠未检测出微生物，但冷却、拌料及内包装阶段细菌含量呈上升趋势，提示拌料和内包装工序存在二次污染可能。高通量测序显示，链球菌属（*Streptococcus*）、肠杆菌属（*Enterobacter*）、肠球菌属（Enterococcus）、乳球菌属（*Lactobacillus*）和不动杆菌属（*Acinetobacter*）贯穿加工全程；拌料调味料自身带菌量较高，带入部分代尔夫特菌属（*Delftia*）、链球菌属、肠杆菌属、肠球菌属等。冷却环境温度过高及内包装样品放置时间过长，导致产品滋生大量兼性厌氧菌。杀菌后成品仍含有代尔夫特菌属、链球菌属和不动杆菌属等。腐败样品优势菌为消化链球菌属（*Peptostreptococcus*）、肠球菌属等，主要是因为杀菌不彻底所致。建议企业加强加工过程的卫生控制，低温储存配料，降低冷却车间的环境温度，缩短内包装后即食脆肠的放置时间，降低初始含菌量，提高后期杀菌强度，以保障即食脆肠产品的安全稳定。研究可为即食脆肠等休闲食品开发及安全生产提供技术支持。

关键词：即食脆肠；环境微生物；高通量测序；优势腐败菌；安全控制

pH 调控大豆分离蛋白与不同带电多糖非共价复合物的制备及结构表征

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摘要：探索不同pH 条件下SPI 与壳聚糖（CS）、葡聚糖（GL）及海藻酸钠（SA）的非共价组装过程。在固定混合比例下，测定蛋白质-多糖复合物（PPCs）的相行为、蛋白质溶解度及表面疏水性（H0）等表征不同pH 条件下蛋白-多糖复合物的非共价组装过程。CS/SA 与SPI 结合，使SPI 在等电点附近的溶解度增加。而GL 与SPI 结合，其溶解度和H_0与SPI 本身相似。电荷密度分析表明，热处理可促进蛋白质与多糖的静电复合，而离子强度的增加则抑制非共价组装。静电复合物的形成对乳液稳定性具有积极作用，而共溶体系则倾向于生成粒径更小的乳液颗粒。研究表明，带电多糖在调控蛋白质结构和增强乳液稳定性方面优于非离子多糖，为开发新型食品界面材料提供了理论依据。

关键词：蛋白质和多糖复合物；pH 调节；非共价相互作用；电荷密度；稳定性

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Enhancing bighead carp cutting: Chilled storage insights and machine vision-based segmentation algorithm development

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Abstract: [Objective] To enhance market demand and fish utilization, cutting processing is essential for fish. [Methods] Bighead carp were divided into four primary cuts: head, dorsal, belly, and tail, collectively accounting for 77.03% of the fish's total weight. These cuts were refrigerated at 4℃ for 10 days, during which the muscle from each cut was analyzed. In addition, a machine vision-based algorithm using color threshold and morphological parameters was developed to segment the image background and divide the bighead carp region for cutting. [Results] *Pseudomonas fragi* proliferated most rapidly and was most abundant in eye muscle (EM), while *Aeromonas sobria* showed similar growth patterns in tail muscle (TM). EM exhibited the highest rate of fat oxidation, and TM experienced the most rapid protein degradation. [Conclusion] Each cut of bighead carp exhibited distinct storage quality characteristics, and the machine vision-based algorithm proved effective for processing bighead carp.

Key words: Bighead carp cutting; Chilled storage; Quality evaluation; Algorithm development; Machine vision

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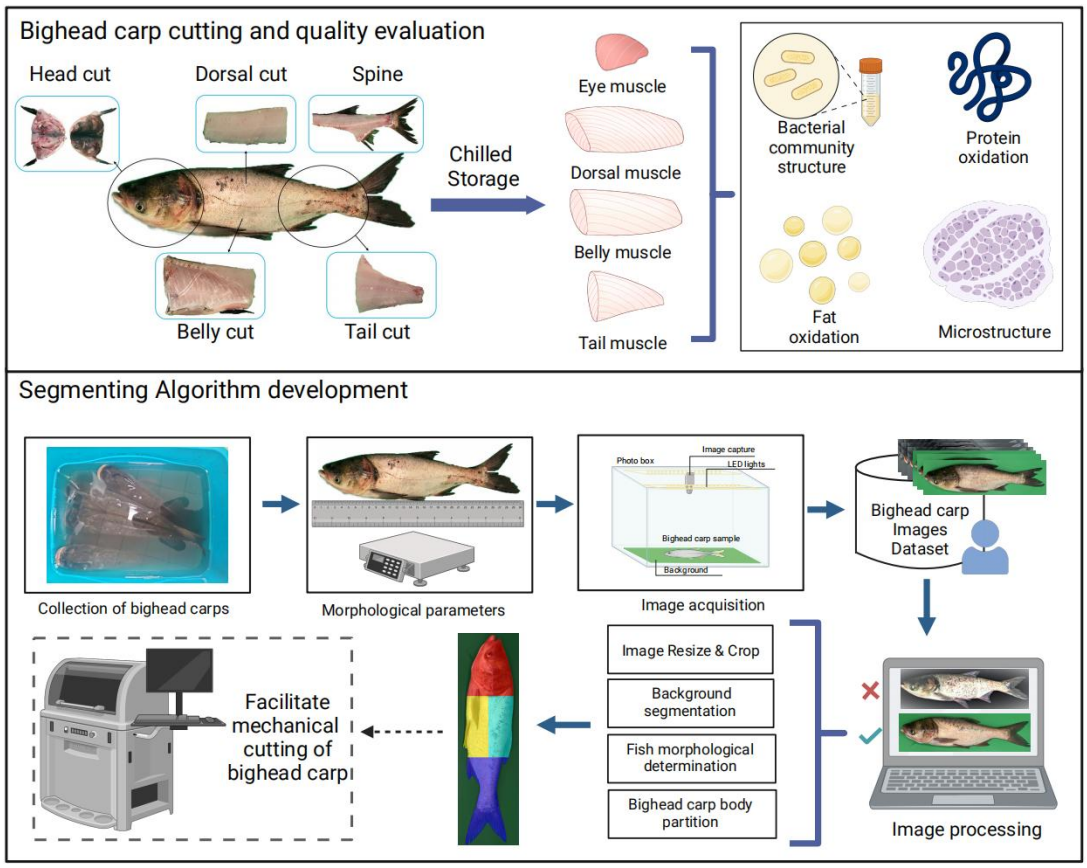

高温杀菌处理对克氏原螯虾虾黄褐变的影响

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摘要：探究在相同杀菌强度下不同杀菌参数（115℃/60 min，121℃/15 min）对克氏原螯虾虾黄褐变的影响。通过测定虾黄部位的色度参数（*L**、*a**、*b**）、5-羟甲基糠醛（5-hydroxymethylfurfural，5-HMF）、氨基酸、还原糖、过氧化值、硫代巴比妥酸值（thiobarbituric acid reactive substance，TBARS）及吡咯类物质含量，分析高温杀菌处理对克氏原螯虾虾黄的影响。结果表明，与对照组相比，115 ℃/60 min 和 121 ℃/15 min 杀菌处理均显著降低虾黄的 *L**、*a**、*b**及 W*值（$P<0.05$），并促进美拉德反应产物的积累，表明高温加速了美拉德反应进程。此外，氨基酸和还原糖含量的增加进一步为美拉德反应提供了底物。121 ℃/15 min 处理组脂质氧化程度显著（$P<0.05$）高于 115 ℃/60 min 和对照组。115 ℃/60 min 处理使吡咯类物质生成增加，121 ℃/15 min 处理使其降低。相关性分析表明，克氏原螯虾虾黄在杀菌过程中的色泽变化与美拉德反应、脂质氧化密切相关；同时，美拉德反应与脂质氧化也存在一定的相关性。高温杀菌损害了虾黄色泽，加剧了美拉德反应与脂质氧化，企业在杀菌时应合理调控参数，控制美拉德反应和脂质氧化程度，以提升小龙虾产品的食用品质。

关键词：克氏原螯虾虾黄；杀菌；美拉德反应；脂质氧化

The Effect of High-temperature Sterilization Treatment on the Browning of Crayfish Hepatopancreas

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Abstract: To explore the effects of different sterilization parameters (115℃/60 min, 121℃/15 min)

on the Browning of crayfish hepatopancreas under the same sterilization intensity. By measuring the chromaticity parameters (L^*, a^*, b^*) and 5-hydroxymethylfurfural (5-hydroxymethylfurfural) of the crayfish hepatopancreas, The effects of high-temperature sterilization treatment on the yellow of crayfish hepatopancreas were analyzed, including 5-HMF, amino acids, reducing sugars, peroxide value, thiobarbituric acid reactive substance (TBARS), and the content of pyrrole substances. The results showed that compared with the control group, the sterilization treatments at 115 ℃ for 60 min and 121 ℃ for 15 min significantly reduced the L^*, a^*, b^* and W^* values of crayfish hepatopancreas ($P < 0.05$), and promoted the accumulation of Maillard reaction products, indicating that high temperature accelerated the Maillard reaction process. In addition, the increase in amino acid and reducing sugar content further provides substrates for the Maillard reaction. The degree of lipid oxidation in the 121 ℃/15 min treatment group was significantly ($P < 0.05$) higher than that in the 115 ℃/60 min and control groups. Treatment at 115 ℃/60 min increased the generation of pyrrole substances, while treatment at 121 ℃ for 15 minutes decreased it. Correlation analysis indicates that the color change of crayfish hepatopancreas during the sterilization process is closely related to the Maillard reaction and lipid oxidation. Meanwhile, there is also a certain correlation between the Maillard reaction and lipid oxidation. High-temperature sterilization damages the yellow color of the crayfish hepatopancreas, intensifies the Maillard reaction and lipid oxidation. Enterprises should reasonably control the parameters during sterilization to control the Maillard reaction and the degree of lipid oxidation, so as to improve the edible quality of crayfish products.

Key words: crayfish hepatopancreas; sterilization; Maillard reaction; lipid oxidation

Functional protein-based emulsions for dysphagia management in the elderly: stability mechanisms, rheological design, and translational prospects

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Abstract: As the global population ages, the demand for safe, nutritious, and palatable foods for elderly individuals with dysphagia has become increasingly critical. Protein-based emulsions have emerged as a prominent area of research due to their tunable mesoscopic structures and swallowing adaptability. This review systematically examines the design principles and applications of various protein-based emulsions in swallowing-friendly foods, assesses the advantages and limitations of different emulsion preparation techniques, and evaluates the methods used to characterize swallowing-friendly foods. On this basis, it further identifies key challenges that require urgent attention, including the difficulty in harmonizing emulsion stability, functionality, and palatability; the gap between standardization and personalization; the insufficiency of clinical validation, and the limitation of cultural adaptability. Future research should be guided by the coupling mechanism of "Interface–Rheology–Swallowing", highlighting multidisciplinary innovation, advancing the specialized medical food industry and providing personalized nutritional solutions for elderly individuals with dysphagia.

Key words: Protein-based emulsions; Dysphagia; Swallowing-friendly foods; Interfacial modulation; Rheological optimization

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丁香酚对中华绒螯蟹生理代谢和营养品质的影响

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摘要：本研究通过测定存活率、基本营养成分和TVB-N等生理指标，分析了丁香酚对冷链物流中中华绒螯蟹（Eriocheir sinensis）生理代谢和营养品质的影响。结果表明，在模拟冷链物流过程结束时，存活率为95.83%，整体活力仍较强。基本营养成分中水分含量下降了0.18%，粗蛋白含量增加了4.18%，粗脂肪和灰分含量没有显著变化。72小时后，TVB-N从4.48 mg N/100g增加到6.54 mg N/100g。结果表明，丁香酚可以减缓能量物质的消耗，保持营养品质，提高中华绒螯蟹的存活率和活力状况。本研究为今后中华绒螯蟹冷链运输的进步提供了有价值的见解。

关键词：中华绒螯蟹；丁香酚；生理代谢

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Metabolomics Analysis Reveals Bitter Taste Formation in off-Season Crab Hepatopancreas Marketed in June of the Lunar Calendar

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Abstract: [Objective]: To investigate the cause of the association between the brown coloration and bitter taste in off-Season crab hepatopancreas marketed in June of the lunar calendar; [Methods]: Nontargeted and widely targeted metabolomics was performed on hepatopancreas samples with bitter (brown, BH) and non-bitter (orange, OH) taste before and after thermal processing. Key differential metabolites, particularly oxylipins, were subjected to targeted quantitative analysis; [Results]: A total of 115 bitter metabolites were identified, including oxylipins, amino acids, small peptides, nucleotides, vitamins, and coenzymes. Seven oxylipins were major contributors to the bitterness of BH. The primary metabolic pathways affecting hepatopancreas bitterness involved the production of unsaturated fatty acids and α-linolenic acid metabolism. Furthermore, specific odorants were produced from OH and BH groups during heat treatment, namely ethyl caproate and methional, respectively; [Conclusion]: This study elucidates the generation of bitter substances in the hepatopancreas of *Eriocheir sinensis* through metabolic pathways and thermal reaction pathways.

Key words: Off-season crabs; Hepatopancreas; Bitterness; Metabolomics; Oxylipins; Odors

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四角蛤蜊原肌球蛋白致敏性的消减技术研究及低致敏性食品的研发

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摘要：目的：四角蛤蜊（*Mactra veneriformis*）是我国沿海主要的低值贝类之一，因其肉质鲜嫩、营养丰富而深受消费者喜爱。近年来，由贝类引发的食物过敏问题日益增多。四角蛤蜊作为高致敏性贝类之一，其引起的食物过敏问题不容忽视。对于贝类过敏患者来说，避免进食相关的致敏原是预防过敏最安全有效的措施。因此，本研究旨在探索消减四角蛤蜊致敏性的技术和开发相关的低致敏食品。**方法：**基于双抗体夹心 ELISA 法，探究了传统加工技术（干制、蒸煮、高温高压、速冻）和新兴加工技术（高静水压、超声、糖基化）对四角蛤蜊可食部中主要过敏原原肌球蛋白（tropomyosin, TM）致敏性的消减效果。采用等电点沉淀和硫酸铵沉淀等方法，从四角蛤蜊中提取和纯化 TM。使用超声和高温高压对 TM 进行联合处理；通过 HPLC、圆二色谱、ANS 荧光探针、SDS-PAGE 等方法，对其结构、致敏性和体外消化稳定性进行系统分析。以质构和致敏性消减率为指标，优化蛤蜊预蒸煮时间。使用感官评定、GC-IMS、电子鼻、电子舌等方法，对感官品质、营养成分、致敏性和微生物安全性等指标进行分析测定，确定产品的高压蒸汽灭菌时间。**结果：**与未处理的样品相比，干制、蒸煮和糖基化处理的蛤蜊中 TM 致敏性没有显著变化（$P>0.05$），而高温高压、速冻、高静水压和超声处理均能显著降低蛤蜊中 TM 的致敏性（$P<0.05$），其中，以超声（500 W，30 min）和高温高压处理的消减效果较好，致敏性分别降低了 32.4%和 26.9%。在不同功率超声与高温高压对蛤蜊的联合处理中，500 W 的超声联合高温高压能使其致敏性消减 52.7%。提取纯化获得的 TM 纯度可达 90%以上。与对照相比，超声联合高温高压处理后的 TM 中没有新的蛋白质条带出现；Cys 含量降低；α-螺旋含量显著降低，向 β-折叠和无规则卷曲转化；巯基含量和表面疏水性显著降低；粒度减小，粒径分布更均匀；致敏性降低 68.1%。联合处理后的 TM 在体外连续胃肠道消化过程中降解速度快，连续消化 1 h 后看不到消解产物；消化率提高 12.25%。蛤蜊预蒸煮 2 min 时，致敏性消减率最大（6.43%），蒸煮损失率较小，硬度、弹性和咀嚼性未发生显著变化，较好保留了蛤蜊肉的品质特性。高压蒸汽灭菌时间优化结果表明，灭菌时间 15 min 时，产品色泽发生一定变化。随着灭菌时间的延长，硬度显著性降低，弹性先增大后减小，咀嚼性无显著差异，15 min 和 20 min 时剪切力低，肉质较嫩。处理组的滋味和气味发生了明显变化，鲜味和咸味较好，主要的挥发性化合物为 2-甲基-3-庚酮、2-丁酮、庚醛、正戊醛、2-己醇和 3-甲基丁醇。15 min 的灭菌处理组在感官评价中的总体可

接受性最高。即食低致敏蛤蜊肉含有较多的蛋白质、碳水化合物与脂肪等营养成分。随着高压蒸汽灭菌时间的延长，TM 含量均显著性降低，5、10、15 和 20 min 处理组的致敏性消减率分别为 45.2%、48.6%、51.9%和 56.5%。在微生物安全性方面，产品符合罐头相关标准。综合来看，2 min 的蒸煮预处理和 121 ℃、15 min 的高压蒸汽灭菌，对于生产即食低致敏蛤蜊肉软罐头最为合适。**结论：**超声和高温高压单一处理对四角蛤蜊可食部中 TM 致敏性的消减效果较好。超声和高温高压处理对消减 TM 致敏性有协同促进作用。将超声和高温高压联合处理技术应用于低致敏蛤蜊食品的开发，得到了一种即食低致敏蛤蜊肉软罐头食品。本研究为开发低致敏蛤蜊加工食品提供了一定的理论基础，为蛤蜊的精深加工提供了新思路和技术支持。

关键词：四角蛤蜊；原肌球蛋白；致敏性；削减技术；低致敏食品

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几种典型磷脂脂质组成及其特性解析

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摘要：为实现南美白对虾 (*Penaeus vannamei*) 加工副产物的高值化利用，本研究采用优化后的超声辅助乙醇法提取虾头总脂 (SHO)，并通过丙酮沉淀法富集虾头磷脂 (SHP)。通过对比 SHO、SHP 及市售磷虾磷脂 (AKP)、蛋黄磷脂 (EYP) 和大豆磷脂 (SBP) 的组成与特性，评估 SHP 应用潜力。薄层色谱显示所有磷脂均以磷脂酰胆碱为主，其次为磷脂酰乙醇胺和溶血磷脂酰胆碱。SHO、SHP 与 AKP 含有丰富的多不饱和脂肪酸 (35.98% - 41.62%)，其中 SHP 的 EPA+DHA 含量相较 SHO 显著提升了 37.80%。磷脂乳化特性研究表明 AKP 和 SBP 的乳化能力最优，而 EYP 乳化稳定性最差。AKP 与 SHP 的加速氧化过程伴有明显的颜色变深和异味产生。但 SHP 的过氧化物值和硫代巴比妥酸值增长速率慢于 AKP，氧化稳定性更好。综上，南美白对虾虾头是制备高不饱和脂肪酸磷脂的优质来源，且在功能特性上展现出一定的开发利用优势。

关键词：南美白对虾虾头；磷脂；脂肪酸组成；乳化性；氧化稳定性

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基于核心微生物群发酵牡蛎的风味形成机制与靶向调控研究

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摘要：本研究旨在探究天然发酵牡蛎酱中的微生物谱及其与风味形成的相关性，挖掘牡蛎源功能微生物资源。结果表明，真菌中的哈萨克斯坦酵母和酿酒酵母以及细菌中的植物乳杆菌与戊糖乳杆菌是形成关键风味的核心功能菌群，与多种酯类、醇类、醛类及酮类物质呈显著正相关。以此四株核心菌种进行定向接种发酵后检测到天然发酵体系中的 12 种关键香气成分。其中，植物乳杆菌显著提升了庚醛、1-辛烯-3-醇等 8 种关键风味物质的含量；酿酒酵母则促进了 1-庚醇、(*E*,*E*)-2,4-庚二烯醛等 5 种物质的积累，植物乳杆菌与酿酒酵母协同促进了 1-辛烯-3-醇、(*E*, *Z*)-2,6-壬二烯醛及庚醛等特征风味的形成。混菌发酵不仅显著提高了天冬氨酸、谷氨酸、赖氨酸等游离氨基酸以及肌苷酸、鸟苷酸等呈味核苷酸的含量，增强了产品的鲜味与甜味。牡蛎源功能菌接种发酵展现出较高的蛋白消化率、抗氧化活性及锌生物富集能力。本研究从微生物与风味物质的关联性入手，验证了核心菌群在复现与优化发酵风味方面的潜力，为传统发酵水产品的风味定向调控与标准化接种发酵提供了理论依据与实践策略。

关键词：牡蛎；核心微生物；风味形成；品质特性

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Flavor Formation Mechanism and Targeted Regulation in Oyster Fermentation Based on Core Microbiota

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Abstract: This study aimed to investigate the microbial profile in naturally fermented oyster paste and its correlation with flavor formation, thereby exploring functional microbial resources derived from oysters. The results indicated that the fungi (*Kazachstania servazzii* and *Saccharomyces cerevisiae*) and the bacteria (*Lactobacillus plantarum* and *Lactobacillus pentosus*), constituted the core functional microbiota responsible for key flavor formation. These microorganisms showed significant positive correlations with various esters, alcohols, aldehydes, and ketones. Directed fermentation using these four core strains successfully replicated 12 key aroma compounds present in the natural fermentation system. Specifically, *L. plantarum* significantly enhanced the contents of eight key flavor substances, including heptanal and 1-octen-3-ol, while S. cerevisiae promoted the accumulation of five compounds, such as 1-heptanol and (*E*, *E*)-2,4-heptadienal. Moreover, the synergistic action of *L. plantarum* and *S. cerevisiae* facilitated the formation of characteristic flavors, including 1-octen-3-ol, (*E*, *Z*)-2,6-nonadienal, and heptanal. Mixed-culture fermentation significantly increased the contents of free amino acids (e.g., aspartic acid, glutamic acid, and lysine) and flavor nucleotides (e.g., inosine monophosphate and guanosine monophosphate), enhancing the umami and sweetness of the product. Moreover, core microbiota fermentation demonstrated high protein digestibility, antioxidant activity, and zinc bio-enrichment capacity. By elucidating the relationship between microorganisms and flavor compounds. This study verifies the potential of core microbiota in replicating and optimizing fermentation flavors, providing a theoretical foundation and practical strategy for targeted flavor regulation and standardized inoculated fermentation of traditional aquatic fermented products.

Key words: oyster; core microbiota; flavor formation; quality characteristics

Effects of soybean dietary fiber on gel properties, protein conformation and volatile compounds of low-salt surimi

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Abstract: This study investigated the regulatory effects and potential mechanism of different addition (0.0 %, 0.3 %, 0.6 %, 0.9 %, 1.2 %, w/w) of soybean dietary fiber (SDF) on the gel properties and fishy volatile compounds of low-salt silver carp surimi (1.25 % NaCl). It was found that adding 0.3 % and 0.6 % SDF significant improved surimi gel strength (to 348.46 or 373.77 g · cm), enhanced the hardness, chewiness, and springiness by 2.70 – 10.69 %, improved the water-holding capacity (to 86.49 % or 85.83 %), and reduced the free water content by 30.10 % and 41.75 %, respectively. Furthermore, SDF addition induced a more ordered secondary structure of protein, as evidenced by a decline in random coil content and an increase in β-sheet structures. Meanwhile, SDF boosted the surface hydrophobicity of proteins, intensified hydrophobic interactions and disulfide bond (by 1.07 – 1.61 times), thereby promoted the unfolding of the protein structure and facilitated the formation of an integrated and compact gel network. It also found that the overall amount of fishy volatile compounds in surimi gels with 0.3 % and 0.6 % SDF decreased by 13.80 % and 7.29 %, respectively. A negative correlation was observed between the 7 detected fishy volatile compounds and gel strength, water-holding capacity, immobile water, and protein surface hydrophobicity. These results suggested that 0.3 % and 0.6 % SDF effectively improved the gel properties of surimi and reduced fishy volatile compounds by enhancing protein structural stability and water-holding capacity.

Key words: Dietary fiber; Gel characteristics; Volatile compounds

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多酚与草鱼血红蛋白互作影响其促氧化能力

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摘要：本研究探讨了迷迭香酸（RA）、咖啡酸（CA）、芦丁（Ru）及山奈酚（KMP）对草鱼血红蛋白（Hb）促氧化活性的抑制效果及其相互作用机制。结果表明，四种多酚均能有效抑制 Hb 的促氧化能力，其中 RA 的抑制效果最为显著。在 0.05–0.2 mg/mL 浓度范围内，各多酚显著减少了 Hb 中游离铁的释放，并对 Hb 产生静态荧光猝灭效应。热力学与结构分析表明，RA、CA、Ru 和 KMP 均能改变 Hb 的二级结构，通过氢键和范德华力自发形成稳定性较高的复合物。进一步结合分子对接与分子动力学模拟发现，RA 在 Hb 的中心空腔中形成更多氢键，构建了结合亲和力更高（–8.799 kcal/mol）、结构更稳定的 Hb–RA 复合物，从而表现出最优的抗氧化活性。本研究为多酚与血红蛋白相互作用机制提供了新的理论见解，也为抑制血红蛋白促氧化活性提供了理论依据。

关键词：血红蛋白；多酚；抗氧化；分子动力学

资助项目：国家自然科学基金项目（31871835）；财政部和农业部国家现代农业产业技术体系（CARS-45-28）；

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新型结构岩藻寡糖资源挖掘及功能评价

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摘要：岩藻寡糖在早期肠道稳态的建立过程中扮演着关键角色[1]。其中，岩藻糖基化母乳寡糖是当前食品领域的研究热点，然而现有研究多集中于少数几种特定结构的岩藻寡糖[2,3]。本研究开发了一种新的岩藻寡糖制备方法，涵盖了如 Gal*p*-α-(1→2)-Fuc*p* 和 Glc*p*-β-(1→4)-Fuc*p* 等多种结构。系统探讨了包括海藻来源岩藻寡糖对益生菌株生长与代谢的调控作用，并通过体外模拟发酵体系，评估其对婴儿粪便来源的肠道菌群的影响。在细胞实验中，比较了不同结构的岩藻寡糖对肠上皮细胞紧密连接损伤的保护效果。此外，通过幼鼠实验，进一步研究了这些新型岩藻寡糖对生命早期肠道发育的潜在影响。结果表明，岩藻寡糖能够选择性促进多种益生菌株的生长，尤其是双歧杆菌。单分子实时测序显示，岩藻寡糖增加了婴儿粪便菌群中双歧杆菌和乳杆菌的丰度。岩藻寡糖能够减少脂多糖刺激的 RAW264.7 细胞炎症因子的产生，且提升了 Caco-2 细胞中 Claudin-1 等紧密连接蛋白的表达水平。此外，岩藻寡糖诱导了幼鼠血液和回肠组织中高水平的免疫球蛋白 A。综上所述，新型结构岩藻寡糖能够调控早期肠道健康水平，相关结果为进一步揭示其在调节肠道免疫发育中的作用机制奠定了基础。

关键词：岩藻寡糖；褐藻糖胶；双歧杆菌；肠道菌群；肠道免疫

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海洋功能性磷脂的酶法定向结构修饰及反应调控研究

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摘要：二十二碳六烯酸（DHA）具有多种重要的生理活性，相较于乙酯型和甘油酯型，DHA-磷脂的生物利用度更高。磷脂酰丝氨酸（PS）是神经膜的重要组成成分，可增强认知功能，相比单纯的 DHA 或 PS，DHA-PS 在改善神经健康方面具有更显著的协同效应。然而，现有 DHA-PS 的酶法制备普遍存在 DHA 纯度低、副反应易发生、酶促效率不足等问题。本研究基于大豆磷脂酰胆碱（PC）水解制备甘油磷酸胆碱（GPC），再与游离 DHA 进行酯化生成 DHA-PC，最后利用磷脂酶 D（PLD）催化转磷脂酰反应制备 DHA-PS 的路径，实现大豆 PC 到 DHA-PS 的定向制备。针对反应过程中 GPC 难以溶解于有机介质，以及传统双相和水相体系传质效率低等影响反应效率的问题，系统构建并完善了水解、酯化及转磷脂酰反应的催化体系及调控研究。

关键词：DHA-磷脂酰丝氨酸；酶法制备；无溶剂体系；皮克林乳液；反应调控

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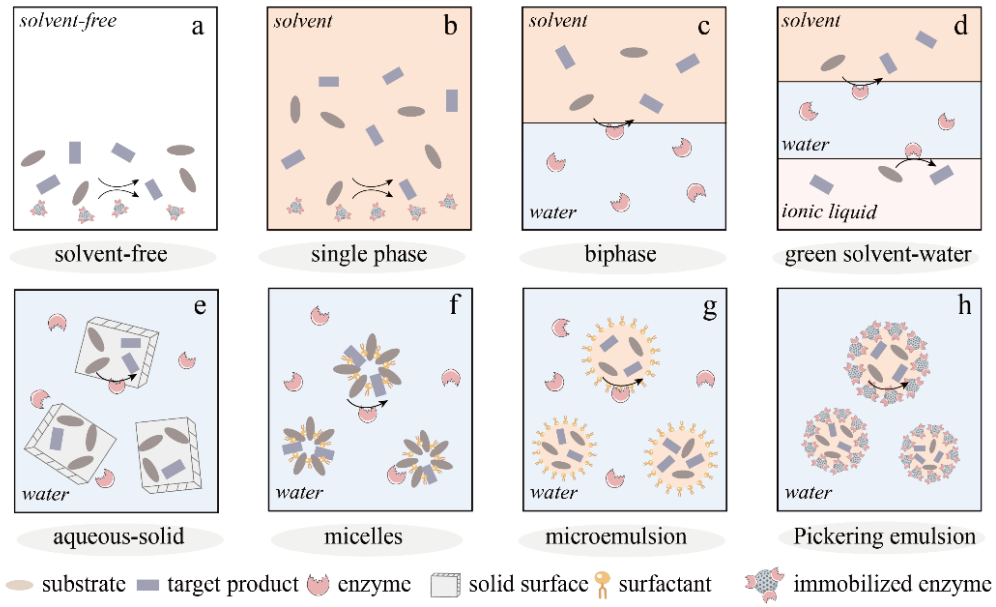
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Pickering emulsion
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target product
enzyme
solid surface
surfactant
immobilized enzyme

海洋多糖精准剪裁工具箱的构建

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摘要：海洋多糖具有丰富的生理活性及良好的胶体性质，应用价值显著。多糖的精准剪裁，即通过精准降解多糖定向制备特定结构的低分子量多糖或寡糖，糖苷酶是多糖精准剪裁的核心工具。然而，由于缺乏作用机制清晰的酶，海洋多糖精准剪裁仍难以实现。本研究基于比较转录组学、结构启发、基因上下文等多维策略发掘了一系列新颖的海洋多糖糖苷酶基因并实现克隆表达；率先基于糖组学方法实现了海洋多糖酶亚位点特异性的快速解析；通过蛋白结晶、X 射线衍射等技术阐明了酶作用机理与构效关系；集成所获得的 30 余种作用方式、200 余个活性显著的酶，构建出海洋多糖的“精准剪裁工具箱”。以此为基础，实现了海洋低分子量多糖及寡糖的精准制备，升级了海洋多糖结构解析策略，并开发了简便特异定量方法。该研究拓展了对海洋多糖糖苷酶的认识，并有助于以特色工具推动海洋多糖及其原料的创新开发。

关键词：海洋多糖；降解；糖苷酶；糖组学；结构生物学

资助项目：中组部“万人计划”青年拔尖人才

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Dietary supplementation with black soldier fly slurry regulates physiological metabolism to improve ovarian odor quality of adult *Eriocheir sinensis*

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Abstract: [Objectives]: This study aimed to improve the fattening of *Eriochier sinensis* by the addition of BSFS to the diet at different concentrations (0%, 6%, 12%, 18%, and 24%) with the goal of regulating ovarian metabolism and enhancing its odor quality; [Methods]: Sensory evaluation, intelligent sensory analysis and GC-MS were employed to screen for the optimal addition concentration. Non-targeted and widely targeted metabolomics were employed to detect differentially metabolites; [Results]: The results showed that an optimal addition of BSFS (12%) significantly improved ovarian odor by upregulating seven aroma compounds ((E)-6,10-dimethyl-5,9-undecaten-2-one, (Z,E)-3,7,11-trimethyl-1,3,6,10-dodecatetraene, 2-n-butylfuran, α-farnesene, benzeneacetic acid, 3,7-dimethyl-1,6-ctadiene, and citronellol) with rOAV ≥ 1. In addition, metabolic results showed that differential metabolites such as TG(14:0_16:1_18:2), PE(18:2_18:3), PC(18:2_18:2), 10'-apo-beta-carotenal, and limonene are key precursor substances related to key aroma substances. Metabolic pathway analysis showed that 12% BSFS could regulate ovarian lipid metabolism, amino acid biosynthesis, thiamine metabolism and other metabolic pathways to change the composition of odor precursor substances, thus enhancing the ovarian odor quality; [Conclusion]: A 12% level of BSFS serves as the optimal level to regulate ovarian physiological metabolism and enhance odor quality. The results of this study provided theoretical and practical references for the development of functional crab feeds and the production of high-quality *E. sinensis*, and helped to realize the quality improvement and efficiency of the *E. sinensis* industry.

Key words: Black soldier fly slurry; *Eriocheir sinensis*; Metabolomics; Odor; Physiological metabolism.

资助项目：农业农村部重点研发计划 (No. 2024YFD2402000)

甲基容受性酶结合糖组学构建紫菜多糖结构表征工作流

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摘要：紫菜多糖是紫菜中的重要活性成分，主要由重复的(1→4)-α-L-半乳糖-6-硫酸盐（L6S）和(1→3)-β-D-半乳糖（G）单元构成，部分 L6S 可被 3,6-脱水-L-半乳糖（LA）取代，且部分 G 残基的 O-6 位可能发生甲基化（Me）修饰。为实现高效精确的结构解析，本研究建立了一种 “酶+糖组学”分析策略：利用甲基容受性琼脂酶 Aga86A_Wa 与紫菜多糖酶 Por16C_Wf 将多糖充分酶解，通过超高效尺寸排阻色谱-高分辨质谱分离并检测产物，并借助糖信息学工具实现自动解析。该方法鉴定出紫菜多糖中连续的同质单元（L6S-G 或 LA-G）和交替的异质单元（L6S-G 与 LA-G 交替排列），以及其甲基化衍生物，例如(L6S-G)Me_{0-1} 等。该方法成功实现了不同采收期、物种和产地的紫菜中的紫菜多糖的结构差异分析，为系统解析紫菜多糖的主要及异质性结构片段提供了可靠、高效的分析手段，也为其构效关系研究奠定了方法学基础。

关键词：紫菜多糖；结构；紫菜多糖酶；糖组学；甲基

资助项目：国家重点研发计划（2023YFD2100605）

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海洋鱼类保鲜技术的研究进展

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摘要：海洋鱼类因高蛋白、低脂肪、富含不饱和脂肪酸等营养特性，在捕捞后极易氧化自溶，发生腐败变质，保鲜难度较大。随着科技快速发展，消费者对食品的要求早已提升为将食品的安全与风味品质作为“首要追求”，因此，开发安全、高效、绿色的保鲜技术成为研究热点。本文综述了近年来应用于海洋鱼类食品中的新型保鲜技术，包括天然防腐剂（如茶多酚、迷迭香、壳聚糖）、物理场辅助冻融技术（如磁场控鲜、超声波）、光动力灭活技术（PDI）以及智能包装（如气调包装、注氧活运包装）等。着重剖析了这些技术在减缓脂肪氧化、抑制微生物生长繁殖、维持食品质构及风味方面的作用机理以及其效能。研究表明，复合保鲜技术（如活性膜+纳米涂层）在延长货架期的同时，还可以更好地保持海洋鱼类的原有风味品质以及营养成分。未来，保鲜技术将朝着绿色化、智能化、精准化、多功能化等多方面发展，最终实现“零损耗、零添加、零妥协”，为海洋水产食品的保鲜提供技术支撑。

关键词：海洋鱼类；保鲜技术；绿色高效；智能化。

香辣蟹的风味轮建立与感官评价分析

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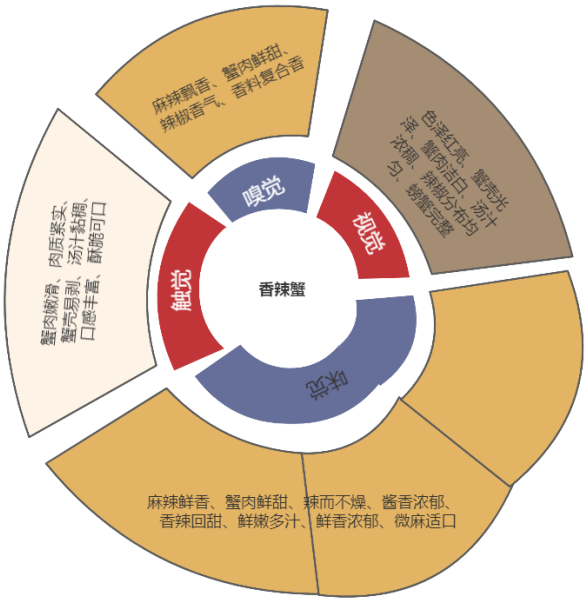
摘要：为了更客观准确、科学直观的构建香辣蟹的风味轮和感官评价体系，探讨香辣蟹的关键性感官特性，本文以香辣蟹为主要研究对象，通过M值法、定量描述分析法（QDA）、方差分析、主成分分析法等，确定香辣蟹的24个描述词，包括视觉描述词6个（色泽红亮、蟹壳光泽、蟹肉洁白、汤汁浓稠、辣椒分布均匀、螃蟹完整）、味觉描述词 8个（麻辣鲜香、蟹肉鲜甜、辣而不燥、酱香浓郁、香辣回甜、鲜嫩多汁、鲜香浓郁、微麻适口）、触觉描述词6个（蟹肉嫩滑、肉质紧实、蟹壳易剥、汤汁黏稠、口感丰富、酥脆可口）及嗅觉描述词4个（麻辣飘香、蟹肉鲜甜、辣椒香气、香料复合香）。根据层次分析法确定感官权重为视觉（20%）、嗅觉（10%）、味觉（40%）、触觉（30%），并建立百分制评分系统。香辣蟹感官风味轮的建立为其品质标准化提供理论依据，对香辣蟹的品质管理、产品研发与优化具有重要的实践意义。

关键词：香辣蟹；风味轮；感官评价；描述词；品质管理



Preparation and properties of ACE inhibitory peptide from by-products of the *Eriocheir sinensis*

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Abstract: [Objectives]: The aim of this study was to isolate and identify novel angiotensin-converting enzyme (ACE) inhibitory peptides from the processing by-products of Chinese mitten crab (Eriocheir sinensis), and to systematically evaluate their in vitro bioactivity, so as to provide a scientific basis for the high-value utilization of aquatic processing waste; [Methods]: Proteins extracted from crab by-products were hydrolyzed using pepsin under optimized conditions. The resulting hydrolysate was subsequently separated by ultrafiltration and further purified via gel chromatography. The peptide sequences were identified using liquid chromatography tandem mass spectrometry (LC-MS/MS), and their ACE inhibitory activities were assessed in vitro; [Results]: The pepsin hydrolysate exhibited significant ACE inhibitory activity. Four novel peptides were identified with sequences ANMFDRQY, VPIGPPF, DVPSFKDL, and VAGPPGMP. These peptides demonstrated high ACE inhibitory capabilities in vitro, with low IC_{50} values, indicating strong potential for blood pressure regulation; [Conclusion]: The results confirm that the by-products of Chinese mitten crab are a promising source of bioactive peptides with notable antihypertensive effects. This study not only contributes to the recycling and valorization of seafood processing wastes but also provides a theoretical foundation for the development of functional foods or natural ACE inhibitory peptides derived from sustainable aquatic resources.

Key words: *Eriocheir sinensis*; by-product utilization; ACE inhibitory peptide

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光催化碳点用于抗菌和降解：从机制到食品领域的应用

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摘要：碳点（CD）作为一种新型纳米材料，因其独特的功能特性和优异的生物相容性，使其被广泛应用于食品的各个领域。特别的，具有优异的光电子转移特性的光催化 CD 在抑制食品腐败菌和降解食品生产过程中不可避免的有害物质的研究被大量报导。因此，深入了解光催化 CD 的抗菌和降解机制至关重要。本文首先介绍了光催化 CD 的合成和分类。随后，从破坏细胞表面、蛋白质的氧化和损伤遗传物质三个方面介绍了光催化 CD 的抗菌机制，并根据不同的光催化降解体系，总结了其降解机理。特别是，本文重点介绍了将光催化 CD 添加到食品包装膜中、降解农残药残等在食品领域的实际应用。最后，讨论了目前限制光催化 CD 及其复合材料在食品领域系统应用的挑战，以帮助指导光催化 CD 在食品工业中的未来发展。

关键词：光催化；碳点；食品；抗菌；降解

Photocatalytic carbon dots for antibacterial and degradation: from mechanism to application in food field

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Abstract: As a new type of nanomaterial, carbon dots (CDs) are widely used in various fields of food

due to their unique functional properties and excellent biocompatibility. In particular, the study of photocatalytic CD with excellent photoelectron transfer characteristics in inhibiting food spoilage bacteria and degrading inevitable harmful substances in food production has been widely reported. Therefore, it is very important to understand the antibacterial and degradation mechanism of photocatalytic CD. This paper first introduces the synthesis and classification of photocatalytic CD. Subsequently, the antibacterial mechanism of photocatalytic CD was introduced from three aspects: destruction of cell surface, oxidation of protein and damage of genetic material. And according to different photocatalytic degradation systems, the degradation mechanism was summarized. In particular, this paper focuses on the practical application of adding photocatalytic CD to food packaging films and degrading pesticide residues in the food field. Finally, the challenges that currently limit the systematic application of photocatalytic CD and its composites in the food field are discussed to help guide the future development of photocatalytic CD in the food industry.

Keywords: photocatalytic; carbon dots; food; antibacterial; degradation

食品中生物活性糖肽的结构、来源、作用机制及应用：综述

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摘要：慢性非传染性疾病（CNCDs）每年导致约 4100 万人死亡，占全球死亡人数的 74%。通过健康摄入膳食营养素可以有效预防这些疾病，每年有望节省超过 270 亿美元的治疗费用。生物活性糖肽通常来源于天然食品，是一种健康营养素，其共价结构克服了多糖和多肽的不稳定性，在治疗慢性非传染性疾病方面展现出显著潜力。其来源主要有二：一是动物、植物和微生物等天然食物来源；二是基于天然产物的绿色合成。生物活性糖肽通过抑制肽聚糖合成发挥抗菌作用，通过诱饵效应增强肠道屏障功能，具有直接或间接的抗癌、免疫调节等活性，在改善代谢综合征（MS）和治疗神经退行性疾病（ND）方面具有潜力。随着生物活性糖肽研究的深入，其有望引领食品与健康领域的重大变革。

关键词：慢性非传染性疾病；糖肽；膳食营养素；共价结构；生物活性；食品健康

Structure, sources, functional mechanisms, and applications of bioactive glycopeptides in food: A comprehensive review

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Abstract: Chronic non-communicable diseases (CNCDs) lead to approximately 41 million deaths annually, representing 74% of global deaths. These diseases can be effectively prevented through a healthy intake of dietary nutrients, potentially saving over US$ 27 billion in treatment costs annually.

Bioactive glycopeptides, commonly derived from natural foods, are healthy nutrients characterized by a covalent structure that overcomes the instability of polysaccharides and peptides, demonstrating signiffcant potential in the treatment of CNCDs. There are two primary sources of bioactive glycopeptides: natural food sources, which include animals, plants, and microorganisms; and green synthesis approaches based on natural products. Bioactive glycopeptides exert antimicrobial effects by inhibiting peptidoglycan synthesis, enhance intestinal barrier function through the bait effect, demonstrate direct or indirect anticancer and immunomodulatory activities, hold potential to improve metabolic syndrome (MS) and treat neurodegenerative diseases (ND). With the advancement of bioactive glycopeptides, they hold the potential to spark a signiffcant revolution in the food and health industry.

Keywords: CNCDs; glycopeptides; dietary nutrients; covalent structure; bioactivity; food health

常压及负压下四种蛋白酶酶解马头鱼的脂肪酸谱及挥发性成分比较分析

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摘要：为比较分析常压及负压下不同蛋白酶酶解马头鱼的脂肪酸谱及挥发性成分，研究设定负压（-30MPa）及常压条件，应用中性蛋白酶(Neutral Protease，NP)、碱性蛋白酶(Alkaline Protease，AP)、胃蛋白酶(Pepsin，PEP0 和木瓜蛋白酶(Papain，PAP)酶解马头鱼，采用气相色谱-质谱联用(GC-MS)比较分析产物脂肪酸谱，同时采用气相迁移色谱(GC-IMS)比较产物的挥发性成分。结果表明：负压组各蛋白酶酶解产物的脂肪酸种类均显著高于常压组（$P<0.05$），排序为 NP≈AP＞PAP＞PEP，负压条件下，NP 产物含 20 种不饱和脂肪酸（如反油酸、棕榈油酸），AP 含 17 种（如亚油酸、EPA、DHA、芥酸）；常压下 NP 含 18 种不饱和脂肪酸（如反油酸、EPA 甲酯），AP 仅 2 种（8-十八碳烯酸、油酸）。同一蛋白酶在负压下释放的脂肪酸种类与数量均显著高于常压，负压有利于底物脂质深度暴露与酶解。GC-IMS 分析表明负压下 AP 酶解产物的挥发性气体组成更为复杂，因此采用 AP 在负压下酶解马头鱼获得不饱和脂肪酸种类和含量最优，本研究为鱼肥中马头鱼脂肪酸的高效提取奠定理论基础。

关键词：酶解；马头鱼；脂肪酸谱；常压；负压

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Comparative Analysis of Fatty Acid Profiles and Volatile Components in Branchiostegus Sanae by Four Proteases under Atmospheric and Negative Pressure Conditions

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Abstract： To comparatively analyze the fatty acid profiles and volatile components of horsehead fish hydrolyzed by different proteases under atmospheric and vacuum pressure conditions, this study employed vacuum pressure (-30 MPa) and atmospheric pressure conditions. Neutral protease (NP), alkaline protease (AP), Pepsin (PEP0), and Papain (PAP) to hydrolyze horsehead fish. Gas chromatography-mass spectrometry (GC-MS) was employed to compare the fatty acid profiles of the products, while gas chromatography-ion mobility spectrometry (GC-IMS) was used to compare their volatile components. Results indicated that the negative pressure group exhibited significantly higher fatty acid diversity in protease-hydrolyzed products compared to the atmospheric pressure group ($P<0.05$), with the order being NP≈AP＞PAP＞PEP. Under negative pressure, NP products contained 20 unsaturated fatty acids (e.g., transoleic acid, palmitoleic acid), AP contained 17 types (e.g., linoleic acid, EPA, DHA, erucic acid); under normal pressure, NP contained 18 unsaturated fatty acids (e.g., trans-oleic acid, EPA methyl ester), while AP contained only 2 types (8-octadecenoic acid, oleic acid). The same protease released significantly more types and quantities of fatty acids under negative pressure than under normal pressure, indicating that negative pressure promotes deeper exposure of substrate lipids and enzymatic hydrolysis. GC-IMS analysis revealed that the volatile gas composition of AP enzymatic products under vacuum pressure was more complex. Therefore, enzymatic hydrolysis of horsehead fish using AP under vacuum pressure yielded the optimal variety and content of unsaturated fatty acids. This study establishes a theoretical foundation for the efficient extraction of fatty acids from horsehead fish in fish feed.

Key words: Enzymatic hydrolysis; Horsehead Fish; Fatty Acid profile; Atmospheric Pressure; Vacuum Pressure

Comparison of Eugenol and Dihydromyricetin Nanofibers: Electrospinning and Maillard Reaction Effects

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Abstract: To develop phenolic-loaded protein nanofibers for active food packaging by overcoming poor solubility and short half-life of eugenol and dihydromyricetin (DHM). Nanofibers loaded with dihydromyricetin or eugenol were fabricated through air-assisted electrospinning, followed by crosslinking of high-concentration dihydromyricetin nanofibers through the Maillard reaction under mild conditions (60°C, 50% relative humidity). Scanning electron microscopy (SEM) revealed that both eugenol and dihydromyricetin loaded nanofibers exhibited similar morphology and diameter distribution, with the Maillard reaction having minimal influence on their structural integrity. Fourier transform infrared (FTIR) spectroscopy confirmed the interaction between eugenol or dihydromyricetin and proteins through hydrogen bonding. X-ray diffraction (XRD) results demonstrated that dihydromyricetin was uniformly distributed within the nanofibers. Nanofibers loaded with varying concentrations of eugenol or dihydromyricetin showed enhanced water vapor barrier properties (WVP) compared to the free nanofibers, with the hydrophobic nature of the phenolic compounds inhibiting water molecule permeation. Notably, a 20% improvement in water vapor barrier was observed after the Maillard reaction. Tensile tests indicated that nanofibers loaded with 0.5% eugenol or 1.0% dihydromyricetin exhibited higher elastic moduli and lower elongation at break. In particular, 20% dihydromyricetin loaded nanofibers displayed a significantly higher elastic modulus (approximately 90 MPa) post Maillard reaction. Both eugenol and dihydromyricetin loaded nanofibers demonstrated comparable antioxidant activity in terms of ferric and copper reducing ability. Furthermore, both eugenol and dihydromyricetin loaded gelatin/zein nanofibers exhibited effective antimicrobial activity. Overall, dihydromyricetin loaded gelatin/zein nanofibers demonstrated comparable physical and functional properties to eugenol loaded nanofibers, with the added benefit of achieving higher loading concentrations. These findings suggest that dihydromyricetin loaded nanofibers hold great promise for active food packaging applications.

Key words: Air-assisted electrospinning; Maillard reaction; dihydromyricetin

脱脂南极磷虾粉酶解肽制备、鉴定及降血糖活性研究

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摘要：本研究以脱脂南极磷虾粉为原料，采用酶解法制备 α-葡萄糖苷酶抑制肽（DAKP），系统研究其制备工艺、结构特性及降血糖作用机制。通过单因素与响应面优化确定最佳工艺条件为：中性蛋白酶加酶量 6×10³ U/g、水解温度 45℃、时间 5.4 h，所得 DAKP 的 α-葡萄糖苷酶抑制率达 43.82%。经 LC-MS/MS 鉴定及分子对接分析，筛得 4 条潜在活性肽（PSFDF、VPFPR、PSFD、LPFQR），可通过氢键和疏水作用与 α-葡萄糖苷酶活性位点结合。动物实验表明，DAKP 能显著降低糖尿病小鼠空腹血糖，改善糖脂代谢紊乱及肝肾功能；代谢组学与 16S rRNA 分析显示，其可通过调节肝脏代谢通路和优化肠道菌群结构实现降糖效果。研究结果为脱脂南极磷虾粉的高值化利用及新型天然降糖功能肽产品的开发提供了科学依据。

关键词：脱脂南极磷虾粉；α-葡萄糖苷酶抑制肽；降血糖活性；代谢组学

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基于纳米碳酸钙的牡蛎肽递送体系构建与结构表征及其消化特性研究

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摘要：牡蛎肽具多种生物活性，但其在胃肠道环境中稳定性差的问题严重限制了其活性发挥。为提高牡蛎肽的稳定性及减少牡蛎壳资源的浪费，本研究首先以牡蛎壳为原料制备了纳米碳酸钙（Nano-calcium carbonate，$CaCO_3$ NPs），然后采用海藻酸钠（Sodium Alginate，ALG）对其进行修饰，并优化修饰工艺；最后将牡蛎肽（Oyster Bioactive Peptides，OBP）负载到ALG-$CaCO_3$ NPs 上，对其进行聚乙二醇（PEG）修饰，构建了牡蛎肽-$CaCO_3$ NPs 纳米体系，并进一步探究其结构稳定性、体外释放及消化特性。正交试验结果表明，$CaCO_3$ NPs 的最佳修饰工艺参数为：ALG 浓度 5 mg/mL、温度 35℃、反应时间 2 h。结构表征结果表明，牡蛎肽-$CaCO_3$ NPs 纳米体系平均粒径为 288.7±7.6 nm，电位为-30.5±0.8 mV，其包封率和装载量分别为 35.69±2.22%和 19.71±1.60%。傅里叶红外光谱（FTIR）表明海藻酸钠通过羧基与 Ca^{2+} 交联形成“蛋盒”结构对 $CaCO_3$ NPs 进行修饰，而牡蛎肽是通过静电作用负载于纳米体系内部。体外释放实验结果显示，牡蛎肽-$CaCO_3$ NPs 纳米体系在模拟胃环境（pH 2.0）中 36 小时累积释放率仅为 40.31±0.63%，而在肠环境（pH 6.8）中释放率显著提升至 93.12±3.76%，表明其具有靶向肠道缓释特性。消化稳定性实验表明，牡蛎肽-$CaCO_3$ NPs 纳米体系可显著提高牡蛎肽的胰脂肪酶抑制活性（胃消化后抑制率从 23.66±0.93%提升至 54.73±1.37%，胃肠消化后抑制率从 4.75±0.38%提升至 24.67±1.31%）。本研究为功能性肽类的稳定化递送系统设计提供了理论支持，同时为牡蛎壳废弃物的高值化利用提供了新途径。

关键词：牡蛎肽；纳米碳酸钙；海藻酸钠修饰；纳米递送系统；消化特性

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车前子壳粉改善未漂洗鱼糜肌原纤维蛋白凝胶特性及其在凝胶产品中的应用

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摘要：蛋白质与可溶性膳食纤维之间的相互作用在鱼糜制品的开发和品质优化中起着至关重要的作用。本研究从未经清洗的鱼糜中提取肌原纤维蛋白，并研究了车前子壳粉（0-12%）对其分子相互作用、凝胶行为和微观结构的影响。车前子壳粉的加入增强了肌原纤维蛋白的疏水相互作用和热稳定性，同时增加了肌原纤维的平均粒径和浊度；在添加量为 6%时，粒径达到最大值 501.99nm，浊度值达到最大值 2.22；与空白组相比，肌原纤维蛋白的溶解度达到最小值 0.11。光谱和分子力分析表明，α-螺旋含量降至 12.69%，而 β-折叠含量增至 58.9%；离子键和二硫键含量分别在添加量为 6%时达到峰值 0.50 和 9.49。车前子壳粉的添加改善了鱼糜凝胶的持水能力和质地特性，在添加量为 6%时，其持水能力达到最高值 93.0%，硬度为 2420.10g，弹性为 3.93。本研究为车前子壳粉对肌原纤维蛋白的影响以及热诱导凝胶性能的有效改善提供了新的见解。

关键词：车前草壳粉；肌纤维蛋白质；分子间相互作用

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Psyllium Husk Powder improves the gel properties of Unwashed Mackerel Surimi myofibrillar protein and its application in gel product

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Abstract:Interactions between proteins and soluble dietary fibers play a crucial role in the development and quality optimization of surimi products. In this study, myofibrillar protein was extracted from unwashed surimi, and the effects of psyllium husk powder (0-12%) on its molecular interactions, gelation behavior, and microstructure were investigated. The incorporation of PHP enhanced the hydrophobic interactions and thermal stability of MP, while increasing the average particle size and turbidity of myofibrils; the particle size reached a maximum of 501.99 nm and the turbidity value reached a maximum of 2.22 at the added amount 6%; meanwhile, the solubility of MP reached a minimum value of 0.11 compared to the blank group. Spectroscopy and molecular force analysis showed that α-helix content decreased to 12.69%, while β-sheet content increased to 58.9%; ionic and disulfide bond contents peaked at 0.50 and 9.49. The addition of PHP improved the water holding capacity and textural characterization of surimi gels, which showed the highest water holding capacity of 93.0%, hardness of 2420.10 g, and elasticity of 3.93 at the amount of 6%. This study provides new insights into the effects of PHP on myofibrillar proteins and the effective improvement of MP heat-induced gel properties.

Key words: Psyllium husk powder; Myofibrillar protein; Molecular interaction.

鲍鱼加工：从技术赋能到畅销爆品的链路与思考

付才力

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摘要：鲍鱼是附加值高的海珍品。液氮速冻提升鲍鱼制品的出品率和品质；但好的技术要领，才会产生显著赋能效果。本报告基于与合作企业从建立鲍鱼加工线开始就同步的长期合作，回顾公司产品快速进入“一带一路”市场并成功成为畅销爆款的历程，总结相关技术延伸到省重点研发项目的链路和目前的项目进展，与大家一起思考展望产业链现在的难点和下一款鲍鱼制品爆款的可能方向。

关键词：鲍鱼；技术赋能；液氮速冻；出品率

High-Pressure Homogenized Seaweed Cellulose Nanofibrils-Based Emulsion Gel: An Innovative Platform for Fucoxanthin Encapsulation and Stability Improvement

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Abstract: Poor solubility and bioavailability have limited the application of fucoxanthin and functional food processing. In order to encapsulate fucoxanthin in delivery systems, cellulose nanofibril-stabilized emulsion gels (CNFs) derived from industrial brown seaweed residue were developed to enhance fucoxanthin delivery. Cellulose nanofibrils (CNFs) were isolated using high-pressure homogenization at 105 MPa through 5, 10, and 15 cycles (denoted as C5, C10, and C15) and yielding reduced crystallinity down to 52.91 ± 2.13% (C15). The minimum particle size of the present CNFs is approximately 37 nm (C15). Moreover, single-factor and orthogonal experiments optimized the stability of the present emulsion. A 17.5 mg/mL CNFs 50% oil phase with coconut oil, 0.5 mg/mL fucoxanthin, and homogenization for 60 s were identified to be the optimal conditions for such emulsion gel. The present emulsions demonstrated a high storage stability at 4 ° C versus 25 ° C, which maintained minimal phase separation over 8 days. The release kinetics showed significant dependencies with fucoxanthin release increasing to 9.22 ±

0.62% at pH 8.0, 9.52 ± 0.58% under 1000 mM NaCl, and 8.25 ± 0.62% at 100 ° C. In addition, the CNFs effectively preserved the antioxidant activity of the fucoxanthin under different pH values, salinities, and temperatures. The results establish seaweed-derived CNFs as effective stabilizers for fucoxanthin encapsulation, enhancing stability while preserving functionality against food-processing stresses. To our knowledge, no prior research has been reported on a fucoxanthin delivery system utilizing an emulsion gel stabilized by cellulose nanofibrils (CNFs). Such emulsions might provide a sustainable strategy for valorizing seaweed waste and advance functional food applications of marine bioactives.

Key words: brown seaweed; nanocellulose; fucoxanthin; emulsion; stability

冷等离子体对水产品加工传质及产品品质的影响与机理研究

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摘要：传质过程在水产品腌制与干制加工中起重要作用，其速率不仅直接决定了加工效率，还对产品品质有重要影响。目前，冷等离子体（cold plasma, CP）在水产品减菌保鲜领域已有大量研究，但其能否促进水产品加工过程中的传质进程，进而对产品品质产生积极效应，仍不明确。本研究聚焦 CP 处理对贻贝干制以及鱼肉腌制过程中水分和 NaCl 迁移的影响及机理，并深入探究其对产品品质的作用。研究结果表明，最佳条件下的 CP 处理可提高贻贝热泵干燥时的有效水分扩散系数至 5.22×10^{-5} m²/h，干燥时长缩短 38.67%，并可提高干制贻贝复水比，降低脂氧化程度。CP 处理也可显著增强鱼肉腌制过程中 NaCl 的扩散，减小腌制时间，并能促进不饱和脂肪酸适度氧化，生成干腌鱼特有的挥发性风味化合物。基于显微表征的机理研究发现，CP 产生的带电粒子以及活性氧/氮物质（ROS/RNS）能够剥离水产品表面的被套膜，并在肌原纤维中形成微孔、孔隙等一系列蚀刻效果，从而加速了加工过程中 NaCl、水分等物质的迁移扩散。本研究为 CP 在水产品加工领域的应用开辟了新的途径，并提供了理论指导和数据支撑。

关键词：冷等离子体；腌制；干制；传质

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Research on the influence and mechanism of cold plasma on mass transfer in aquatic product processing and product quality

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Abstract: The mass transfer process is crucial for the salting and drying of aquatic products, directly influencing processing efficiency and product quality. While cold plasma (CP) has been extensively studied for microbial reduction and preservation of aquatic products, its impact on mass transfer during processing remains unclear. This study explores CP's effects on moisture and sodium chloride (NaCl) migration in mussels and fish, assessing its impact on product quality. Results show that CP treatment, under optimal conditions, enhances moisture diffusion in mussels by increasing the effective moisture diffusion coefficient to 5.22×10^{-5} m^2/h, reducing drying time by 38.67%, and improving rehydration while mitigating lipid oxidation. In fish salting, CP improves NaCl diffusion, reduces salting time, and promotes moderate oxidation of unsaturated fatty acids, enhancing flavor compound development. Mechanistic studies reveal that CP-generated charged particles and reactive species disrupt aquatic product membranes, forming micropores and voids that accelerate NaCl and moisture migration. This research introduces a novel CP application in aquatic processing, providing theoretical and empirical support for its benefits.

Key words: Cold plasma; Curing; Drying; Mass transfer

乳酸菌源群体感应淬灭酶 LpPVA 对蜂房哈夫尼亚菌和温和气单胞菌双菌种生物膜的抑制作用

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摘要：蜂房哈夫尼亚菌（*Hafnia alvei*）和温和气单胞菌（*Aeromonas sobria*）等腐败菌常共存于食品加工环境中，形成多物种生物膜，其生物膜的形成与群体感应密切相关。本文通过构建蜂房哈夫尼亚菌和温和气单胞菌双菌种生物膜模型，探究了乳酸菌源群体感应淬灭酶青霉素 V 酰基化酶（*Lp*PVA）对单/双菌种生物膜的形成、代谢活性、疏水性、胞外多糖、胞外蛋白及群体感应和生物膜相关基因的影响。结果表明，蜂房哈夫尼亚菌和温和气单胞菌通过 N-酰基高丝氨酸内酯（AHLs）信号分子进行交流，促进双菌种生物膜的形成。*Lp*PVA 酶（0.1 mg/mL）能够完全淬灭 AHLs 活性，显著下调单/双菌种群体感应相关基因（*halI*、*halR*、*luxI* 和 *luxR*）和生物膜相关基因（*motb*、*csgD*、*ahaI* 和 *flaA*），进而抑制胞外多糖、胞外蛋白的合成，降低生物膜代谢活性、疏水性。对蜂房哈夫尼亚菌、温和气单胞菌和双种生物膜的形成抑制率分别为 75.01%、76.85%和 76.14%，对胞外多糖的抑制率分别为 78.03%、72.78%和 72.41%，对胞外蛋白的抑制率分别为 37.82%、48.74%和 53.04%，对代谢活性的抑制率分别为 50.37%、51.14%和 52.51%，疏水性分别为 28.96%、32.52%和 30.22%。此外，扫描电镜观察发现，经 *Lp*PVA 酶处理的双菌种生物膜结构变得松散，孔隙变大，无明显的片状聚集。本研究为开发针对多物种生物膜的新型绿色生物生物保护剂提供理论基础。

关键词：群体感应淬灭酶；青霉素 V 酰基化酶；双菌种；生物膜；抑制

Inhibitory effect of lactic acid bacteria-derived quorum quenching enzyme LpPVA on the dual-species biofilm formed by Hafnia alvei

and Aeromonas sobria

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Abstract: *Hafnia alvei* and *Aeromonas sobria* are common spoilage bacteria in food processing environments, where they often coexist and form multi-species biofilms, which was closely associated with quorum sensing (QS). In the study, a dual-species biofilm model of *H. alvei* and *A. sobria* was constructed to investigate the effects of a lactic acid bacteria-derived quorum quenching enzyme, penicillin V acylase (*Lp*PVA), on single- and dual-species biofilms. The examined aspects included biofilm formation, metabolic activity, hydrophobicity, extracellular polysaccharide and protein production, as well as the expression of QS- and biofilm-related genes. The results indicated that *H. alvei* and *A. sobria* communicate via N-acyl homoserine lactones (AHLs) signaling molecules, promoting the formation of dual-species biofilms. Treatment with *Lp*PVA (0.1 mg/mL) completely quenched AHLs activity, significantly downregulated the expression of QS-related genes (*halI*, *halR*, *luxI*, and *luxR*) and biofilm-related genes (*motB*, *csgD*, *ahaI*, and *flaA*), thereby inhibiting the synthesis of extracellular polysaccharide and protein, and reducing metabolic activity and hydrophobicity of the biofilms. The inhibition rates on biofilm biomass were 75.01%, 76.85%, and 76.14% for *H. alvei*, *A. sobria*, and the dual-species biofilm, respectively. The inhibition rates on EPS were 78.03%, 72.78%, and 72.41%; on extracellular protein were 37.82%, 48.74%, and 53.04%; and on metabolic activity were 50.37%, 51.14%, and 52.51%, respectively. The hydrophobicity values decreased to 28.96%, 32.52%, and 30.22%, respectively. Scanning electron microscopy further revealed that the *L*pPVA-treated dual-species biofilm exhibited a loose structure with enlarged pores and no significant clustered aggregation. This study provides a theoretical foundation for developing novel green biocontrol agents targeting multi-species biofilms.

Keywords: Quorum quenching enzymes (QQE); Penicillin V acylase; Dual-species; Biofilm; Inhibition

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Fucoxanthin Stabilized by Pickering Emulsion and Seaweed Cellulose Nanofibrils Encapsulation with High-Pressure Homogenization

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Abstract： Poor solubility and bioavailability have limited the application of the fucoxanthin in drug and functional food processing. In order to encapsulate the fucoxanthin in delivery systems，in this study, the cellulose was isolated from industrial brown algae residues, and high pressure homogenized into cellulose nanofibrils (CNFs). Then, the fucoxanthin was encapsulated into the Pickering emulsion stabilized by the CNFs. The effect of high pressure homogenized on the characteristic of cellulose and the stability of fucoxanthin emulsion was evaluated. The results indicated that the diameter of CNFs with 105 MPa homogenized was 87 nm, respectively. The degree of polymerization and the crystallinity index of CNFs significantly decreased with the rising homogenization pressure from 0 to 140 MPa. The CNFs with 105 MPa homogenized showed the high Zeta potential and benefit thermal stability. In addition, the Pickering emulsion stabilized by CNFs with 1.0 mg/mL fucoxanthin showed the highest freeze-thaw, centrifugal and stored stability. Furthermore, the Pickering emulsion with 1.0 mg/mL fucoxanthin showed high stability and antioxidant activity under different pH values, salinity, temperature and UV light exposure duration. The encapsulation efficiency of fucoxanthin was 51.63±2.43% and 44.79±1.58% after 12 days at 4℃ and 25℃. In conclusion, the CNFs upon the Pickering emulsion droplets might prevent the fucoxanthin from degradation with processing and storage factors. This novel approach using CNFs in Pickering emulsions improves stability and bioavailability, offering a promising solution for applications in food and marine drugs.

Keywords： Fucoxanthin; Cellulose nanofibrils; Pickering emulsion; Encapsulation; Stability

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LuxS/AI-2 型群体感应系统介导调控耐冷性摩根菌组胺形成机制

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摘要：耐冷性摩根菌 (*Morganella psychrotolerans*) 是水产品中重要的组胺产生菌，可引发组胺中毒。群体感应 (Quorum Sensing, QS) 作为细菌间通讯的关键机制，其信号分子 Autoinducer-2 (AI-2) 在调控微生物群体行为中具有广泛作用。研究以 *M. psychrotolerans* 为对象，明确了外源添加 AI-2 前体物质（S）-4,5-二羟基-2,3-戊二酮 (DPD)，引起菌株组胺生成量显著提升。结合转录组学与代谢组学联合分析发现，外源添加 DPD 后菌株 298 个基因和 206 种代谢物发生显著变化。KEGG 通路富集分析显示，甘氨酸/丝氨酸/苏氨酸代谢、组氨酸代谢及 ABC 转运蛋白通路在基因和代谢层面均呈现显著共富集。进一步研究发现，AI-2 通过激活甲基循环促进 S-腺苷甲硫氨酸合成，进而加速组氨酸脱羧酶基因表达，最终导致组胺生成量增加。此外，ABC 转运通路的上调可能通过促进组氨酸摄取间接影响组胺合成。结果表明，AI-2 通过多通路协同调控 *M. psychrotolerans* 的组胺形成代谢网络。研究成果为基于 QS 开发水产品组胺新型控制技术提供了分子靶点，对保障水产品质量安全具有重要应用价值。

关键词：LuxS/AI-2；群体感应；耐冷性摩根菌；组胺

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LuxS/AI-2 Quorum Sensing System-Mediated Promotes Histamine Formation by *Morganella psychrotolerans*

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Abstract: *Morganella psychrotolerans* is a psychrotolerant histamine producer and can cause histamine food poisoning via various seafood sources. Autoinducer-2 (AI-2) is a major quorum-sensing (QS) signal molecule recognized and produced by a wide variety of bacteria thereby playing a critical role in regulating the communications and behaviors of various microbes. Our study was investigated the effect of AI-2 on histamine formation by *M. psychrotolerans*. The results showed that the histamine concentration was increased by the addition of (S)-4,5-dihydroxy-2,3-pentanedione (DPD), the precursor to all AI-2s, in broth culture and in tuna. Based on the integration analysis of transcriptomics and metabolomics, we identified 298 differential expressed genes and 206 differential metabolites in the DPD-added group compared with the control group. The Kyoto Encyclopedia of Genes and Genomes pathway analysis revealed that the Glycine, serine and threonine metabolism, Histidine metabolism, and ATP-binding cassette (ABC) transporter pathway were significantly co-enriched as shown by the transcriptomics and metabolomics data. Furthermore, AI-2 mediated the increase of histamine formation in the strain mainly through the activated methyl cycle (AMC). AI-2 may mediate the regulation of histamine formation in *M. psychrotolerans*, involving several regulatory pathways. These results provide new insights into the histamine formation in aquatic products.

Key words: Quorum Sensing; LuxS/AI-2; *Morganella psychrotolerans*; Histamine

鱼糜蛋白凝胶品质调控与增材制造技术研究

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摘要：为践行“大食物观”与海洋强国战略，解决低值鱼糜凝胶网络不稳定、传统鱼糜制品形态单一的问题，本研究围绕鱼糜蛋白凝胶调控与增材制造技术展开探索。凝胶品质调控上，以天然外源物质构建分子设计策略，研究胶原蛋白、植物蛋白、膳食纤维等调控因子作用机制，通过强化蛋白交联、优化凝胶网络，提升鱼糜凝胶质构、持水性与稳定性，支撑低值鱼糜高值化。增材制造方面，创新引入“手性”概念开发对映 3D 打印技术，突破复杂仿生食品无支撑打印瓶颈；优化鱼糜墨水制备与打印参数，开发 3D 打印仿生对虾、双蛋白布丁等新品。本研究构建“凝胶调控—形态创新”技术体系，为鱼糜产业升级、仿生海洋食品开发及“蓝色粮仓”建设提供理论与技术支撑。

关键词：鱼糜；蛋白凝胶；3D 打印；仿生海洋食品

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利用靶向蛋白质组学与特异性显微技术研究海参(Apostichopus japonicus) 体壁中原纤蛋白的存在状态

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摘要：原纤蛋白是结缔组织中一种重要的结构蛋白。刺参中原纤蛋白的存在状态尚未见报道，这限制了我们对其在刺参微结构中的作用的理解。本文旨在利用靶向蛋白质组学和特异性显微技术阐明刺参体壁中原纤蛋白的组织构造。结果表明三种高丰度原纤蛋白亚型的含量分别为 0.96、2.54 和 0.15 μg/g（湿重）。选取丰度最高的原纤蛋白部分序列（631-921aa）用于半抗原的制备，通过动物免疫成功制备出效价高于 1:64000 的抗刺参原纤蛋白抗体。在微观尺度下观察到原纤蛋白以原纤束的形式分散存在于体壁组织中；在纳米尺度下可见其存在于胶原纤维附近，部分与胶原纤维发生缠绕。刺参体壁中主要的胶原蛋白与原纤蛋白分子的化学计量比约为 250:1。这些结果有助于理解原纤蛋白在刺参微观结构中的作用。

关键词：海参；原纤蛋白；靶向蛋白质组学；抗体；显微

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Refrigeration–Reheating Induced Fishy Odor in Cooked Chinese Mitten Crab (*Eriocheir sinensis*): Formation and Intrinsic Factors

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Abstract : This study investigated the changes in odor quality of cooked Chinese mitten crab (*Eriocheir sinensis*) during refrigeration and reheating, focusing on volatile flavor compounds and lipid oxidation as key contributors to fishy odor formation. The results showed that refrigeration and reheating caused significant odor changes, as fishy odor was detected during refrigeration and further strengthened after reheating. A total of 52 odor compounds were identified, primarily aldehydes, alcohols, ketones, and hydrocarbons, with nonanal and 1-octen-3-ol showing significant increases during refrigeration ($p < 0.05$). Lipid oxidation indicators such as POV and TBARS significantly increased ($p < 0.05$), suggesting that lipid oxidation plays a major role in the fishy odor formation. The contents of unsaturated and polyunsaturated fatty acids decreased significantly ($p < 0.05$), particularly C18:2N6C, C20:5, and C22:6. OAV and PLS-DA analyses identified nonanal, hexanal, and (E)-2-octenal as key differential fishy odor compounds. Correlation analysis further revealed that the degradation of C18:2N6C was highly negatively correlated with nonanal ($p < 0.01$), while the oxidative degradation of EPA (C20:5) and DHA (C22:6) was significantly associated with nonanal, hexanal, and (E)-2-octenal ($p < 0.05$). This study provides insights into the components, pathways, and control measures for the fishy odor formation during the refrigeration-reheating process of cooked *E.sinensis*.

Key words: *E.sinensis*; refrigeration-reheating; lipid oxidation; fishy odor

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Inhibitory Effects of Fe^{2+} and an Oyster-Derived Peptide on Xanthine Oxidase

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Abstract: Xanthine oxidase (XOD) facilitates the conversion of hypoxanthine and xanthine into uric acid, making it a critical therapeutic target for regulating purine metabolism and treating hyperuricemia. This study investigated the inhibitory effects of metal ions and oyster-derived bioactive peptides on XOD activity. XOD, with a molecular weight of approximately 145 kDa, was purified to homogeneity from pig liver using successive chromatographic techniques. The enzyme exhibited optimal activity at 40 °C and pH 8.0, with a melting temperature of 59.6 °C. Among metal ions evaluated, Fe^{2+} demonstrated the most significant inhibitory effect via a static quenching mechanism, acting as a mixed-type inhibitor. Furthermore, bioactive peptides were prepared from oysters via hydrolysis with alkaline proteinase, followed by ultrafiltration, chromatographic purification, and mass spectrometry analysis. The most potent inhibitory peptide, identified as NDWPIGRG (NG8), demonstrated a half-maximal inhibitory concentration (IC_{50}) of 1.04 ± 0.25 mmol/L. The inhibition exhibited by NG8 was determined to be reversible and of mixed-type. Molecular docking study revealed that the interaction between NG8 and XOD was primarily mediated by hydrogen bonding and electrostatic interactions, with Asn768, Lys771, and Glu802 on XOD identified as key interacting residues. This study underscores the potential of pig liver-derived XOD as a target enzyme for the screening of inhibitory compounds, such as Fe^{2+} and the oyster-derived inhibitory peptide NG8 (NDWPIGRG), thereby providing a theoretical foundation for the development of natural functional foods.

Key words: Inhibitory peptide; Oyster; XOD; Molecular docking

海洋源功能性脂质对肾脏疾病的改善效果及作用机制

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摘要：肾脏疾病的发病率在全球均呈快速增长趋势，目前慢性肾脏疾病的治疗主要以药物治疗、营养支持、替代治疗为主。海洋生物体内的功能性脂质因其独特的结构与生理活性，在疾病防治领域受到广泛关注。课题组新近研究发现，富含 DHA/EPA 的磷脂可以通过调节肾脏脂质代谢、改善线粒体功能及抗氧化防御系统、遏制肾脏细胞凋亡等途径改善外源性药物诱导的急性肾损伤。富含 EPA 的缩醛磷脂可以通过作用于肾素-血管紧张素-醛固酮系统、抑制肾脏纤维化因子和调节体内炎症信号通路等改善高血压肾症。未来，基于海洋功能性脂质的作用机制解析及其在体内代谢转化规律的研究，将为开发新型肾脏疾病营养干预与辅助治疗策略提供科学依据。

关键词：磷脂； DHA/EPA；肾脏疾病

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The improvement effect and mechanism of marine derived functional lipids on kidney disease

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Abstract: The incidence rate of kidney disease is growing rapidly all over the world. At present, the treatment of chronic kidney disease mainly focuses on drug treatment, nutritional support and substitution treatment. Functional lipids in marine organisms have received widespread attention in

the field of disease prevention and treatment due to their unique structure and physiological activity. The research team recently found that phospholipids rich in DHA/EPA can improve exogenous drug-induced acute kidney injury by regulating renal lipid metabolism, improving mitochondrial function and antioxidant defense system, and inhibiting renal cell apoptosis. Acetal phospholipids rich in EPA can improve hypertensive nephropathy by acting on the renin angiotensin aldosterone system, inhibiting renal fibrosis factors, and regulating inflammatory signaling pathways in the body. In the future, the analysis of the mechanism of action of marine functional lipids and their metabolic transformation in vivo will provide scientific basis for the development of new nutritional intervention and adjuvant therapy strategies for kidney diseases.

Key words: Phospholipid; DHA/EPA; kidney disease

Development of a Rapid Enzymatic Quantification Method for Hyaluronic Acid Based on Gene-Mining of Hyaluronate Lyase

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Abstract: Hyaluronic acid (HA) is widely used in food, pharmaceutical, and cosmetic industries, where rapid and reliable quantification is essential for quality control. Traditional assays such as the carbazole method and chromatography are often limited by matrix interference, high cost, and complex operation. Here, a gene-mining strategy was applied to the PL16 family of hyaluronate lyases to identify efficient enzymes for HA quantification. Through a weighted scoring system evaluating activity, stability, and specificity, Hly16A from *Streptomyces koganeiensis* was selected as the optimal enzyme. Hly16A exhibited high specific activity (137.5 U/mg), broad pH tolerance (3-11), and good thermostability. Based on its catalytic performance, a rapid enzymatic quantification method was developed, showing high linearity (R^2>0.999) over 40-600 μg/mL and completing detection within 30 min. The method was free from interference by chondroitin sulfate, heparin, or alginate and achieved 97-106% recoveries in commercial samples. This work provides a simple, specific, and low-cost enzyme-based approach for HA quantification and exemplifies a post-genomic strategy for polysaccharide detection.

Key words: enzymatic quantification; hyaluronic acid; hyaluronate lyase; gene mining

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无水运输过程中 CO2 含量调控对南美白对虾存活率和应激反应的影响

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摘要：本研究旨在探讨环境中 CO_2 含量对南美白对虾（*Penaeus vannamei*）无水保活运输存活率及其氧化和组织学形态的影响。对照组活虾在 13℃的高氧(≥95% O_2)环境模拟无水运输 12h 后，CO_2 浓度由 0%升至 14.43%，存活率为 73.33%；而以 $Ca(OH)_2$ 作为 CO_2 吸收剂可完全吸收环境中 CO_2(0%CO_2)，且存活率显著增高至 100%。研究发现消除环境 CO_2 可将血浆中 HCO_3^-浓度和 CO_2 总含量(TCO_2)分别降低 36.23%和 35.45%。CO_2 消除组内对虾肝胰腺的丙二醛(MDA)含量为 33.22 nmol/mg 显著低于对照组的 25.97 nmol/mg，表明消除环境中的 CO_2 可减轻氧化损伤。组织学显示对照组鳃丝上皮细胞肿胀、脱落；肝胰腺细胞空泡化。而 CO_2 吸收剂组鳃和肝胰腺组织结构完整，表明环境中 CO_2 含量的减少有效保护了对虾的组织形态完整性，并最终保持了较高的无水运输存活率。

关键词：南美白对虾；无水运输；CO_2 控制；高碳酸血症；应激反应

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蛋白纤维体系对鱼明胶乳液凝胶特性的影响研究

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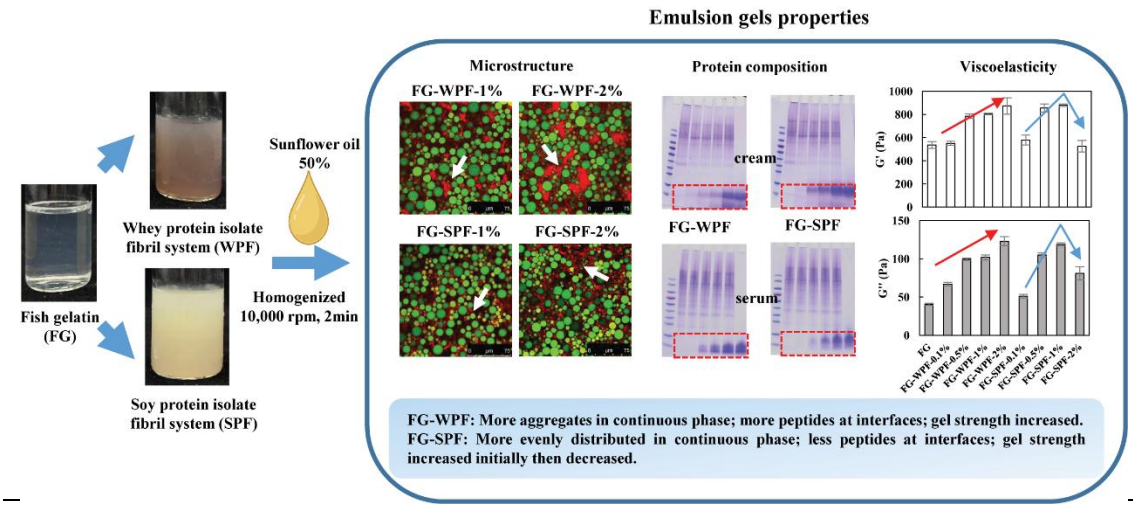
摘要：明胶是构建乳液凝胶的重要原料，鱼明胶（fish gelatin，FG）作为哺乳动物明胶的替代物备受关注，但其界面活性和结构稳定性不足限制了应用。为改善其性能，本研究将 FG 与乳清分离蛋白纤维体系（whey protein isolate fibril system, WPF）及大豆分离蛋白纤维体系（soy protein isolate fibril system, SPF）复配，系统评估了不同来源与浓度蛋白纤维对 FG 乳液凝胶结构、界面行为、流变特性及稳定性的影响。结果表明，在 pH 7 条件下，FG 与 WPF 或 SPF 通过静电作用形成复合物，显著提升了表面疏水性和界面活性。随着 WPF 浓度升高，乳液液滴粒径减小且储能模量（G′）增加，说明其可有效增强乳液乳析稳定性以及乳液凝胶粘弹性。相比之下，低浓度 SPF（0.1%）导致乳液液滴聚并，粒径增大，但进一步增加浓度则显著减小粒径，同时适量 SPF 有助于改善 FG 乳液凝胶强度。然而，当 SPF 浓度过高时，凝胶储能模量反而下降。综上，WPF 与 SPF 均能通过调控界面吸附和结构特性提升 FG 乳液的乳析稳定性与凝胶结构的刚性，为鱼明胶基功能食品材料的开发提供了理论支持。

关键词：鱼明胶；蛋白纤维体系；乳液凝胶；乳析稳定性；流变学特性



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Fusion of near-infrared and Raman spectroscopy with machine learning strategies: non-destructive rapid assessment of freshness and TVB-N value prediction in Pacific white shrimp (Litopenaeus vannamei)

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Abstract: Total volatile base nitrogen (TVB-N) is a key indicator of shrimp freshness. Nevertheless, traditional detection methods are cumbersome, time-intensive, and destructive. Here, a rapid and non-destructive method based on near-infrared (NIR) and Raman spectroscopy for the assessment of TVB-N content in Litopenaeus vannamei was proposed. A prediction model was constructed based on three machine learning methods, namely convolutional neural networks, extreme learning machines, and backpropagation, which were combined with low-level data fusion and mid-level fusion strategy to predict TVB-N content. The calibration coefficient of prediction (R2p) values of the feature-lever prediction models constructed using Savitzky-Golay (SG) smoothing for NIR and Raman spectroscopy were 0.846 and 0.784, respectively. Notably, Medium-level data fusion combined with the extreme learning machines model showed the best prediction results with R2p and root mean square error of prediction values of 0.986 and 0.677 mg/100 g, respectively, and the R2 values of the feature-level fusion models optimized with feature selection algorithms, such as competitive adaptive re-weighted sampling, successive projection algorithm, and genetic algorithm all exceeded 0.96. These findings verified the complementary advantages of NIR and Raman spectroscopic data in monitoring the quality and effectiveness in freshness assessment. In particular, with the assistance of portable spectroscopic instruments, these two spectroscopic techniques provide an efficient, non-destructive, and real-time technical method for monitoring the freshness of L. vannamei.

Key words: Litopenaeus vannamei; Total volatile basic nitrogen; Spectral analysis machine learning; Data fusion; Non-destructive detection

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脱水处理对虾夷扇贝闭壳肌结构与氧化的影响

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摘要：扇贝闭壳肌是食品工业中一种重要的海洋资源，本研究对比四种脱水方式（热风 HAD、真空热风 VFAD、微波脱水 MWD 和真空冷冻脱水 VFD）对扇贝闭壳肌组织结构、理化和蛋白氧化特性的影响。结果表明，VFD 最佳地保持了组织的超微结构完整性，维持了其表面纤维结构，并且其复原率（78%）和复水率（186.5%）均优于 HAD、VFAD 和 MWD。脱水方式的不同不会造成蛋白 zeta 电位显著差异，但 HAD 引起的颗粒团聚程度最大，其次是 MWD。值得注意的是，与 HAD 相比，VFD 提高了蛋白质稳定性，使巯基含量增加了 163.2%，羰基形成减少了 48.1%，而 MWD 则产生了相反的效果。多光谱分析显示，MWD 后蛋白质二级和三级结构严重破坏，VFD 则最大程度地减少了构象变性。多维度数据模型分析结果显示扇贝闭壳肌干燥敏感性参数的排序如下：表面疏水性＞硬度＞β-转角含量＞二酪氨酸交联＞横向弛豫时间 T_{23}。这些发现暗示 VFD 是减轻扇贝加工过程中结构降解和氧化损伤的最佳方法，为提高即食扇贝产品的技术功能质量提供了切实可行的见解。

关键词：虾夷扇贝；闭壳肌；脱水；氧化稳定性

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空气暴露胁迫基于 AMPK 途径对凡纳滨对虾代谢调控及肌肉风味的调控机制

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摘要：空气暴露胁迫是鲜活水产品在无水运输中的主要胁迫因素。本文研究了凡纳滨对虾（*Penaeus vannamei*）在空气暴露过程中其肌肉组织中 AMPK 调控的能量物质代谢途径以及相关代谢产物对肌肉风味的影响。结果显示，空气暴露 4 h 时肌肉中的 AMPK 上游激活信号（AMP/ATP 比值与细胞质 Ca^{2+}）显著上升；随后 AMPK 基因与 p-AMPK 蛋白在空气暴露 8 h 后表达量最高，说明对虾在空气暴露 8 h 后肌肉中 LKB1/CaMKK‐AMPK 途径被激活并引发糖酵解提供能量。此外，肌肉组织中 ATP 和蛋白质在 AMPK 调控下发生降解，分别生产 IMP 和游离氨基酸等呈味物质。肌肉的电子舌检测结果显示：暴露后肌肉鲜味增强，4 h 甜味最高、苦味最低，整体风味最佳。综上所述，凡纳滨对虾主要通过肌肉中的 AMPK 通路调控的代谢调节来维持能量稳态，并提高肌肉的整体风味。

关键词：凡纳滨对虾；无水运输；AMPK；生理机制；风味

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AMPK-mediated regulation of metabolism and flesh flavor under air exposure stress in Penaeus vannamei

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Abstract: Air exposure stress is the primary stressor during waterless transport of live aquatic products. We investigated AMPK-regulated energy-metabolic pathways in the flesh during air exposure and the impacts of related metabolites on shrimp (*Penaeus vannamei*) flesh flavor. An elevated AMP/ATP ratio and increased cytosolic Ca^{2+} were observed, indicating the upstream activation signals of AMPK was aroused. Subsequently, AMPK transcript and phosphorylated AMPK (p-AMPK) protein in the flesh peaked at 8 h, indicating activation of the LKB1/CaMKK‐AMPK axis and an enhanced glycolytic flux to meet energy demand. In addition, under AMPK regulation, ATP and proteins in the flesh underwent catabolism, yielding inosine 5'-monophosphate (IMP) and free amino acids (FAAs) as taste-active compounds. Electronic-tongue analysis revealed increased umami after exposure, with sweetness peaking at 4 h, bitterness minimized at 4 h, and overall flavor optimal at 4 h. Collectively, these findings indicate that *Penaeus vannamei* maintains energy homeostasis primarily through AMPK-mediated metabolic regulation in the flesh, while possibly improving overall flesh flavor.

Key words: *Penaeus vannamei*; waterless transport; AMPK; physiological mechanism; flavor

生物保鲜剂对冻藏小龙虾的保鲜效果研究

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摘要：为提升小龙虾冻藏品质，本研究探讨了生物保鲜剂（MNP，ε-聚赖氨酸盐酸盐/迷迭香提取物/茶多酚）、液氮速冻（NQ）和化学防腐剂（PS）对冷冻小龙虾的保鲜效果。通过理化指标（pH、TBARS、TVB-N）、蛋白质降解（总巯基/羰基含量、TCA-可溶性肽、SDS-PAGE）、水分分布（WHC、LF-NMR）、质构特性及电子舌分析，综合评价各组保鲜效能。结果表明，MNP 处理相较于 NQ 及 PS 组显著延缓了冻藏小龙虾品质劣变。MNP 组 TBARS 值和 TVB-N 值增幅最低，总巯基含量最高而羰基含量最低，肌球蛋白重链和肌动蛋白降解明显减少，说明蛋白质氧化降解得到有效抑制；WHC 和 LF-NMR 分析表明，MNP 处理减少了小龙虾的水分迁移并增强了结合水的稳定性，且在贮藏后期更为明显；质构和电子舌分析进一步表明 MNP 组硬度、咀嚼性保持最佳，风味变化最小。综上，生物保鲜剂能有效维持冷冻小龙虾的理化特性、蛋白质稳定性、水分分布及感官品质，其效果优于 NQ 和 PS 处理，具有应用于冷冻水产品保鲜的潜力。

关键词：小龙虾；生物保鲜剂；贮藏品质；蛋白质氧化;

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基于小分子诱导策略的细胞培育鱼脂肪高效制备

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摘要：目的：细胞培育鱼肉是强化未来高品质食品需求，缓解传统水产养殖系列问题的重要策略。海水鱼富含多饱和脂肪酸脂肪，是维持细胞培育鱼肉营养与风味品质的核心物质。本研究拟聚焦探寻海水鱼干细胞高效成脂策略挖掘，以期实现高品质细胞培育与脂肪制备。方法：通过系统筛选植物源小分子化合物，鉴定出补骨脂二氢黄酮与脱氢松香酸为核心成脂诱导成分，并优化其浓度与外源脂质补充策略；构建无血清替代培养体系，结合生长因子、抗氧化剂与载体蛋白，支持脂肪干细胞在 2D 与 3D 微载体培养环境下的成脂分化。结果：小分子诱导系统可激活 PPARγ 通路，促进脂质合成与积累，转录组与代谢组分析进一步证实该系统可调控脂代谢相关通路与脂肪酸组成；在低刚度明胶微载体三维培养体系中，脂质积累与成脂基因表达显著增强。基于该无血清诱导策略，实现了大体系细胞培育鱼脂肪的制备。结论：本研究建立了一种化学定义明确、无动物源成分的成脂诱导平台，为细胞培育鱼脂肪的规模化生产提供了理论基础与技术支撑。

关键词：成脂分化；细胞农业；无血清诱导；大黄鱼；可食用微载体

A Strategy for High-Efficiency Production of Cultivated Fish Fat via Small Molecule-Induced Differentiation

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Abstract: **[Objective]:** Cultivated fish meat presents a promising approach to meet the growing demand for high-quality food products while mitigating challenges associated with conventional aquaculture. Marine fish are rich in polyunsaturated fatty acid-rich lipids, which are essential for maintaining the nutritional and sensory quality of cultivated fish. This study aims to establish an efficient adipogenic strategy for marine fish stem cells, thereby enabling high-quality cultivated muscle production and lipid biosynthesis; **[Methods]:** A systematic screen of plant-derived small molecules identified bavachinin and dehydroabietic acid as principal adipogenic inducers. Their concentrations and exogenous lipid supplementation regimes were optimised. A serum-free culture system was established, integrating growth factors, antioxidants and carrier proteins to support adipogenic differentiation of adipose-derived stem cells under both two-dimensional and three-dimensional microcarrier culture conditions; **[Results]:** The induction system activated the PPARγ pathway, enhancing lipid synthesis and accumulation. Transcriptomic and metabolomic analyses confirmed modulation of lipid metabolic pathways and fatty acid profiles. Three-dimensional culture on low-stiffness (10 kPa) gelatin-based microcarriers significantly increased lipid deposition and upregulation of adipogenic genes. Using a serum-free induction protocol, we have achieved the large-scale production of cultivated fish fat; **[Conclusion]:** We have established a chemically defined, animal-component-free platform for adipogenic induction, providing a scientific and technical foundation for scalable production of cultivated fish adipose tissue.

Key words: Adipogenic differentiation; Cellular agriculture; Serum-free induction; *Larimichthys crocea*; Edible microcarriers

Synergistic cryoprotection of L-proline and L-phenylalanine by gradient control of ice inhibition and osmolyte pressure regulation

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Abstract: The present work explored the synergistic effects and the corresponding mechanisms of L-proline and L-phenylalanine on frozen fish fillets. The results suggested that the combination of L-proline and L-phenylalanine (Pro+Phe) exerted synergetic cryoprotective roles on frozen fish fillets, as evidenced by lower mass loss (19.19%) and higher water holding capacity (71.54%). Besides, the structural stability of myofibrillar protein against F-T cycles was higher in the Pro+Phe, with comparable sulfhydryl contents and Ca^{2+}-ATPase activity with the commercial antifreeze. The large contact area with water molecules and the loose structure of L-phenylalanine accounted for their outstanding ice recrystallization inhibition (IRI) performance (lowest %MGS, 32.91%) relative to L-proline. Besides, the osmotic pressure regulation (7.05%) and freezing point depression (140.00%) of L-proline were largely responsible for preserving tissue integrity. Hence, the synergistic effects of the IRI activity of L-phenylalanine and osmotic pressure regulation from L-proline contributed to the improved quality of frozen fish fillets.

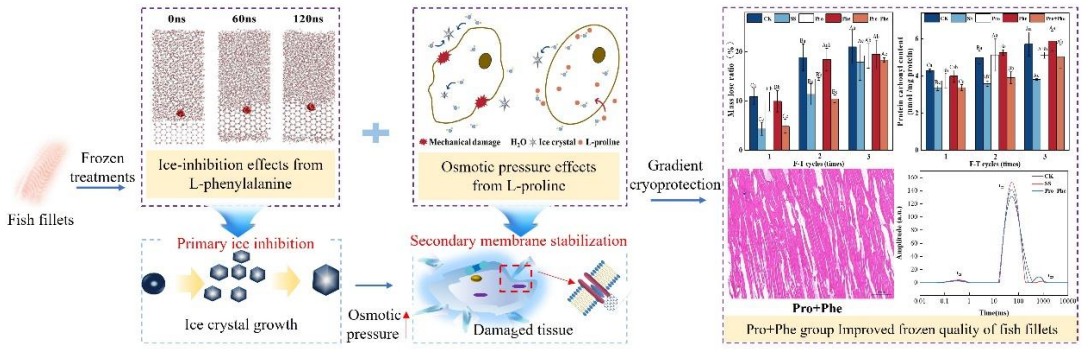

Figure 1 Abstract of the paper

Key words: Cryoprotection; L-proline; L-phenylalanine; Ice recrystallization inhibition; Osmotic pressure regulation.

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Mechanisms of Protein Degradation and Non-volatile Taste Precursor release in the body meat of Eriocheir sinensis Under Various Thermal Processing Methods

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Abstract: This study investigated the degradation patterns of muscle proteins and the release characteristics of non-volatile taste precursors in Eriocheir sinensis subjected to various thermal processing methods. The extraction of total protein, SDS-PAGE, protein solubility, surface hydrophobicity, intrinsic fluorescence, and DIA-proteomics .were determined. The results demonstrated that thermal processing significantly promoted the accumulation of non-protein nitrogen components and induced irreversible protein degradation. Compared with other groups, the BK group exhibited higher protein solubility ($P<0.05$) and a remarkable increase in proteins with molecular weights below 17 kDa. KEGG enrichment analysis revealed significant involvement of nucleotide metabolism, phenylalanine metabolism, glutathione metabolism, and fatty acid biosynthesis pathways. Protein degradation induced by thermal processing was mainly associated with ATP degradation, amino acid metabolism, glycolysis, and lysosomal pathways, with a total of 11 major differential proteins identified. Notably, alanyl aminopeptidase, glutaminase, AMP dehydrogenase, and succinate dehydrogenase were significantly upregulated following heat processing, potentially contributing to taste variations. Moreover, nucleoside kinase, AMP deaminase, L-serine dehydratase, and cytosolic non-specific dipeptidase were found to facilitate the accumulation of small peptides and enhance umami perception.

Keywords: *Eriocheir sinensis*; Thermal processing; Protein degradation; DIA-proteomic; Taste precursors

The Effects of Tilapia Fillets at Different Center Temperatures on the In Vitro Digestion Characteristics of the Elderly

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Abstract: [Objective] This study investigated the *in vitro* digestion characteristics of tilapia fillets steamed to different center temperatures (60, 70, 80, and 90°C) under elderly gastrointestinal conditions, as well as the influence of both intrinsic (protein physicochemical properties) and extrinsic (texture characteristics) factors; [Methods] Texture properties and protein physicochemical characteristics (solubility, turbidity, surface hydrophobicity, aggregation, TCA-soluble peptides, and SDS-PAGE profiles) of steamed tilapia fillets were determined. The INFOGEST static model was applied to simulate *in vitro* digestion under both control and elderly conditions. Protein digestibility was assessed, while microstructure and infrared spectra were examined before and after digestion; [Results] Results showed a significant reduction in digestibility with increasing temperature, reaching the lowest value at 90°C (78.98%). Texture properties peaked at 70°C, while microstructural and physicochemical analyses indicated protein denaturation, gelation, and re-aggregation, which collectively impaired digestibility. Correlation analysis revealed that texture mainly influenced gastric digestion, whereas protein physicochemical properties determined intestinal digestion; [Conclusion] Overall, center temperature markedly modulates the *in vitro* digestive behavior of tilapia fillets in the elderly, highlighting the need to balance texture and protein properties when developing dietary strategies for this population.

Key words: Tilapia fillet; *In vitro* digestion; Elderly model; Texture; Protein physicochemical properties; Center temperature

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抗氧化碳点：合成，活性，机制及其在食品工业中的应用

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摘要：抗氧化剂可以抑制食品腐败，预防营养流失，提高食品质量，在食品保护中发挥重要的作用。纳米材料由于具有清除自由基的巨大潜力，因此被广泛用作抗氧化剂。其中，碳点（CDs）因其相对较高的生物相容性和独特的物理化学特性而备受关注。本文回顾了 CDs 作为新型抗氧化剂在食品工业中应用的最新研究进展。我们首先讨论了各种抗氧化 CDs 的合成方法，然后介绍了不同 CDs 的抗氧化活性以及影响其抗氧化活性的因素。然后，讨论了关于 CDs 抗氧化机制的各种猜想。该综述特别关注了 CDs 作为抗氧化剂在食品工业中的应用，例如：食品包装材料、食品添加剂。最后，还介绍了开发更稳定、更高效的抗氧化 CDs 及其大规模应用所面临的挑战和前景。

关键词：碳点；抗氧化剂；自由基；抗氧化机制

Antioxidant carbon dots: synthesis, activity, mechanism and application in the food industry

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Abstract: Antioxidants play an important function in food preservation by inhibiting food spoilage, preventing nutrient loss and improving food quality. Nanomaterials have recently been widely used as antioxidants because of their remarkable potential to scavenge free radicals. Of them, owing to their relatively high biocompatibility and unique physicochemical properties, carbon dots (CDs) have garnered considerable attention. This paper reviews the recent advances of CDs as a new antioxidant in food industry. We here first discuss the methods for synthesizing various antioxidant CDs, followed by the antioxidant activities of different CDs and factors influencing these activities. Then, the various conjectures on the antioxidant mechanism of CDs are discussed. The review particularly focuses on applying CDs as antioxidants in the food industry, such as food packaging materials, food additives etc. Finally, the challenges and prospects for developing more stable and efficient antioxidant CDs and their large-scale applications are described.

Keywords： Carbon dots；Antioxidants；Free radicals；Antioxidant mechanisms

鱼胶原蛋白肽的风味调控及其机制解析

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摘要：目的：鱼胶原蛋白肽具有多种生物活性，但其不良风味限制该原料在食品工业中的广泛应用。为解决这一关键问题，本研究旨在系统评价低度美拉德反应、酶促糖基化反应及转肽反应三种风味调控策略对胶原蛋白肽风味特征的影响，并深入解析其作用机制。方法：以罗非鱼皮胶原蛋白为原料，采用生物酶解耦合低度美拉德反应、酶促糖基化以及转肽反应对胶原蛋白肽进行修饰。通过系统表征修饰产物的理化及结构特征，在此基础上，利用感官评价、电子舌分析、液质联用、气质联用、分子对接、味觉受体细胞模型，分析修饰前后产物的风味轮廓、滋味属性及挥发性成分的变化。结果：氨基葡萄糖诱导的低度美拉德反应能够显著降低了胶原蛋白肽的不良气味，同时促进了芳香族化合物的生成。感官评价结合电子舌分析表明，修饰后胶原蛋白肽的苦味强度降低，咸味、鲜味强度显著增加。酶促糖基化修饰显著增强胶原糖肽的咸味感知，分子对接和味觉受体细胞模型证实了胶原糖肽通过与 ENaC 和 TRPV1 受体的结合模式。此外，转肽修饰形成富含芳香氨基酸的 γ-谷氨酰肽，能够通过与 CaSR 结合进而显著增强咸味和鲜味感知。结论：本研究为胶原蛋白肽的靶向风味调控提供了理论依据，并为食品工业中的减盐提鲜供了新策略。

关键词：胶原蛋白肽；美拉德反应；酶法糖基化；转肽反应；减盐

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Flavor modulation of fish collagen peptides and elucidation of underlying mechanisms

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Abstract: [Objective]: Fish collagen peptides possess various bioactivities, but their undesirable flavor limits their broad application in the food industry. To address this critical issue, this study aims to systematically evaluate the effects of three flavor-modification strategies, namely Maillard reaction, enzymatic glycosylation, and transpeptidation, on the flavor profile of collagen peptides, and to elucidate the underlying mechanisms. [Methods]: Tilapia skin collagen was used as the raw material. Collagen peptides were modified using enzymatic hydrolysis coupled with mild Maillard reaction, targeted enzymatic glycosylation, and transpeptidation. The physicochemical and structural characteristics of the modified products were systematically characterized. Subsequently, the changes in flavor profile, taste attributes, and volatile compounds before and after modification were analyzed using sensory evaluation, electronic tongue, LC-MS/MS, GC-MS, molecular docking, and taste receptor cell models.[Results]: Glucosamine-induced mild Maillard reaction significantly reduced the undesirable odor of collagen peptides and promoted the formation of aromatic compounds. Sensory evaluation combined with electronic tongue analysis showed that the bitterness intensity of modified peptides decreased, while the saltiness and umami intensities significantly increased. Enzymatic glycosylation significantly enhanced the saltiness perception of collagen glycopeptides. Molecular docking and taste receptor cell models confirmed that collagen glycopeptides interact with ENaC and TRPV1 receptors. In addition-glutamyl peptides abundant in aromatic amino acids, formed via transpeptidation, significantly enhanced saltiness and umami perception by binding to CaSR.[Conclusion]: This study provides a theoretical foundation for the targeted flavor modulation of collagen peptides and offers novel strategies for salt reduction and umami enhancement in the food industry.

Key words: Collagen peptides; Maillard reaction; Enzymatic glycosylation; Transpeptidation; Salt reduction

羟基功能化抗氧化抗菌碳点的制备及其在虹鳟鱼保鲜中的应用

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摘要：2023 年，虹鳟鱼产量达到 4.11 万吨，占全球鳟鱼总产量的 4%。然而，微生物污染以及脂质和蛋白质的氧化导致了约 15%的水产品发生腐败。为了防止腐败，本研究开发了一种双功能木糖醇-2-羟丙基-β-环糊精碳点(xβ-CDs)，具有超强抗氧化和高效抗菌能力。xβ-CDs 主要通过羟基发挥作用，对 DPPH、ABTS 和·OH 自由基的抑制率分别达到 96.31%、99.74%和 99.72%，与维生素 C 的抗氧化能力相当。xβ-CDs 通过破坏细菌细胞壁和膜的完整性，对多种腐败细菌表现出有效的抗菌活性，并将总蛋白、AKP 和 ATP 酶水平分别降低了 51.25%，70.08%和 57.80%。储藏实验表明，xβ-CDs 可将虹鳟鱼片的保质期延长 3 天。这些结果表明，xβ-CDs 具有在食品保鲜中预防细菌感染、蛋白质氧化和脂质氧化的潜力，提供了一种新颖的解决策略。

关键词：碳点；抗氧化剂；抗菌；蛋白质氧化；食品保鲜

Preparation of Antioxidant and Antibacterial Carbon Dots with Hydroxyl-Functionalized for Rainbow Trout Preservation

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Abstract: In 2023, Rainbow trout production reached 41,100 tons, which was 4% of the global trout

production. However, microbial contamination and lipid and protein oxidation cause spoilage in 15% of the total aquatic products generated. To avoid spoilage, this study developed bifunctional xylitol-2-hydroxypropyl-β-cyclodextrin carbon dots (xβ-CDs) with super antioxidant and high antimicrobial abilities. The xβ-CDs primarily exert their effects through hydroxyl groups, causing significant inhibition of DPPH, ABTS, and·OH radicals, with inhibition rates of 96.31%, 96.74%, and 99.72%, respectively, which in line with the antioxidant capacity of vitamin C. The xβ-CDs demonstrated effective antibacterial activity against various spoilage bacteria by disrupting the bacterial cell wall and membrane integrity and reducing total protein, AKP, and ATP enzyme levels by 51.25%, 70.08%, and 57.80%, respectively. Storage experiments unveiled that the xβ-CDs effectively prolonged the shelf life of Rainbow trout fillets by 3days. These results suggested that the xβ-CDs present a novel strategy for preventing bacterial infections, protein oxidation, and lipid oxidation in food preservation.

Keywords: Carbon dots；Antioxidants；Antibacterial；Protein oxidation；Food preservation

Glycosylation-Induced Modifications in Cod Skin Peptides: Impacts on Zinc Chelation and Antimicrobial Activity

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Abstract: This study investigates the effects of glycosylation modifications on the zinc chelation capacity and *Escherichia coli* inhibitory activity of cod skin peptides, while elucidating the structural and property differences between maltose- and maltodextrin-derived glycosylated cod skin peptide zinc complexes. This study involved the production of products through Maillard reactions between maltose and maltodextrin with cod skin peptides, which were conducted over a period of 4 to 7 hours, followed by chelation with zinc ions. The resulting products were characterized by means of liquid chromatography and Fourier-transform infrared spectroscopy, while their antimicrobial activity was evaluated through Oxford cup diffusion assays and minimum inhibitory concentration (MIC) determinations. The results indicate that the maltose system demonstrated the highest zinc chelation capacity among the glycosylation products formed after 4 hours, achieving a chelation rate of 79.0548 mg/g. This corresponded to an antibacterial zone diameter of 17.35 ± 0.54 mm. The maltodextrin system demonstrated its maximum zinc chelation capacity at 6 hours for the corresponding glycosylation products, achieving a zinc chelation rate of 78.9467 mg/g. This was accompanied by significantly enhanced antimicrobial activity, as evidenced by an inhibition zone diameter of 18.87 ± 0.56 mm. In conclusion, both cod skin peptide zinc chelates exert antimicrobial effects by compromising the cell membranes of *Escherichia coli*. Notably, the maltodextrin-based formulation exhibits enhanced antimicrobial activity, thereby offering a promising foundation for the development of innovative zinc supplements and antimicrobial agents.

Key words: Zinc ion; Cod skin peptide; Maltose; Maltodextrin; *Escherichia coli*

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Study on the Characteristics of Maillard Reaction Products from Cod Skin Peptides Modified with Mannose and Polydextrose and Their Zinc Chelating Capacity

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Abstract : The modification of cod skin peptides was investigated through the Maillard reaction using various sugar sources, followed by chelation with zinc ions, to facilitate the development of novel zinc supplements. Mannose and polydextrose were individually incubated with cod skin peptides under controlled conditions of 90 ℃ and pH 7.4 for varying durations (4-7 h) to generate Maillard reaction products (MRPs). These MRPs were subsequently subjected to chelation with zinc ions to yield glycosylated peptide-zinc complexes. The products were characterized using liquid chromatography, circular dichroism spectroscopy, degree of grafting measurement, chelation rate analysis, and Fourier transform infrared spectroscopy. Zinc solubility during simulated digestion was evaluated, along with resistance to dietary inhibitors. It was demonstrated that the grafting degree of the mannose system was significantly increased from 12.79% at 4 hours to 83.77% at 7 hours, while the polydextrose system exhibited grafting degrees of 58.82% at 4 hours and 82.02% at 7 hours. Regarding zinc chelation capacity, a zinc content of 397.16 μmol·L^{-1} was achieved by the mannose system at 4 hours, corresponding to a chelation capacity of 79.43 mg·g^{-1}, whereas the polydextrose system reached 407.47 μmol·L^{-1} at 7 hours, corresponding to 80.49 mg·g^{-1}. Both chelates were demonstrated to possess high solubility in the intestinal environment and exhibit robust resistance to inhibitory effects from oxalate and phytate. It is indicated that mannose- and polydextrose-modified cod skin peptide Maillard reaction products possess significant zinc chelating capacity, providing a theoretical basis for the development of efficient and stable peptide-zinc chelates as promising novel zinc supplements.

Key words: Cod skin peptide; Maillard reaction; Mannose; Polydextrose; Zinc chelation

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High internal phase Pickering emulsion by Ovalbumin-EGCG: Application for stabilizing Lutein

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Abstract: This study investigated the effect of different concentrations of epigallocatechin gallate (EGCG) covalently bound to ovalbumin (OVA) by the alkaline method on the structure and function of the covalent complex. It also involved the application of OVA-EGCG covalent complex as an emulsifier of corn oil emulsions and used these emulsions to enhance the protective delivery capacity of lutein. The results indicate that compared with the other groups, the total phenolic content and disulfide bond content in the OVA-EGCG 10:1 complex were significantly enhanced, while the free amino and free sulfhydryl content were significantly reduced. Spectral analysis revealed that EGCG compounded OVA with a changed structure and morphology, resulting in improved emulsification. Simultaneously, the high internal phase Pickering emulsion (HIPPEs) stabilized by the OVA-EGCG 10:1 covalent complex exhibited excellent physical stability. Additionally, the lutein encapsulation efficiency of HIPPEs stabilized by the OVA-EGCG 10:1 covalent complex was up to 94.08%. Simulated gastrointestinal digestion demonstrated that HIPPEs stabilized by the OVA-EGCG 10:1 covalent complex effectively enhanced the lutein bioavailability from 22.87% to 46.30%. In summary, the HIPPEs prepared in this study can be used for better delivery of lutein.

Keywords: High internal phase Pickering emulsion; Ovalbumin; Epigallocatechin gallate; Alkali method; Lutein

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Preparation and Performance Study of κ-Carrageenan-Modified Tuna Skin Gelatin Hydrogels

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Abstract: Tuna skin, a byproduct of tuna processing, is exceptionally rich in gelatin and possesses inherent gelling properties, making it an excellent raw material for hydrogel preparation. However, the amino acid composition of fish skin gelatin is low in proline and hydroxyproline, resulting in limited gel properties for unmodified fish skin gelatin. Furthermore, as a natural polymer hydrogel, fish skin gelatin hydrogel relies solely on intermolecular forces such as hydrogen bonding, hydrophobic interactions, or electrostatic forces for cross-linking. Consequently, its cross-linked structure is weak, exhibiting poor mechanical properties and thermal instability. These limitations significantly restrict the application of fish skin gelatin hydrogel.In this study,κ-carrageenan (KC) was incorporated into the tuna skin gelatin (TSC) system to enhance the texture, mechanical strength, microstructure, and rheological properties of tuna skin gelatin gels. Within the tuna skin gelatin system, hydrophobic interactions and disulfide bonds significantly increased, while hydrogen bonds and electrostatic interactions decreased. When KC is incorporated into the tuna skin gelatin system, the gelatin and KC form an interwoven gel network structure through non-covalent intermolecular interactions, promoting the formation of additional intermolecular hydrogen bonds, increasing the crosslinking density, and facilitating the electrostatic interaction between the sulfate groups in the carrageenan and the amino groups in the gelatin. This study provides positive reference value for advancing the high-value utilization of natural by-products and the development of functional hydrogels.

Keywords: Tuna skin gelatin;κ-carrageenan;Cross-linked structure;Gel properties;Hydrogel

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Effect of Enzymatic Hydrolysates from Sea Cucumber Ovum on Fish Storage Quality and Antifreeze Activity

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Abstract: Protein denaturation induced by ice crystal formation is the main contributor to the deterioration of fish quality during frozen storage. This study aims to extract hydrolysates capable of inhibiting protein denaturation from sea cucumber ovum using three types of proteases (Pepsin, trypsin and neutral protease). The enzymatic hydrolysates of sea cucumber ovum protein are capable of stabilizing protein structures through interactions and preventing protein unfolding and aggregation caused by various factors. Thus, they are potential protectors against protein denaturation. This study investigated the effectiveness of various enzymatic hydrolysates of sea cucumber ovum protein in mitigating the quality deterioration and oxidative reactions of mackerel under freeze–thaw cycles. Following the freeze–thaw cycles, the SCOPH, SCOTH, SCONPH, and Con groups displayed reduced Ca^{2+}-ATPase activity, with values of 1.44, 1.55, 1.71, and 1.20 U/mg protein, respectively, when compared to the FF group. The results show that an enzymatic hydrolysates of sea cucumber ovum, identified as SCONPH, efficiently maintained the textural properties and oxidative and conformational stability of mackerel fillets during frozen storage. In addition, SCONPH inhibited water migration and microstructural damage to myofibrillar proteins during the freeze-thaw cycles, thereby maintaining overall fish quality. The results of this study indicate that SCONPH, a marine-derived bioactive enzymatic hydrolysate of sea cucumber ovum protein, is a promising candidate for sea cucumber ovum use in marine-based food preservation technologies.

Key words: Sea cucumber ovum; Freeze-thaw cycles; Myofibrillar protein; Antifreeze; Aquatic product preservation; Protein denaturation

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Study on Salmon Skin Collagen Peptides-Calcium Interactions and Effects on Digestive Enzyme Inhibitors

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Abstract: Type II diabetes is the most common form of diabetes. However, existing therapeutic drugs such as metformin and acarbose, while effectively lowering blood glucose, can also cause adverse reactions, including nausea, diarrhea, abdominal pain, and bloating. Peptide inhibitors, because of their wide availability, clear mechanisms of action, minimal toxicity and side effects, and the use of bioactive peptides derived from salmon by-products such as fish skin, are safer and more environmentally friendly compared to chemically synthesized drugs. Existing studies have shown that digestive enzymes are calcium-dependent enzymes. Therefore, the present study investigated the role of salmon fish skin collagen digests based on peptide-calcium interactions interacting with the calcium binding site of digestive enzymes to inhibit digestive enzyme activity. The research first extracted salmon skin collagen hydrolysates using simulated digestion and characterized the chelation products through UV spectroscopy, infrared spectroscopy, and scanning electron microscopy. Subsequent enzyme kinetics analysis indicated that the sample digested with pepsin for 2 hours followed by trypsin for 3 hours (SCP 2h+T 3h) exhibited the most effective inhibitory effect on digestive enzymes, producing a reversible mixed-type inhibition on both pepsin and trypsin. This study utilized enzymatic degradation of fish skin proteins to prepare bioactive peptides with digestive enzyme inhibitory activity, serving as novel digestive enzyme inhibitors for glycemic control, and provides a theoretical basis for the high-value utilization of salmon skin.

Key words: Salmon Skin; Calcium-binding; Collagen; Peptide

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Egg white-derived peptide IRW (Ile-Arg-Trp) reduces blood pressure in spontaneously hypertensive rats via inhibiting lipase and stabilizing fat metabolism

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Abstract: The ovotransferrin-derived peptide IRW has been confirmed to lower blood pressure in spontaneously hypertensive rats by activating angiotensin-converting enzyme 2. Given the well-established association between non-alcoholic fatty liver disease and hypertension, as well as IRW's previously documented lipid-modulating effects, this study aims to elucidate the regulatory role of the protein peptide IRW in the pathogenesis of non-alcoholic fatty liver disease in hypertensive rats. *In vitro* experiments utilised a synthetically produced and characterised IRW, revealing that IRW exerts a concentration-dependent inhibitory effect on pancreatic lipase. This inhibition induces changes in its secondary structure, thereby suppressing its activity and reducing fat absorption through non-competitive inhibition. IRW exerts its effects by modulating the expression of *Fabp* and *Apoa* families in the mesenteric artery, which are associated with lipid metabolism, alongside the adhesion molecules *Vcam1* and *lcam1* linked to atherosclerosis. This regulation suppresses the expression of *SREBP1* and *PPARα*, thereby reducing hepatic lipid metabolism. Consequently, IRW inhibits fat absorption, lowers hepatic lipid levels, and exerts antihypertensive effects.This research provides a theoretical basis for the application of the peptide IRW in the prevention and adjunctive treatment of non-alcoholic fatty liver disease.

Keywords: Peptide IRW; Pancreatic lipase; Lipid metabolism; Transcriptomics

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Cryoprotective activity of different characterized fractions isolated from sea cucumber intestinal protein hydrolysates against salmon

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Abstract: Freezing is the primary preservation method for salmon, and frozen product transportation requires cryoprotectant protection. However, current cryoprotectants, particularly traditional sugar-based ones, have significant drawbacks including high calorie content, high sugar levels, and associated health risks. Consequently, developing novel cryoprotectants that are natural, highly effective, and with clearly understood mechanisms has become a research priority. This study utilized sea cucumber intestinal protein as raw material, hydrolyzed with neutral protease, and evaluated the effects of different fractions on salmon freeze-thaw stability. Using ultrafiltration membrane separation, we obtained two fractions (<3 kDa, UMSF-1; >3 kDa, UMSF-2), and via solid-phase extraction separation, we acquired hydrophilic (SPESF-1) and hydrophobic (SPESF-2) fractions. These were analyzed for their effects on meat texture, water retention capacity, lipid oxidation, and myofibrillar protein stability. Results indicated that SPESF-2-treated frozen fish fillets demonstrated optimal cryoprotective activity, significantly maintaining uniform meat texture, excellent water retention, and effectively inhibiting myofibrillar protein denaturation and aggregation. These findings suggest that SPESF-2 from sea cucumber intestinal protein hydrolysates shows great promise as a novel protein-based cryoprotectant.

Key words: Sea cucumber intestinal protein; Neutral protease hydrolysates; Membrane separation; Solid phase extraction; Myofibrillar proteins

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Construction and Performance Study of Salmon Skin Gelatin Dual-Crosslinked Hydrogels Synergistically Enhanced by Peptide-Zinc Chelate Complexes

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Abstract: Fish skin gelatin serves as an excellent raw material for preparing biocompatible hydrogels. However, its mechanical properties−such as insufficient hardness, elastic tensile extensibility, and thermal instability−limit its further application in wound dressings, tissue engineering, and implantable scaffolds. To effectively enhance gel properties while maintaining biocompatibility, this study developed a synergistic enhancement strategy based on peptide-zinc chelates. This study developed a salmon skin gelatin hydrogel by inducing a protein-coupling reaction with 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride/N-hydroxysuccinimide (EDC/NHS), forming amide bonds to promote cross-linking of the network structure. Subsequently, the gels were systematically compared by placing them in solutions of zinc sulfate and peptide-zinc chelators, respectively, to evaluate their respective effects on enhancing gel properties. The results indicate that compared to zinc ion treatment alone, the hydrogel treated with the peptide-zinc chelator exhibits significant advantages in mechanical properties and structural stability. The peptide-zinc chelator not only serves as an efficient zinc ion carrier but also forms additional interactions (e.g., hydrogen bonds) with gelatin molecules within the hydrogel network through its peptide chains. This facilitates the construction of a denser and more stable dual-crosslinked network within the hydrogel. Specifically, the gel exhibits markedly enhanced hardness, elastic modulus, and compressive resistance, alongside improved thermal stability and network density. This study confirms that the peptide-zinc chelate is a highly efficient and multifunctional gel-enhancing agent superior to zinc ions alone. This strategy not only provides a novel approach for developing high-performance fish skin gelatin hydrogels but also expands the application of peptide-mineral chelates in biomaterials. The enhanced hydrogels prepared hold broad application prospects in food, pharmaceutical, and tissue engineering fields.

Keywords: Salmon Skin Gelatin; Hydrogel; Peptide-Zinc Chelator; Mechanical Properties

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Cryoprotective Effects of Salmon Skin Antifreeze Peptides on the Quality of Salmon Fillets During Low-Temperature Fluctuations

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Abstract: Repetitive temperature fluctuations during transportation and storage promote ice crystal formation in salmon fillets, leading to protein denaturation, lipid oxidation, and quality loss. Salmon skin, a major by-product of salmon processing, is a potential source of antifreeze peptides (AFPs) but remains underutilized. This study examined the cryoprotective effects of salmon skin-derived AFPs on salmon fillets subjected to repeated freeze–thaw cycles. Fillets treated with AFPs were evaluated for texture, color, water-holding capacity, volatile odor profiles, protein conformation, biochemical indices, and microstructure. AFP treatment improved textural properties, maintained color stability, and reduced thawing, cooking, and centrifugal losses. It also limited aldehyde and sulfide accumulation, preserved α-helix structure, enhanced Ca^{2+}-ATPase activity, and inhibited protein and lipid oxidation. Microstructural analysis showed compact fibers and intact sarcolemma in treated samples, contrasting with severe disruption in controls. This study showed that salmon skin AFPs mitigate freeze–thaw damage in salmon fillets by stabilizing proteins and reducing oxidative deterioration, highlighting their potential as natural cryoprotectants for seafood preservation.

Keywords: Salmon skin; Freeze-thaw cycles; Myofibrillar protein; Antifreeze peptide; Protein oxidation

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Preparation of Sea Cucumber Collagen Hydrolysate and its Inhibitory Effect on α-Glucosidases

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Abstract: Non-alcoholic fatty liver disease (NAFLD) is a chronic disorder with abnormal liver lipid buildup. Emerging evidence shows digestive enzymes like α-glucosidase regulate lipid/glucose homeostasis via postprandial metabolism, potential for treating NAFLD. This study explored sea cucumber collagen peptides' α-glucosidase inhibitory effect via biological interactions. Five sea cucumber collagen hydrolysates were prepared differently. The results showed that the hydrolysate obtained after digestion with pepsin for 2-hour, followed by digestion with trypsin for 3-hour (SDP 2h + T 3h), demonstrated the most potent inhibitory impact on the activity of α-glucosidase. Peptide RDDPEPSYK (RDD) isolated from it was identified as a specific inhibitor. RDD, comparable to commercial acarbose, reduced lipid accumulation and suppressed lipid synthesis-related proteins (SREBP-1C, FAS). These findings suggest sea cucumber collagen peptides have high potential in anti-obesity and anti-hepatic steatosis therapies.

Key words: Sea cucumber; Collagen; α-Glucosidase; Separation; Non-alcoholic fatty liver disease

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保温发酵制备长吻鮠内脏粗鱼油及其脂肪酸组成分析

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摘要：为实现淡水鱼加工废弃物的高值化利用，本研究以长吻鮠内脏为原料，采用盐渍保温发酵法提取粗鱼油，主要探究了不同盐添加量、不同发酵时间、不同提取方式对所得粗鱼油品质的差异。结果表明，在 35℃下，发酵 3 d、加盐量为 10%时，具有较高的提取率（94.68±2.49%）、碘值（141±0.43 g·100g^{-1}）、不饱和脂肪酸相对含量（53.89±2.36%），其中二十碳五烯酸（Eicosa-pentaenoic acid, EPA）和二十二碳六烯酸（Docosahexenoic acid, DHA）的总含量为 8.33±1.68%，而酸价（3.50±0.08 mg·g^{-1}）、过氧化值（12.44±0.06 meq·kg^{-1}）、水分及挥发物含量（0.24±0.02%）较低，各理化指标均满足 SC/T 3502—2016 要求。该研究发现，发酵法比蒸煮法所得粗鱼油的品质更好、颜色更橙黄明亮，具有鱼油特有的腥味，在一定程度上可以延缓氧化酸败，提高粗鱼油中不饱和脂肪酸的含量。

关键词：长吻鮠内脏；粗鱼油；保温发酵；脂肪酸组成

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Analysis of the composition of crude fish oil and fatty acids of

Leiocassis longirostris viscera prepared by insulation fermentation

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Abstract: To achieve the high-value utilization of freshwater fish processing waste, this study used the viscera of Leiocassis longirostris as raw material and extracted crude fish oil using a salt-preserved warm fermentation method. It primarily investigated the differences in the quality of the obtained crude fish oil with varying salt amounts, fermentation times, and extraction methods, and conducted an analysis. The results showed that at 35°C, when fermentation for 3 days and salt addition was 10%, the extraction rate (94.68±2.49%), iodine value (141±0.43 g·100g^{-1}), and the relative content of unsaturated fatty acids (53.89±2.36%) were high at 35°C, among which Eicosa-pentaenoic acid (EPA) and Docosahexenoic acid (Docosahexenoic acid, DHA) was 8.33±1.68%, while the acid value (3.50±0.08 mg·g^{-1}), peroxide value (12.44±0.06 meq·kg^{-1}), water and volatile content (0.24±0.02%) were low, and all physical and chemical indicators meet the requirements of SC/T 3502-2016. The study found that the crude fish oil obtained by fermentation had better quality and a brighter orange-yellow color compared to that obtained by cooking, had the characteristic fishy smell of fish oil, and could to some extent delay oxidation and rancidity, while increasing the content of unsaturated fatty acids in the crude fish oil.

Key words: Leiocassis longirostris viscera, crude fish oil,insulation fermentation, fatty acid composition

Study on the Effects of representative spice polyphenols on the in vitro digestive properties of tilapia myofibrillar protein and its mechanism of action: based on physical and chemical properties and enzyme activity

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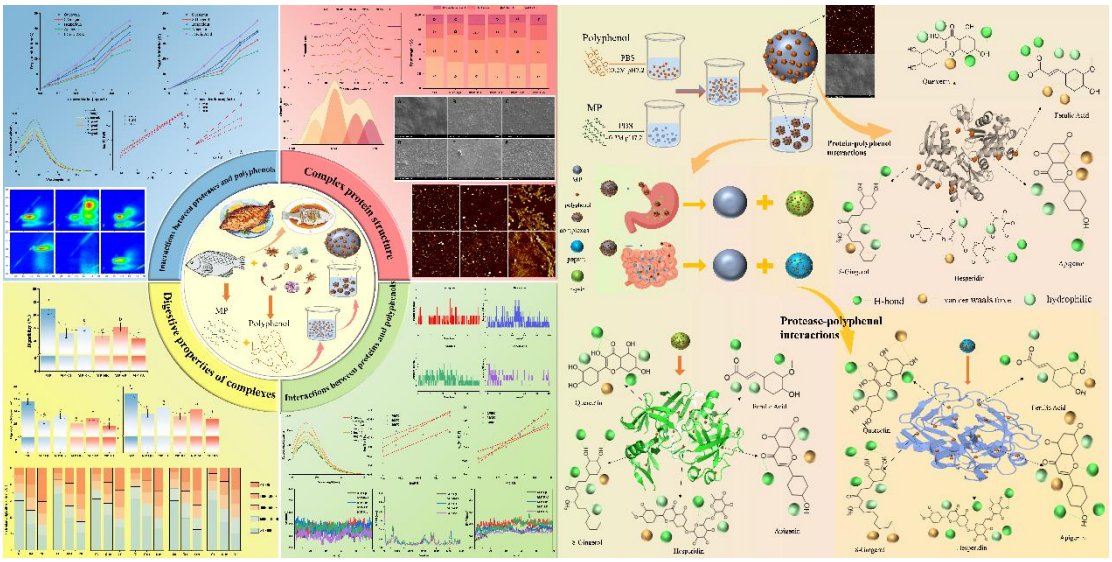
Abstract: Food flavorings are essential components in processing due to their safety, efficacy, and

additional flavor and nutritional benefits. To investigate the effects of polyphenolic compounds in flavorings on protein digestibility, this study selected five high-concentration phenolic compounds (quercetin, 8-gingerol, naringin, apigenin, and ferulic acid) from flavorings to prepare protein-polyphenol complexes. Simulated gastrointestinal digestion results showed that protein digestibility was significantly reduced after polyphenol binding; SEM and AFM revealed that protein structure was disrupted by polyphenol addition; FT-IR confirmed changes in secondary structure, particularly a reduction in α-helix content. Fluorescence spectroscopy, molecular docking, and molecular dynamics results indicated that polyphenols bind to proteins via non-covalent bonds, exhibiting quenching effects on fluorescent amino acid residues in proteins; two-dimensional and three-dimensional spectroscopy and molecular docking confirmed that the five phenolic compounds bind to digestive enzymes via hydrogen bonds and hydrophobic interactions, causing static fluorescence quenching of digestive enzymes and reducing their digestive activity. This study provides insights into the interaction mechanisms between plant-derived polyphenols, tilapia protein, and proteases at the physicochemical and enzymatic activity levels, which may help expand the application of tilapia protein-polyphenol complexes in the food industry and provide a basis for the development and optimization of tilapia processed foods.

Key words: Tilapia protein; Spice polyphenols; Enzyme activity; Vitro simulated digestion; Fluorescence quenching; Molecular docking; Protein interaction

Graphical abstract:



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通过肽组学和分子对接方法发现南美白对虾（Litopenaeus vannamei）虾头酶解物中的新型鲜味肽及增鲜作用

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摘要：本研究以南美白对虾（*Litopenaeus vannamei*）虾头水解物为原料制备新型鲜味肽，并研究其鲜味机制。采用超滤、凝胶色谱法和 LC-MS/MS（液相色谱-串联质谱法）从虾头的酶解物分离鲜味组分 G2 和 G3。随后，在毒性和鲜味预测分析的基础上，从两种组分中合成并表征了虾头水解物共 10 种潜在新型鲜味肽。分别为 ENAANNYAR、FDNL、FSGVPDR、LTDW、NAGQDPGLAR、PDPFT、SDYLN、VGSSNFR、WDEGL、YTVFDR。感官评估和电子舌分析证实了它们独特的鲜味特性，且具有鲜味/鲜味增强和增盐功能，味觉识别阈值范围为 0.125 至 0.25 mg/mL。分子对接分析表明，这些肽通过氢键和疏水相互作用与 T1R1/T1R3 鲜味受体相互作用，关键结合残基被鉴定为 ASP^{88}、ASN^{130} 和 ASP^{198} 和 GLN^{230}。这项研究提供了一种从海鲜副产品中筛选鲜味肽的新方法，并为其在食品工业中作为天然鲜味增强剂的应用奠定了基础。

关键词：南美白对虾虾头；鲜味肽；感官评价；分子对接；T1R1/T1R3

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超声改性κ-卡拉胶与海藻酸钠复合水凝胶的制备及性能研究

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摘要：为了制备性能优良的κ-卡拉胶（Kappa-Carrageenan，KC）基水凝胶，本文采用超声波对 KC 进行改性处理制备超声改性 κ-卡拉胶（Ultrasonic modified Kappa-Carrageenan，UM-KC），再将 UM-KC 与海藻酸钠（Sodium Alginate，SA）以不同配比进行复配，分别采用 $CaCO_3$ 和 $CaCl_2$ 二级交联法制备 UM-KC/SA 复合水凝胶，测定不同 UM-KC/SA 配比及交联程度对水凝胶含水率、溶胀率、力学性能（拉伸强度、断裂伸长率）、红外光谱及微观结构的影响。结果表明，超声处理显著提高了 KC 的溶解度（$p<0.05$）；当 UM-KC 与 SA 质量比为 1:2 时，经二级交联的水凝胶综合性能最优，其含水率达 93.26%，溶胀率 0.45%，断裂伸长率为 182.00%，拉伸强度为 0.2037 MPa；红外光谱显示，复合水凝胶刚性增强；扫描电镜（SEM）显示，该水凝胶呈蜂窝状多孔结构。因此，UM-KC 与 SA 复配，结合二级交联技术可制备性能优良的复合水凝胶，这将为开发海藻多糖基新型医用水凝胶敷料提供新思路和技术基础。

关键词：κ-卡拉胶；超声波改性；海藻酸钠；水凝胶

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Fabrication and Characterization of Ultrasound-Modified κ-

Carrageenan/Sodium Alginate Composite Hydrogels

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Abstract：To prepare high-performance Kappa-Carrageenan (KC)-based hydrogels, this study employed ultrasonic treatment to modify KC, resulting in ultrasonic modified Kappa-Carrageenan (UM-KC). The UM-KC was then blended with sodium alginate (SA) at varying mass ratios. Composite UM-KC/SA hydrogels were fabricated using a two-step crosslinking method involving $CaCO_3$ and $CaCl_2$. Determine the effects of different UM-KC/SA ratio and crosslinking degrees on the water content, swelling ratio, mechanical properties (tensile strength, elongation at break), infrared spectra and microstructure of hydrogel. The results demonstrated that ultrasonic treatment significantly enhanced the solubility of KC ($p < 0.05$). When the ratio of UM-KC to SA is 1:2, the comprehensive performance of the hydrogel after secondary crosslinking is the best. The composite hydrogel achieving a water content of 93.26%, a swelling ratio of 0.45%, an elongation at break of 182.00%, and a tensile strength of 0.2037 MPa. Infrared spectroscopy indicated enhanced rigidity in the composite hydrogels, while scanning electron microscopy (SEM) revealed a honeycomb-like porous structure. In conclusion, the combination of UM-KC and SA, along with the two-step crosslinking technique, enables the preparation of high-performance composite hydrogel. This study provides novel insights and a technical foundation for developing advanced medical hydrogel dressings based on algal polysaccharides.

Key words：Kappa-Carrageenan; Ultrasound modification; Sodium alginate; hydrogel

超声辅助酶处理对罗非鱼肌原纤维蛋白溶解度和热稳定性的影响

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摘要：在盐浓度低于 0.3 M 的溶液中，肌原纤维蛋白（MP）相互聚集会引起溶解度降低。针对此现象，本文研究了超声联合谷氨酰胺酶处理（UGT）对低盐溶液（含 0.1 M 氯化钠）中 MP 的影响，并进一步研究其热稳定性。结果表明，UGT 提高了 MP 的溶解度（61%）、巯基含量、浊度和疏水性，但降低了其粒径、ζ电位和荧光强度。FTIR 表现为酰胺 A 峰蓝移、酰胺 I 峰强度降低，证实了 MP 解聚。然而，超声(480 W、20min）后热处理（60℃、30min）提高了超声-酶处理 MP（UEMP）的荧光强度，并促使酰胺 A 峰红移，但对粒径、ζ电位和分子量影响较小，表明局部有序性增强。流变学显示热处理增加了 UEMP 的粘度。综上，适度加热可以破坏 UEMP 之间的相互作用并调节其结构，从而增强其溶解度和热稳定性。

关键词：超声波；酶处理；肌原纤维蛋白；低盐不溶性

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Effects of Ultrasonic-Assisted Enzymatic Treatment on the Solubility and Thermal Stability of Myofibrillar Protein from Tilapia (Oreochromis mossambicus)

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Abstract: In solutions with salt concentrations below 0.3 M, the aggregation of myofibrillar proteins (MPs) reduces their solubility. To change this phenomenon, we examined the effects of ultrasonic treatment combined with glutaminase (UGT) on MPs in low-salt solutions containing 0.1 M NaCl, while also evaluating their thermal stability. Results showed that UGT increased MP solubility (61%), total thiol content, turbidity, and hydrophobicity, but decreased particle size, ζ-potential, and fluorescence intensity. FTIR analysis revealed blue-shifting of the amide A peak and reduced intensity of the amide I peak, confirming MP depolymerization. However, thermal treatment (60℃,30min) following ultrasonic treatment (480 W, 20min) enhanced fluorescence intensity in ultrasonic-glutaminase-treated MPs (UEMP) and induced red-shifting of the amide A peak, with minimal effects on particle size, ζ-potential, or molecular weight, indicating enhanced local order. Rheological studies demonstrated that thermal treatment increased the viscosity of UEMP. In conclusion, moderate heating disrupts interactions between UEMP and modulates their structure, thereby improving both solubility and thermal stability.

Keywords: Ultrasound; Enzymatic treatment; Myofibrillar protein; Low-salt insolubility

来自海带的纤维素特性表征及其作为新型面包改良剂对面团、面筋和淀粉的影响

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摘要：采用天然改良剂开发新型面包配方已成为提升烘焙产品质量的重要组成部分。本研究系统评估海带纤维素（GC）作为天然面包改良剂的应用潜力，并对纤维素改良面团、面筋以及面筋蛋白和淀粉进行了全面研究。结果表明，GC 具有优良的持水性与持油性，能够有效吸附胆固醇、不饱和脂肪与饱和脂肪，并展现出明显的葡萄糖吸附能力、抗氧化活性、α-淀粉酶抑制能力及延缓葡萄糖扩散的作用。GC 的添加改善了面团色泽，影响了面筋中麦谷蛋白含量及其持水性，同时调节了淀粉的溶解度。面包感官品质的提升与 GC 形成的纤维素交联网络密切相关。在 GC 添加量为 1%（m/m）时，面包的感官品质和冷藏稳定性均达到最佳，展现了海洋副产品在商业化烘焙中的良好应用潜力。

关键词：纤维素；面包；质地；贮藏稳定性；感官表征

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Fusion of near-infrared and Raman spectroscopy with machine learning strategies: non-destructive rapid assessment of freshness and TVB-N value prediction in Pacific white shrimp (Litopenaeus vannamei)

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Abstract: Total volatile base nitrogen (TVB-N) is a key indicator of shrimp freshness. Nevertheless, traditional detection methods are cumbersome, time-intensive, and destructive. Here, a rapid and non-destructive method based on near-infrared (NIR) and Raman spectroscopy for the assessment of TVB-N content in Litopenaeus vannamei was proposed. A prediction model was constructed based on three machine learning methods, namely convolutional neural networks, extreme learning machines, and backpropagation, which were combined with low-level data fusion and mid-level fusion strategy to predict TVB-N content. The calibration coefficient of prediction (R2p) values of the feature-lever prediction models constructed using Savitzky-Golay (SG) smoothing for NIR and Raman spectroscopy were 0.846 and 0.784, respectively. Notably, Medium-level data fusion combined with the extreme learning machines model showed the best prediction results with R2p and root mean square error of prediction values of 0.986 and 0.677 mg/100 g, respectively, and the R2 values of the feature-level fusion models optimized with feature selection algorithms, such as competitive adaptive re-weighted sampling, successive projection algorithm, and genetic algorithm all exceeded 0.96. These findings verified the complementary advantages of NIR and Raman spectroscopic data in monitoring the quality and effectiveness in freshness assessment. In particular, with the assistance of portable spectroscopic instruments, these two spectroscopic techniques provide an efficient, non-destructive, and real-time technical method for monitoring the freshness of L. vannamei.

Key words: Litopenaeus vannamei; Total volatile basic nitrogen; Spectral analysis machine learning; Data fusion; Non-destructive detection

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Preservation of Litopenaeus vannamei under critical temperature and minimal water conditions：survival and stress responses

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Abstract :[Objective]Maintaining the survival and quality of Litopenaeus vannamei (L. vannamei) in household settings proves particularly challenging; [Methods]This study aimed to explore a critical temperature and minimal-water preservation technology with supporting equipment, and investigate its effects on the survival, physicochemical properties, and intestinal microbial responses of L. vannamei during preservation;[Results]Using single-factor experiments and machine learning design, optimal parameters were identified: 7.5° C, 27‰ salinity, and 2° C/h cooling rate, which achieved a 90.4% survival rate over 12 hours. Texture profile analysis showed stable muscle hardness, elasticity, and cohesiveness, with progressive changes in springiness and adhesiveness. Antioxidant assays revealed that peroxidase activity in shrimp muscle increased by 33.5%, total antioxidant capacity enhanced by 52.1%, and malondialdehyde content reached 6.61 nmol/mg protein at 12 hours. HPLC analysis indicated that essential amino acids decreased by 42.3%–49.5% at 6 hours but recovered to initial levels by 12 hours; adenosine triphosphate degraded by 23.8%, while hypoxanthine riboside accumulated by 55.0%. GC-MS showed aldehydes decreased from 72.87% to 48.40%, while ketones rose from 6.05% to 18.65%. 16S rRNA sequencing revealed a shift in the intestinal microbiota from Clostridia-dominated to Bacteroidota-enriched.; [Conclusion]Supported by the device, this technology ensures high survival and quality, offering a practical solution for household shrimp preservation.

Key words: *Litopenaeus vannamei*; preservation technology; model prediction; quality evaluation; intestinal microbiota

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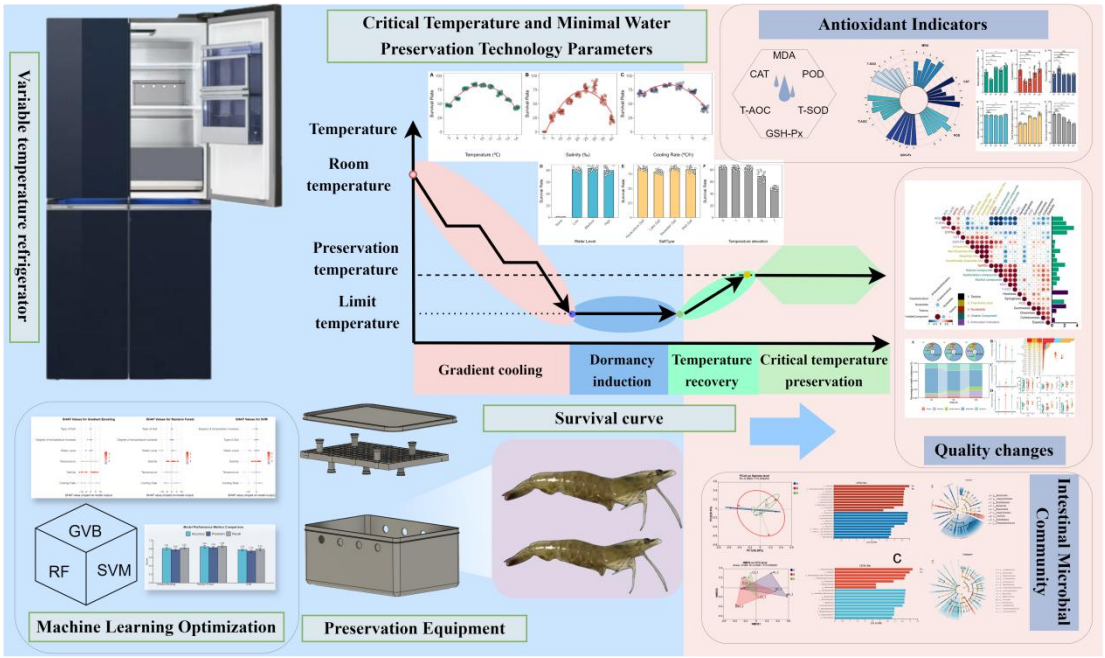

仿刺身胶原蛋白源抗氧化降糖肽的虚拟筛选及其作用机制研究

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摘要：糖尿病是以胰岛素抵抗或分泌不足致高血糖为特征的慢性病。长期高血糖会通过氧化应激加剧疾病及其并发症。本研究基于生物信息学分析仿刺参胶原蛋白潜在生物活性肽，获得 151 个无毒无致敏性的肽段。基于分子对接虚拟筛选出 7 个可同时靶向胰高血糖素样肽-1 受体、葡萄糖依赖性促胰岛素多肽受体和 Kelch 样 ECH 相关蛋白 1 的肽段。其中 DCDPRL 与多靶点之间形成氢键、盐桥、疏水相互作用和范德华力，具有最优结合潜力，且能有效清除多种自由基。此外，通过软脂酸联合葡萄糖诱导的 IR-HepG2 细胞模型和四氧嘧啶联合葡萄糖诱导的高血糖斑马鱼幼虫模型共同验证了 DCDPRL 的抗氧化和降血糖活性。DCDPRL 能够通过多靶点调控发挥其降血糖和抗氧化活性，展现了其在糖尿病治疗中的潜在应用价值。

关键词：仿刺参胶原蛋白；生物活性肽；抗氧化；降血糖；斑马鱼

Screening and Function Mechanisms of Antioxidative and Hypoglycemic Peptides Derived from Collagen of the Apostichopus Japonicus

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Abstract: Diabetes mellitus is a common chronic non-communicable disease characterized by elevated blood glucose due to insulin resistance or insufficient insulin secretion. Persistently high blood glucose levels will lead to oxidative stress damage, further exacerbating the progression of diabetes and its complications, thereby creating a vicious cycle. This study identified 151 non-toxic and non-allergenic peptide segments with potential biological activity from sea cucumber collagen through bioinformatics analysis. Molecular docking-based virtual screening identified 7 peptides capable of simultaneously target glucagon like peptide-1 receptor (GLP-1R), glucose dependent insulinotropic peptide receptor (GIPR), and Kelch like ECH related protein 1 (Keap1). Among these, DCDPRL formed hydrogen bonds, salt bridges, hydrophobic interactions, and van der Waals forces with multiple targets, exhibiting optimal binding potential (GLP-1R: −104.025 kcal/mol, GIPR: −90.005 kcal/mol, Keap1: −112.037 kcal/mol), along with significant scavenging capacities for DPPH radicals, ABTS radicals, hydroxyl radicals (•OH), and superoxide anion radicals ($•O^{2-}$). Furthermore, the antioxidant and hypoglycemic activities of peptide DCDPRL were validated in both the oleic acid-glucose-induced IR-HepG2 cell model and the alloxan-glucose-induced hyperglycemic zebrafish larva model. DCDPRL exerts its hypoglycemic and antioxidant effects through multi-target regulation, demonstrating its potential therapeutic value in diabetes management.

Keywords: *Apostichopus japonicus* collagen; bioactive peptides; antioxidant; hypoglycemic; zebrafish

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基于鱼皮胶原蛋白肽糖基化产物的海洋功能脂质微胶囊的制备及性能探究

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摘要：蛋白水解物/多肽通常对环境应激敏感，限制了其在食品中的应用。因此，本研究通过传统湿热法与微波法制备鳕鱼皮胶原蛋白肽-聚葡萄糖糖基化产物，并以其为壁材，采用喷雾干燥与冷冻干燥技术构建南极磷虾油（AKO）微胶囊。结果表明，微波法（20 min）可显著提升糖基化效率，接枝度达 46.22%，优于湿热法（10 h），且形成乳液粒径稳定，30 天内无分层。喷雾干燥所得微胶囊结构致密、粒径较小，在 AKO 浓度为 6%时包埋率达 81.1%，显著高于冷冻干燥（67.86%）。体外消化实验中，喷雾干燥微胶囊 2 小时内游离脂肪酸释放率达 87.6%，并在 25℃条件下可将 AKO 贮存期延长 168 天。综上，微波辅助糖基化结合喷雾干燥技术可有效提升 AKO 微胶囊的包埋性能与氧化稳定性。

关键词：糖基化反应；鱼皮胶原蛋白肽；微波法；传统水浴法；微胶囊

Preparation and Properties of Marine Functional Lipid Microcapsules based on Glycosylated Products of Fish Skin Collagen Peptide

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Abstract: Proteolytic products/peptides are typically sensitive to environmental stress, limiting their application in food products. Therefore, this study prepared collagen peptide-polyglucose glycosylation products from cod skin collagen using both traditional wet-heat and microwave methods. These products were then employed as wall materials to construct Antarctic krill oil (AKO) microcapsules via spray drying and freeze-drying techniques. Results indicate that the microwave method (20 min) significantly enhances glycosylation efficiency, achieving a grafting degree of 46.22%, outperforming the wet-heat method (10 h). The resulting emulsion exhibits stable particle size with no phase separation observed over 30 days. Spray-dried microcapsules exhibited dense structures and smaller particle sizes, achieving 81.1% encapsulation efficiency at 6% AKO concentration—significantly higher than freeze-dried capsules (67.86%). In vitro digestion tests showed that spray-dried microcapsules released 87.6% of free fatty acids within 2 hours and extended AKO storage stability by 168 days at 25°C. Collectively, microwave-assisted saccharification combined with spray drying effectively enhances the encapsulation performance and oxidative stability of AKO microcapsules.

Keywords: Maillard conjugate; Fish skin collagen peptide; Microwave method; Spray drying; Microcapsule

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防冻无残留水凝胶在冷藏食品包装中的应用

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摘 要：全球每年因微生物污染导致数十亿吨食物流失或浪费。食品包装能有效防止污染与浪费，但传统包装常缺乏足够的保鲜性能。水凝胶凭借其卓越的包封特性，可促进活性物质的释放并延长其作用时间，成为替代传统包装、长期维持食品品质的理想选择。本研究通过物理交联制备了负载可见光响应型催化抗菌碳点（CPCDs）的水凝胶（GP-1）。研究发现该水凝胶展现出快速凝胶化特性等性能。根据实验结果表明，GP-1 展现出低膨胀率与低释放速率，通过高效负载 CPCDs 实现持续可见光催化抗菌效应。其适宜粘度使该材料能以小于 0.5N 的力轻松无残留地剥离虹鳟鱼表面。保鲜实验表明，GP-1 可以将虹鳟鱼的货架期延长 3 d。这些结果表明，GP-1 在食品储存领域具有广阔的应用前景。

关键词：水凝胶；抗菌食品包装；无残留剥离；虹鳟鱼保鲜

A novel antifreeze, residue-free photocatalytic hydrogel for refrigerated food package

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Abstract: Globally, billions of tons of food are lost or wasted annually due to microbial contamination. Food packaging can effectively prevent contamination and waste, but traditional packaging often lacks adequate preservation properties. Hydrogels, with their excellent encapsulation properties, facilitate the release and prolonged action of active substances, making them promising alternatives to traditional packaging for maintaining food quality over extended periods. In this study, a hydrogel (GP-1) loaded with visible light-responsive catalytic antibacterial carbon dots (CPCDs) was prepared via physical crosslinking. The hydrogel exhibited rapid gelation, excellent biocompatibility, and mechanical propertiesGelation properties and other characteristics. GP-1 demonstrated low swelling and re lease rates, enabling sustained visible light-catalyzed

antibacterial effects by efficiently loading CPCDs. Moreover, its appropriate viscosity allowed easy residue-free peeling from the surface of Oncorhynchus mykiss with a force of less than 0.5N, the shelf life of Oncorhynchus mykiss by over 3 days according to various freshness indicators. GP-1 fabrication is simple and cost-effective, offering promising applications in food storage.

Keywords: hydrogel; antibacterial food packaging; no residual peeling; Oncorhynchus mykiss preservation

食物基质演化诱导的冻藏熟制凡纳滨对虾“香气”劣化机制

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摘要：熟制凡纳滨对虾（Litopenaeus vannamei）具有独特的风味，水分、食物基质变化对熟制凡纳滨对虾冻藏过程中品质和挥发性物质的影响尚不清楚，在不同冻藏时间下，熟制凡纳滨对虾的解冻损失和蒸煮损失均呈上升趋势、水分含量和离心损失呈现下降趋势；总巯基含量和 Ca 2 +-ATPase 活性显著降低，羰基含量和 MDA 值随冻藏时间延长不断增加。共鉴定出 129 种挥发性化合物，通过风味稀释因子（FD）≥8 和气味活性值（OAVs）确定了 11 种关键香气物质。壬醛、1-庚烯-3-酮、4-甲基戊酸乙酯和异戊酸是影响其香气的重要因素。本研究对熟制凡纳滨对虾冻藏过程中的香气动态调控及关键香气成分进行了研究，为该产品的储藏提供了理论依据。

关键词：凡纳滨对虾;水分变化;蛋白氧化;挥发性化合物

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SC2-3, a Marine Glycopeptide from Nereis succinea: Alleviating Cyclophosphamide-Induced Immunocompromise in Mice via Macrophage Polarization

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Abstract: Cancer chemotherapy not only causes leukopenia and organ toxicity but also suppresses immune function, posing a serious threat to human health. Marine glycopeptides show great potential in immune regulation, adjuvant therapy, and intestinal health protection, owing to the unique metabolic characteristics of marine organisms. A marine glycopeptide, SC2-3 with a molecular weight of 5061 Da, was isolated and purified from Nereis succinea. Monosaccharide composition, NMR data, Amino acid composition analysis and SDS-PAGE analyses identified SC2-3 as a glycoprotein. The N-glycome results of SC2-3 performed by MALDI-TOF-MS, revealed that SC2-3 contain fucosylated N-glucans with shorter glycan chains compared to human-derived N-glycans. SC2-3 exerted a significant immune-enhancing effect on macrophages in vitro. In vivo studies showed that SC2-3 at various concentrations increases organ indices (spleen and thymus), blood cell counts (eosinophils, basophils, platelets, white blood cells, lymphocytes), and serum levels of IL-1β, TNF-α, and IL-6 in cyclophosphamide-induced immunocompromised mice. It also repaired cyclophosphamide-damaged/atrophied tissues (spleen, thymus, intestine). Mechanistically, SC2-3 could induce differentiation of RAW264.7 cells into the M1 phenotype, markedly promote NO and ROS release, upregulate secretion of pro-inflammatory cytokines IL-1β, TNF-α, and IL-6, and activate the TLR4/NF-κB signaling pathway. Additionally, SC2-3 upregulated intestinal epithelial tight junction proteins and normalized the overexpression of MUC-2, thereby maintaining intestinal barrier integrity. These findings highlight the potential of SC2-3 as a novel marine-derived immune enhancer and promote the high-value utilization of Nereis succinea.

Key words: Nereis succinea, glycopeptide, structural characterization, immunoactivity, macrophage polarization

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【Graphical abstract】

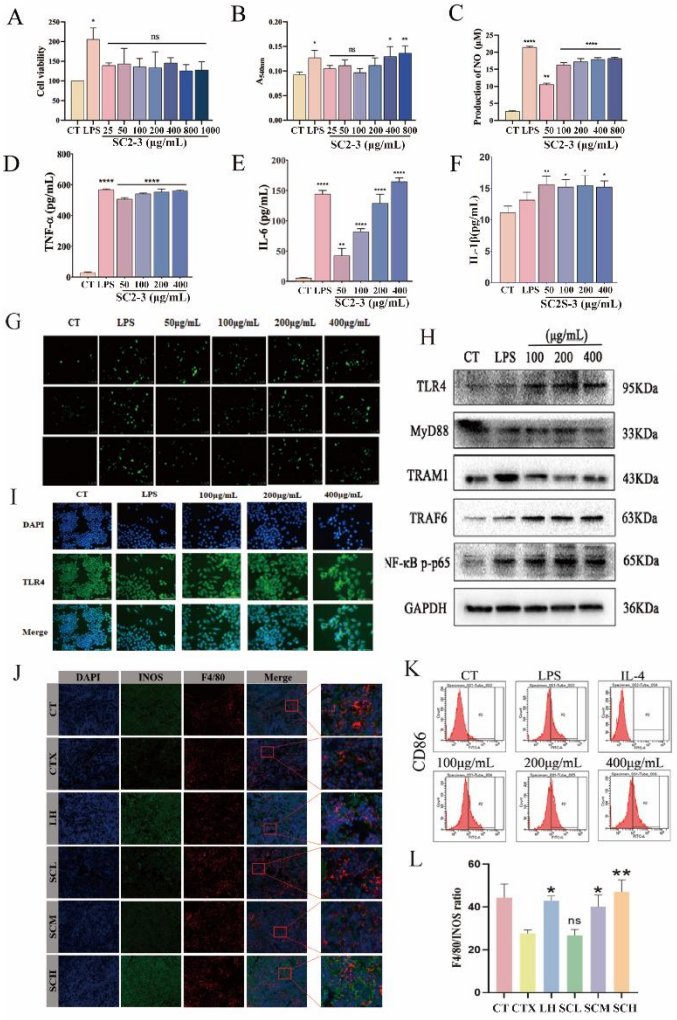

Fig.1 Immune activation effect of SC2-3 in vitro. (A) Cell viability of RAW264.7 at different concentrations of SC2-3; (B) Effects of SC2-3 on phagocytic activity of RAW264.7 cells; (C) Effects of SC2-3 on NO secretion in RAW264.7 cells; (D-F) The effect of SC2-3 on the secretion of TNF-α, IL-6 and IL-1β in RAW264.7 cells; (G) Effect of SC2-3 on ROS release from RAW264.7 cells; (H) Expression of TLR4, MyD88, TRAM1, TAKF6 and NF-κB p-p65 in RAW264.7 cells in each group. (I) Effects of SC2-3 on TLR4 protein on RAW264.7 cells; (J) Immunofluorescence was used to co-stain F4/80 and iNOS in the spleen of mice in each group (n=3). (K) The effect of SC2-3 on M1 marker CD86 in RAW264.7 cells. (L) The proportion of iNOS-positive cells in F4/80-positive macrophages in the spleen of mice in each group (n=3).

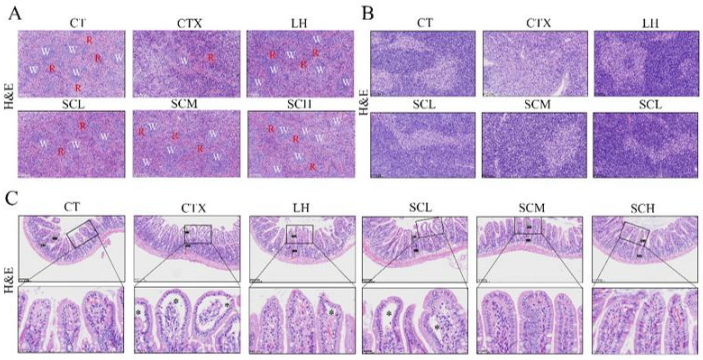

Fig. 2 SC2-3 restored CTX-induced thymus and spleen damage in mice. (A) H&E staining of spleen（R is red pulp; W is white pulp, n＝3）;(B) H&E staining of thymus（n＝3）;(C) Protective effect of SC2-3 on intestinal barrier damage in CTX-treated mice.

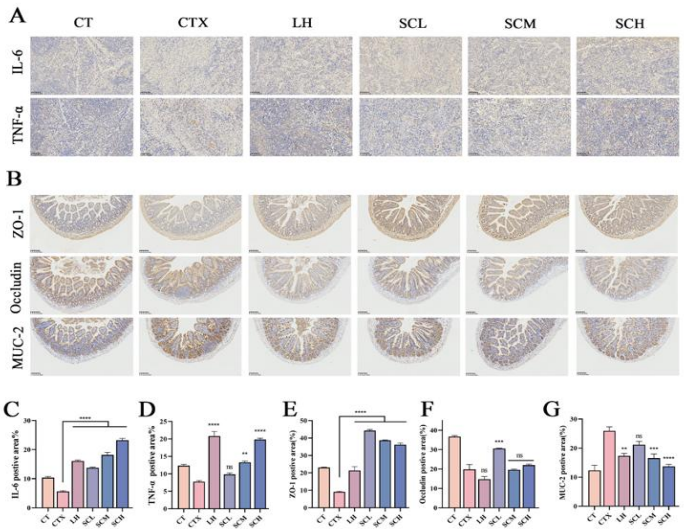

Fig. 3. Immunohistochemical analysis of SC2-3 on spleen and intestinal related indexes in CTX-induced immunocompromised mice. (A)Immunohistochemical analysis of IL-6 and TNF-α in the spleen ; (B) Immunohistochemical analysis of ZO-1、Occludin and MUC-2 in the intestines; (C)Statistical chart of IL-6; (D) Statistical chart of TNF-α;(E) Statistical chart of ZO-1;(F) Statistical chart of Occludin; (G) Statistical chart of MUC-2.

食品来源的黄嘌呤氧化酶抑制肽的研究进展：制备、作用机制及深度学习的应用

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摘要：高尿酸血症（HUA）是指血清尿酸水平超过正常范围（即男性 7.0 mg/dL，女性 6.0 mg/dL）的一类代谢性疾病，与许多慢性疾病的发展密切相关。近来年，食品来源的黄嘌呤氧化酶（XOD）抑制肽因安全性、营养价值和高活性等特性受到广泛关注。主要通过两种方法进行制备：传统方法，例如酶水解、化学合成和微生物发酵；以及新兴技术，例如生物信息学、噬菌体展示和人工智能。食品来源的 XOD 抑制肽可能通过抑制 XOD 活性、促进尿酸（UA）排泄、维持肠道稳态和减轻炎症来调节 UA 代谢。此外，深度学习模型可以更准确地预测肽-XOD 相互作用，从而加速新型 XOD 抑制肽的发现和优化。因此，XOD 抑制肽作为一种新型、天然、安全和多样化的调节高尿酸血症的补充剂具有巨大的潜力。

关键词：XOD 抑制肽；HUA；构效关系；机制；新兴技术

Preparation, functional mechanism, and deep-learning application of food-derived xanthine oxidase-inhibitory peptides: A comprehensive review

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Abstract : Hyperuricemia (HUA) is a metabolic disorder characterized by elevated serum uric acid (SUA) levels (>7.0 mg/dL in men and >6.0 mg/dL in women). HUA has become a global health concern and is strongly associated with various chronic diseases. In recent years, food-derived xanthine oxidase (XOD)-inhibitory peptides have gained significant attention due to their safety, nutritional value, and potent biological activity. Food-derived (including plants and animals) XOD-

inhibitory peptides are mainly prepared by two methods: conventional methods, such as enzymatic hydrolysis, chemical synthesis, and microbial fermentation; and emerging technologies, such as bioinformatics, phage display, and artificial intelligence. In the optimization of peptides based on the structure-activity relationship, the XOD inhibitory activity was significantly enhanced. Food-derived XOD-inhibitory peptides may regulate UA metabolism by inhibiting XOD activity, promoting UA excretion, maintaining intestinal homeostasis, and reducing inflammation. Furthermore, deep learning models can more accurately predict peptide-XOD interactions, thereby accelerating the discovery and optimization of novel XOD-inhibitory peptides. Considering their safety and therapeutic potential, XOD-inhibitory peptides hold significant potential as supplements for HUA management.

Key words: XOD-inhibitory peptide, HUA, Structure-activity relationship, Mechanism, Emerging technologies

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介质阻挡放电等离子体对卵形鲳鲹冷藏过程品质调控效应与影响作用研究

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摘要：为探究低温等离子体（Cold plasma, CP）处理对卵形鲳鲹（Trachinotus ovatus）的减菌效果以及在冷藏过程中品质变化的影响。以 CP 处理的卵形鲳鲹为处理组、未处理卵形鲳鲹为对照组，通过分析在 4℃条件下鱼肉的感官、菌落总数、pH 值、持水力、挥发性盐基氮、硫代巴比妥酸反应物等指标来研究鱼肉贮藏期间的品质变化。结果表明：低温等离子体处理可改善卵形鲳鲹感官品质，抑制 TVB-N 与 pH 值的上升，提升鱼肉持水性，并减缓 TBARS 值增长速率。与对照组相比，处理组能显著降低脂肪酶与脂氧合酶（LOX）活性，有效抑制贮藏过程中脂质氧化，减少亚油酸、EPA、DHA 等多不饱和脂肪酸降解。同时，低温等离子体处理可增加游离氨基酸总量及呈味氨基酸含量，对提升鱼肉滋味具有积极作用。

关键词：卵形鲳鲹；低温等离子体；减菌；冷藏；品质改善

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麻醉保活运输方式对刺参品质和生理状态影响的研究

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摘要：本文旨在探究麻醉保活运输方式对刺参品质和生理状态的影响，以解决其远距离无水运输易自溶及营养流失的问题。研究采用硫酸镁、丁香酚及薄荷醇等麻醉剂处理刺参，分析其在 7 天麻醉保活过程中相关酶活性、基因表达及品质指标的变化。结果显示，麻醉处理能显著抑制碱性磷酸酶、酸性磷酸酶、丙酮酸激酶及乳酸脱氢酶活性，降低代谢速率与能量消耗，缓解氧化应激与饥饿胁迫；其中硫酸镁处理效果最佳，能上调HSP70、HSP90 等热休克蛋白基因表达，增强抗逆能力，并稳定免疫相关基因表达。进一步研究发现，硫酸镁与牛磺酸复配可有效延缓体壁蛋白降解与水分流失，延长保活时间，显著改善刺参在无水胁迫下的品质与存活状态。研究表明，麻醉保活技术通过调控生理代谢与应激响应，为刺参跨区域供应提供了可行解决方案。

关键词：刺参；无水保活运输；无水硫酸镁；牛磺酸；生理状态

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茶多酚、L-抗坏血酸对不同贮藏温度下即食海参品质的影响

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摘要：为探讨茶多酚（TP）和 L-抗坏血酸（AA）对不同贮藏温度的即食海参在贮藏过程中的保鲜效果，本研究比较了不同浓度（5g/L、10g/L）的 TP 与 AA 处理对即食海参在 4℃和 0℃贮藏过程中多项品质指标的影响，包括即食海参感官评分、体壁硬度、水分状态和分布、可溶性蛋白、挥发性盐基氮（TVB-N）、胶原蛋白和羰基含量等的变化。结果表明，随着贮藏时间的延长，TVB-N 和可溶性蛋白含量逐渐升高；在相同贮藏时间下，5g/L TP 处理组的 TVB-N 含量最低。即食海参体壁感官评分、体壁硬度、胶原蛋白、羰基含量及不易流动水含量随贮藏时间延长逐渐降低。在 4℃和 0℃的贮藏条件下，5g/L TP 处理组的即食海参中胶原蛋白含量高于对照组。因此，贮藏过程中采用 5g/L TP 浸泡液可有效缓解在贮藏过程中的品质变化，提升即食海参的贮藏时间。

关键词：即食海参；茶多酚；L-抗坏血酸；贮藏；品质变化

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萝卜纤维素基抗菌抗氧化碳点的制备及其抗菌和抗氧化性能的研究

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摘要：全球每年水产品微生物污染高达 25%，传统抑菌材料存在潜在毒性，而生物质碳源制备的碳点兼具低毒、高生物相容性和成本优势。本研究以萝卜纤维素为原料合成的碳点（R-CDs）展现出良好的抗菌与抗氧化性能。研究表明，R-CDs 对温和气单胞菌的最小抑菌浓度为 2 mg/mL，其抗菌机制主要通过破坏细菌细胞壁/膜结构，导致胞内蛋白、DNA 及关键酶泄漏，并诱导细菌内活性氧（ROS）水平升高，进一步加剧氧化损伤，导致细菌死亡。同时，R-CDs 具有良好的体外抗氧化能力，对 DPPH 和 ABTS 自由基清除率分别达 93.8%和 99.36%。当浓度为 600 μg/mL 时，可显著提升 HEK-293 细胞内的 SOD 和 GSH 水平，降低 MDA 含量，且溶血率仅为 1.74%，显示出良好的生物安全性。因此，R-CDs 是一种兼具高抗菌、抗氧化性与生物相容性的材料。

关键词：萝卜纤维素；碳点；抗菌；抗氧化；高生物相容性

Preparation of radish cellulose-based antimicrobial and antioxidant carbon dots and their antimicrobial and antioxidant properties

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Abstract: The microbial contamination of aquatic products is as high as 25% every year in the world. Traditional antibacterial materials have potential toxicity, while carbon dots prepared from biomass carbon sources have low toxicity, high biocompatibility and cost advantages. In this study, carbon dots (R-CDs) synthesized from radish cellulose showed good antibacterial and antioxidant properties. The results showed that the minimum inhibitory concentration of R-CDs against Aeromonas sobria was 2 mg/mL. The antibacterial mechanism of R-CDs was mainly through destroying the bacterial cell wall/membrane structure, leading to the leakage of intracellular proteins, DNA and key enzymes, and inducing the increase of reactive oxygen species (ROS) level in bacteria,

further aggravating oxidative damage and leading to bacterial death. At the same time, R-CDs had good antioxidant capacity in vitro, and the scavenging rates of DPPH and ABTS free radicals were 93.8% and 99.36%, respectively. When the concentration was 600 μg/mL, it could significantly increase the levels of SOD and GSH in HEK-293 cells, reduce the content of MDA, and the hemolysis rate was only 1.74%, showing good biosafety. Therefore, R-CDs are a kind of material with high antibacterial, antioxidant and biocompatibility.

Key words: Radish cellulose; Carbon dots; Antimicrobial; Antioxidant; Highly biocompatible

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Effect of protein hydrolysates on advanced glycationend-products in frozen-thawed and reheated minced squid

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Abstract: The effects of the formation of advanced glycation end-products (AGEs), including Nε-carboxymethyllysine (CML) and Nε-carboxyethyllysine (CEL), in preheated minced squid treated with protein hydrolysates were investigated during frozen-thawed cycles and reheating. Lipid oxidation indexes, protein oxidation indexes and precursors of AGEs were also analyzed to explore the pathways of protein hydrolysates on AGEs and to reveal the mechanism of AGEs generation. During frozen-thawed cycles, the contents of AGEs, thiobarbituric acid reactive substances, glyoxal, and methylglyoxal in minced squid showed a continuous increasing trend, and the level of sulfhydryl groups decreased continuously. Reheating resulted in a significant increase in CML (53.4 − 160.4%) and CEL (2.7 − 76.9%), while glyoxal (4.6 − 11.9%) and methylglyoxal (2.0 − 11.8%) decreased. Protein hydrolysates inhibited both lipid oxidation and protein oxidation during frozen-thawed cycles and reheat compared to the blank group. The average level of AGEs in the experimental group after reheating was lower than that of the blank group by 37.0% (CML) and 32.9% (CEL). The results indicated that the addition of protein hydrolysates had a better inhibitory effect on the generation of AGEs during reheating.

Key words: Nε-carboxymethyllysine; Nε-carboxyethyllysine; Protein hydrolysates; Cryoprotectants; Minced squid

资助项目：海洋食品加工与安全控制国家重点实验室开放课题（SKL202310）

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水凝胶智能包装的制备及虹鳟鱼保鲜中的应用

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摘要：鱼类腐败造成的经济损失每年超过 250 亿欧元。智能监测鱼类的新鲜度可有效减少经济损失和食物浪费。本研究制备并表征了一种基于海藻酸钠-共色素复合物的双功能水凝胶智能包装，为了加强智能包装的响应灵敏性，选取多种花青素进行比较研究，并通过共色素沉着和海藻酸钠-共色素花青素间的离子络合，加强花青素的显色效果和稳定性，以满足后续基于花青素的智能包装可以应对多种应用环境。扫描电镜（SEM）结果表明，由不同明胶（GE）/聚乙烯醇（PVA）比例制备出的三种水凝胶，SA-BAs/BIs-PCT-2 具有较小的孔径和更均匀的分布。傅里叶红外光谱（FT-IR）和 X 射线衍射（XRD）证明其内部的酯化反应和醇醛缩合反应的发生。在金黄色葡萄球菌、大肠杆菌等抑菌实验中，成功证明水凝胶具有广谱挥发抑菌性能。水凝胶抗冻性能测试证明水凝胶的结构稳定性和显色稳定性。在虹鳟鱼的贮藏实验中，水凝胶智能包装成功将虹鳟鱼的货架期延长了 2 天。

关键词：食物腐败；花青素；共色素沉着；水凝胶智能包装；货架期

Preparation of Hydrogel-Based Smart Packaging and Its Application in Rainbow Trout Freshness Preservation

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Abstract : Fish spoilage causes economic losses exceeding 25 billion euros annually. Intelligent monitoring of fish freshness can effectively reduce economic losses and food waste. This study prepared and characterized a dual-functional hydrogel smart packaging based on a sodium alginate-co-pigment complex. To enhance the responsiveness of the smart packaging, multiple anthocyanins were selected for comparative research. The color development effect and stability of anthocyanins were strengthened through co-pigmentation and ionic complexation between sodium alginate and anthocyanin co-pigments, ensuring the subsequent anthocyanin-based smart packaging can adapt to diverse application environments.Scanning electron microscopy (SEM) results indicate that among

the three hydrogels prepared with different gelatin (GE)/polyvinyl alcohol (PVA) ratios, SA-BAs/BIs-PCT-2 exhibits smaller pore sizes and more uniform distribution. Fourier transform infrared spectroscopy (FT-IR) and X-ray diffraction (XRD) confirmed the occurrence of esterification and aldol condensation reactions within the hydrogels. Antimicrobial tests against Staphylococcus aureus and Escherichia coli successfully demonstrated the hydrogel's broad-spectrum volatile antimicrobial properties. Freeze-thaw stability testing confirmed the hydrogel's structural integrity and color stability. In rainbow trout storage experiments, the hydrogel smart packaging successfully extended the fish's shelf life by 2 days.

Keywords Food spoilage; Anthocyanins; Co-pigmentation; Hydrogel smart packaging; Shelf life

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卵形鲳鲹α-葡萄糖苷酶抑制肽的制备及其理化特性研究

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摘要： 为实现卵形鲳鲹(Trachinotus ovatus)高值化利用，选用卵形鲳鲹为原料，以 α-葡萄糖苷酶 (α-glucosidase, AG) 抑制率、水解度为评价指标，采用酶解法筛选制备 α-葡萄糖苷酶抑制肽（α-glucosidase inhibitory peptide, AGIP）的最佳条件。在此基础上，分析了酶解产物体外模拟胃肠液消化前后其抑制活性的变化，并对 AGIP 的分子质量分布及氨基酸组成进行了测定。结果表明，卵形鲳鲹复合蛋白酶 4 h 的酶解产物 (AGIP) 具有最高的 AG 抑制活性 (58.66±0.75%)，其水解度为 14.07±0.09%，该法制备所得的 AGIP 经体外模拟胃肠液消化后 AG 抑制率提高至 66.55%；酶解物的相对分子质量集中分布在 3kD 以下 (占 96.13%)；酶解物中疏水性氨基酸相对含量较高。

关键词：卵形鲳鲹；α-葡萄糖苷酶抑制肽；降血糖；理化特性

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Synergistic Antioxidant and Anti-Inflammatory Effects of TG-STEH (TGase-Glycosylated Skipjack Tuna Enzyme Hydrolysate) and Its Potential in Inflammatory and Oxidative Stress-Related Diseases

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Abstract: Oxidative stress and inflammation are tightly interconnected, as excessive reactive oxygen species (ROS) induce biomolecular damage and trigger inflammatory responses. Antioxidants alleviate oxidative damage by scavenging free radicals or inhibiting their production, and functional peptides with antioxidant activity have shown potential in mitigating inflammation through oxidative stress modulation. This study investigated the antioxidant and anti-inflammatory properties of TG-STEH (TGase-Glycosylated Skipjack Tuna Enzyme Hydrolysate), a novel compound, to explore its applications in functional foods or pharmaceuticals. Antioxidant activity was evaluated using four key assays: DPPH and hydroxyl radical scavenging, total antioxidant capacity, and iron-reducing capability. Results demonstrated that TG-STEH significantly enhanced total radical scavenging activity and overall antioxidant capacity. For anti-inflammatory assessment, a LPS-induced RAW 264.7 mouse macrophage in vitro model was employed, with ELISA, western blot, and immunofluorescence analyses revealing that TG-STEH markedly reduced the expression of inflammatory cytokines (IL-1β, IL-6, and TNF-α) and modulated protein expressions in inflammatory signaling pathways. Collectively, these findings indicate a synergistic interaction between the antioxidant and anti-inflammatory effects of TG-STEH, highlighting its potential for developing functional foods or pharmaceuticals targeting inflammatory and oxidative stress-related diseases.

Key words: TG-STEH; Antioxidant activity; Anti-inflammatory effect; Synergistic mechanism

海洋功能性磷脂的酶法定向结构修饰及反应调控研究

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摘要：二十二碳六烯酸（DHA）具有多种重要的生理活性，相较于乙酯型和甘油酯型，DHA-磷脂的生物利用度更高。磷脂酰丝氨酸（PS）是神经膜的重要组成成分，可增强认知功能，相比单纯的 DHA 或 PS，DHA-PS 在改善神经健康方面具有更显著的协同效应。然而，现有 DHA-PS 的酶法制备普遍存在 DHA 纯度低、副反应易发生、酶促效率不足等问题。本研究基于大豆磷脂酰胆碱（PC）水解制备甘油磷酸胆碱（GPC），再与游离 DHA 进行酯化生成 DHA-PC，最后利用磷脂酶 D（PLD）催化转磷脂酰反应制备 DHA-PS 的路径，实现大豆 PC 到 DHA-PS 的定向制备。针对反应过程中 GPC 难以溶解于有机介质，以及传统双相和水相体系传质效率低等影响反应效率的问题，系统构建并完善了水解、酯化及转磷脂酰反应的催化体系及调控研究。

关键词：DHA-磷脂酰丝氨酸；酶法制备；无溶剂体系；皮克林乳液；反应调控

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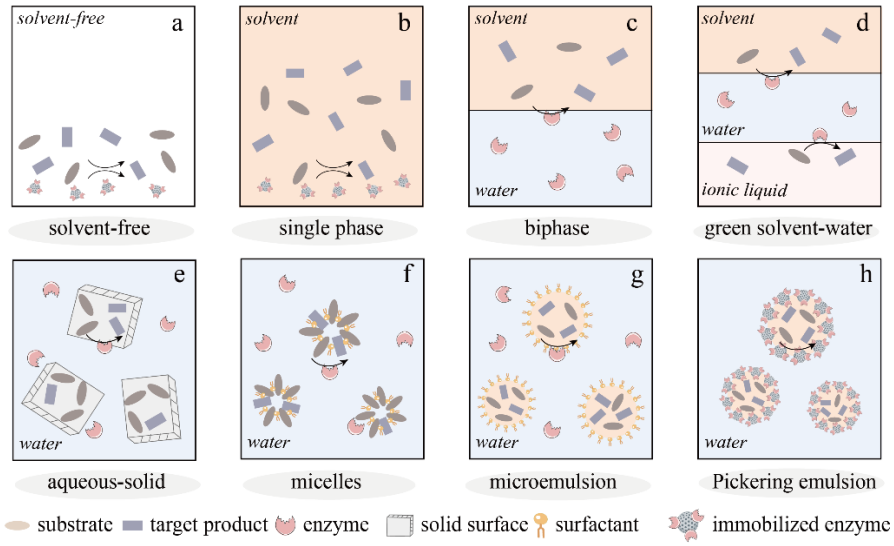

大豆分离蛋白对阿拉斯加鳕鱼肉挤压诱导质构化的协同作用：蛋白质构象转变和纤维结构的形成

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摘要：本研究使用高水分挤压技术，将阿拉斯加鳕鱼肉（APM）与大豆分离蛋白（SPI）混合挤压，探究了 APM-SPI 复合蛋白挤出物纤维结构形成的基本机理。从宏观微观结构、质构特征、纤维度、粘度、热力学性质、二级结构的变化等方面分析了挤出物的纤维结构特性及变化。研究表明，随着 SPI 含量的增加，挤出物颜色更深和更强的纤维度。适度的 SPI 加入会降低硬度和咀嚼性，同时提高表观粘度。结构分析表明，从 α-螺旋到 β-折叠构型的构象转变、二硫键的增加及高分子量蛋白质复合物的形成有利于纤维结构的形成。这些发现建立了一个理论框架，并为高水分挤压鱼肉产品的工业规模生产提供了技术指导，有可能推动可持续海鲜加工的创新，以满足消费者对优质营养替代品的需求。

关键词：高水分挤压；阿拉斯加鳕鱼肉；大豆分离蛋白；结构特性；物理化学性质

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超声辅助酶解罗非鱼皮制备抗氧化肽研究

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摘要：本研究以高蛋白、低脂肪的罗非鱼皮为原料，探讨超声波辅助酶解技术制备抗氧化肽的工艺。对水、酸预处理鱼皮进行超声处理，发现在超声功率 600 W、超声时间 10 min 的条件下，酸预处理鱼皮酶解得到的活性肽得率最高，达 88.71%，对 DPPH •、ABTS+ • 和羟基自由基的 IC50 值分别为 5.15±0.19、2.56±0.15 和 2.45±0.12 mg/mL。 活性肽结构表征显示，超声处理能有助于打开胶原蛋白的三螺旋结构，增加 α -螺旋含量，降低 β -折叠含量和蛋白质粒径，从而暴露更多酶切位点，提高酶解效率。最后，通过超滤和反相-高效液相色谱对酶解产物进行分离，获得抗氧化活性最强的肽组分，其对三种自由基的 IC50 值分别为 0.93±0.07、2.67±0.15 和 1.01±0.33 mg/mL。

关键词：罗非鱼皮；超声处理；抗氧化肽

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ε-聚赖氨酸/果胶/小麦面筋蛋白/海藻酸钠复合膜在黑鱼鱼片冷藏保鲜中的应用

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摘要：在果胶/小麦面筋蛋白/海藻酸钠（HGX）复合膜基础上，添加不同含量 ε -PL 制备 JHGX 复合膜，测定其性能并分析结构，并应用于黑鱼鱼片的冷藏保鲜，分析对冷藏鱼肉品质的影响。研究发现，当 ε -PL 的添加量为 0.75 % 时，JHGX 复合膜对大肠杆菌和金黄色葡萄球菌的抑菌圈直径分别达到（11.08±0.22）mm 和（11.80±0.32）mm，具有明显的抑菌活性。将 JHGX 复合膜应用于黑鱼鱼片的冷藏保鲜中，发现 ε -PL 的添加有效抑制了微生物的生长，延缓了鱼片蛋白质的分解，有效降低了过氧化值，减少了腐败物质的生成。 以 TVB-N 为评价指标，与 PE 包装膜相比，JHGX 复合膜将黑鱼鱼片的保质期延长了 2 d。

关键词： ε -聚赖氨酸；鱼片；冷藏；保鲜；抑菌

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改性金属有机骨架材料(UIO-66)选择性富集罗非鱼皮抗氧化肽

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摘要：本研究采用金属有机骨架材料 MIL - 53 (Cr)、ZIF - 8 和 UIO - 66 选择性富集罗非鱼皮抗氧化肽。研究发现，UIO-66 富集的活性肽具有最高的抗氧化性以及较高的吸附容量。随后，选择-COOH、-NH2、-OH 三种官能团对 UIO-66 进行官能团改性，制备获得 NH2-UIO-66、COOH-UIO-66、OH-UIO-66 三种材料并应用于活性肽富集。发现 NH2-UIO-66、COOH-UIO-66、OH-UIO-66 对性肽的最大吸附量分别为 153.43 mg/mL、123.2 mg/mL、168.29 mg/mL，吸附行为符合准二级吸附动力学模型和 Langmuir 模型。其中 NH2-UIO-66 富集肽的抗氧化能力最强，对 DPPH •、ABTS+ •和羟基自由基（•OH）清除能力的 IC50 分别为 1.02±0.09、2.87±0.16 和 2.22±0.15 mg/mL。官能团改性提高了 UIO-66 的表面亲水性，通过尺寸排阻性和亲水相互作用能够实现对亲水性抗氧化肽的特异性富集。

关键词：抗氧化肽；MOFs；UIO-66；

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FABP4 特异性单域抗体的筛选与表征

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摘要：【目的】构建高质量的基于鲨鱼 lgNAR 的 VNAR 合成文库，并从中淘选脂肪酸结合蛋白 4（Fatty Acid-Binding Protein 4，FABP4）的高特异性高亲和力鲨源单域抗体，研究单域抗体对 FABP4 的抑制活性。【方法】设计了一种新型的 VNAR 框架，并在 CDR3 区域引入不同长度和位点的突变，从而构建 VNAR 人工抗体库。利用噬菌体展示技术，从该合成文库中筛选出针对 FABP4 的特异性 VNARs，并采用 HEK293F 细胞进行抗体的表达与纯化。最后在小鼠胰岛 β 细胞中检验这些 VNARs 对 FABP4 的抑制效果。【结果】成功构建了库容量为 1.17×1010 CFU、具有 100%多样性的鲨源单域抗体合成文库。基于上述文库，以重组 FABP4 为靶标经三轮淘选，获得 14-4D、14-1D、15-1C、15-4C、15-10C、16-3A 等 6 条 VNAR。这些 VNAR-Fc 融合蛋白与 FABP4 结合的 KD 值为 9.75~3360 nM，其中 15-1C-Fc 的 KD 值为 9.75 nM。对 15-4C-Fc 进行 CDR3 优化得到突变体 TST，KD 值由 3.36 μM 降至 55.5 nM（≈60.5 倍）。在小鼠胰岛 β 细胞 FABP4 损伤模型中，16-3A、15-1C 和 14-11D 展现出显著促进胰岛素分泌的能力；TST、16-3A 和 15-1C 能有效恢复细胞活力至接近对照组水平，且 16-3A 对 FABP4 的抑制效力与阳性对照 BMS309403 相当。【结论】本研究制备的鲨鱼 VNAR 合成抗体文库可作为不同抗原筛选的平台，基于该文库筛选得到了 FABP4 高亲和力 VNAR，并对其结合能力进行详细表征，最后在胰岛 β 细胞模型中验证了抗体对 FABP4 的抑制活性，为 FABP4 靶标抗体的开发提供了新方向。

关键词：鲨源单域抗体合成文库；脂肪酸结合蛋白 4；高亲和力筛选；序列优化；抑制活性

黄曲霉毒素 B1 特异性纳米抗体的筛选与表征

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摘要：【目的】初步建立了一种基于纳米抗体的黄曲霉毒素 B1（Aflatoxin B1，AFB1）竞争性 ELISA 检测方法，并评估了其在农产品和食品复杂基质样本中的检测性能。【方法】本研究采用噬菌体展示技术，以 AFB1-BSA 偶联物为固相包被抗原，对鲨源合成抗体文库进行生物淘选，获得候选 VNAR 序列，经过真核表达制备，得到 VNAR-Fc 融合蛋白，利用非竞争/竞争 ELISA、生物膜干涉技术及复杂样品基质效应，评估抗体的亲和力、灵敏度、特异性及理化稳定性。【结果】成功筛选到两株抗 AFB1 特异性纳米抗体（14-1-2B 与 14-6H），测得其平衡解离常数 KD 值分别为 528 nM 和 137 nM。竞争 ELISA 结果显示，14-1-2B 和 14-6H 半抑制浓度（Half Maximal Inhibitory Concentration，IC50）分别为 0.417 ng/mL 和 0.216 ng/mL，特异性良好，且对黄曲霉同家族毒素无交叉反应。该两株抗体能在 70℃高温下保持活性，在极端 pH（pH2 和 12）中保留 50%的活性，并在 70%的有机溶剂中仍能维持 60%的结合能力。在花生、大米和玉米样本的加标回收率在 70.0%至 124.0%之间。【结论】本研究初步探索了鲨源纳米抗体应用于农产品中黄曲霉毒素 B1 检测的可能性，也可为其它真菌毒素纳米抗体的开发提供关键技术参考。

关键词：黄曲霉毒素 B1；鲨源纳米抗体；筛选；表征；食品安全

皱纹盘鲍 MMP-3 和-16 对胶原降解的研究

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摘要：【目的】研究基质金属蛋白酶（Matrix Metalloproteinase，MMPs）在皱纹盘鲍肌肉软化中的作用机制，为抑制该水产动物肌肉软化提供理论依据。【方法】开展含 MMP 激活剂与抑制剂的鲍鱼肌肉 4 ℃冷藏实验，结合质构分析和扫描电子电镜（SEM）观察。克隆并原核表达皱纹盘鲍 MMP-3 与 MMP-16 的催化结构域，经纯化获得重组蛋白 rMMP3c 与 rMMP16c，分析酶学性质。通过 SDS-PAG E、圆二色谱等分析二者单独及协同降解 I 型胶原蛋白的效果，结合羟脯氨酸计算协同指数，辅以吡啶交联含量、红外光谱、扫描电镜和质谱分析。【结果】MMP 活性对皱纹盘鲍肌肉硬度及组织微观结构有显著影响。rMMP3c 与 rMMP16c 最适温度为 37 ℃、最适 pH 为 8，rMMP3c 热稳定性更优，Ca^{2+}、Ba^{2+}和低浓度 Zn^{2+}有激活作用，高浓度 Zn^{2+}及 EDTA 等抑制剂可抑制酶活，且具较高 NaCl 耐受性。二者协同降解 I型胶原蛋白时，8h 即可基本降解完全，对三股螺旋结构破坏更迅速，协同指数始终高于 1.6，表现出显著协同效应；rMMP3c 主要作用于胶原纤维表面，rMMP16c 则降解深层稳定结构。【结论】系统阐明了皱纹盘鲍 MMP-3 和 MMP-16 的酶学性质及其协同降解肌肉胶原蛋白的分子机制，为延缓该鲍鱼贮藏期间肌肉软化提供重要理论依据和新思路。

关键词：皱纹盘鲍；基质金属蛋白酶；胶原蛋白；协同降解；肌肉软化

裙带菜配子体生物质利用
-从高效增殖到活性组分的功能挖掘与应用潜力评估

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摘要： [目的] 分析环境因子对裙带菜配子体生物量及叶绿素、藻胆蛋白、糖脂、类菌孢素氨基酸（MAAs）积累的影响，优化培养条件并评价 MAAs 的抗氧化、抗炎及保鲜功能，为配子体规模化培养与高附加值开发提供理论依据。[方法] 采用单因素实验与均匀设计结合网络神经-遗传算法，优化光质、温度、营养盐、光照强度及光周期等培养条件；通过薄层层析色谱、紫外光谱、高效液相色谱等技术，开展 MAAs 的分离分析、活性评价及应用潜力评估。[结果] 明确了促进配子体生物量及 MAAs 积累的优化培养条件；MAAs 对 DPPH 和 ABTS 自由基的清除率呈浓度依赖性；50 和 100 μM MAAs 溶液可显著抑制斑马鱼神经丘周围的巨噬细胞数量，1.0% 浓度 MAAs 保鲜纸能有效延长鲜切梨贮藏期。[结论] 环境因子可显著调控裙带菜配子体生长及活性组分积累，优化培养条件能提升 MAAs 产量；MAAs 具备优异的抗氧化、抗炎及保鲜活性，为裙带菜配子体资源的规模化利用与高附加值产品开发奠定基础。

关键词： 裙带菜；配子体；藻胆蛋白；糖脂；类菌孢素氨基酸

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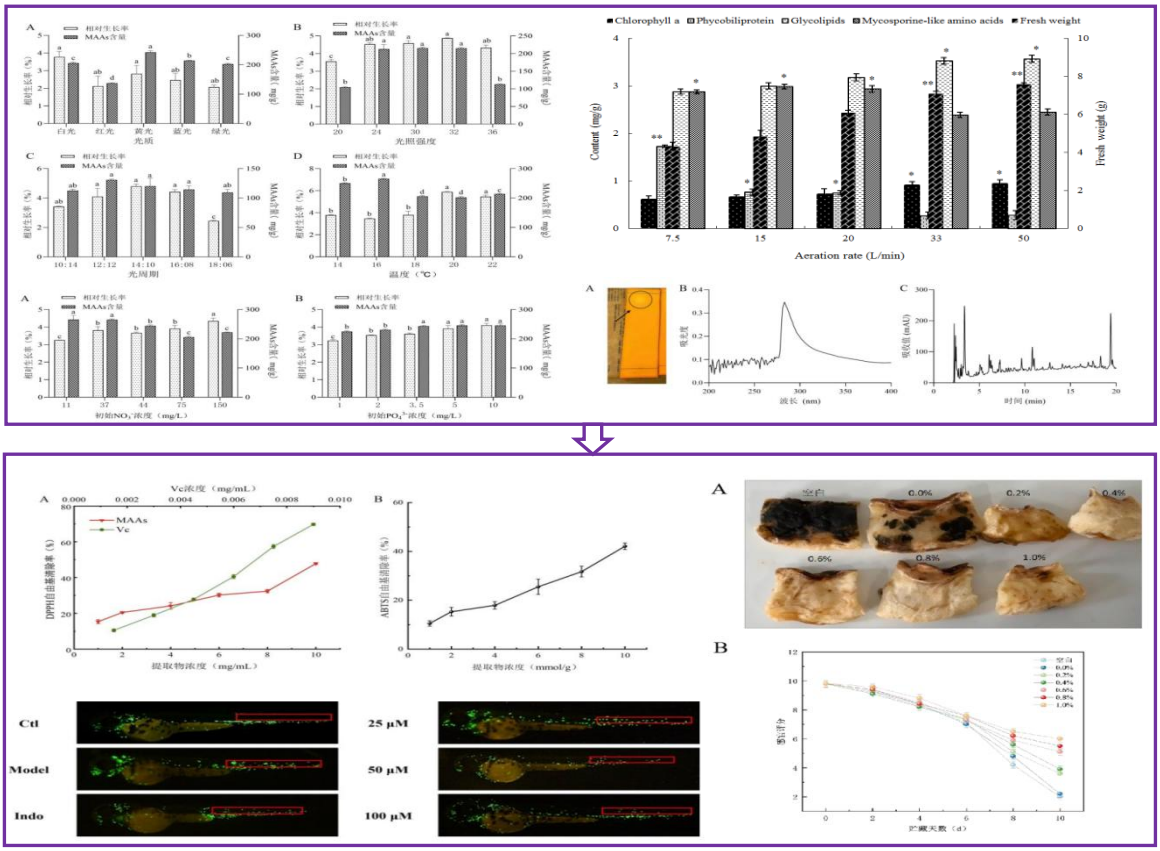
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光周期
温度（℃）
初始NO3-浓度（mg/L）
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MAAs
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Vc浓度（mg/mL）
DPPH自由基清除率（%）
ABTS自由基清除率（%）
提取物浓度（mg/mL）
提取物浓度（mmol/g）
空白
0.0%
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0.4%
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0.8%
1.0%
Ctl
Model
Indo
25 μM
50 μM
100 μM

基于脑电图研究不同酸异味程度的秘鲁鱿鱼（Dosidicus gigas）对脑部感知的影响及其潜在机制

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摘要： 秘鲁鱿鱼（Dosidicus gigas）的市场价值受到其强烈的酸异味显著限制，其本身固有的酸异味严重影响了消费者的接受度。本研究采用了多模态方法，结合脑电图（EEG）、电子感官技术和传统的感官评估，以表征不同酸异味强度下的感知属性及神经相关性，旨在探讨其潜在机制。感官分析表明，巨型鱿鱼的酸异味主要由酸味、苦味及后味共同作用所致。平均 EEG 信号的频谱表明，δ 波和 α 波频段中表现出显著的响应。不同强度的酸异味引发了明显不同的时间响应，感知差异在刺激开始后的 0-200 毫秒和 950-1500 毫秒内逐渐显现。拓扑分布和源定位结果表明，前额皮层和右颞叶是酸异味的主要响应区域。因此，EEG 被证明是一种有前景的客观评估工具，能够量化常规感官评估面板通常忽略的微妙味觉变化，为水产品品质评估提供了新的思路。

关键词：秘鲁鱿鱼；酸异味；脑部感知；头皮脑电图；味觉

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Effects of different sour off-flavor in jumbo squid (Dosidicus gigas) on brain perceptions via scalp electroencephalogram and the underlying mechanisms

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Abstract: The commercial utilization of jumbo squid (Dosidicus gigas) faces significant constraints due to its pronounced sour off-flavor. This investigation employed a multimodal approach combining electroencephalography (EEG), electronic sensing technology, and conventional sensory evaluation to characterize the perceptual attributes and neural correlates of varying off-flavor intensities, aiming to explore the underlying mechanisms. Sensory profiling indicated that sour off-flavor of jumbo squid was mainly attributed to the combined effects of sourness, bitterness, and persistent aftertaste. Further analysis using the electronic tongue and electronic nose clarified the distinct characteristics of the squid sour off-flavor at varying intensities. The spectrum analysis of averaged EEG signals revealed robust neural activation patterns, with particularly prominent responses in the δ and α frequency bands. Distinct levels of sour off-flavor elicited clearly different temporal dynamics, with perceptual distinctions emerging within the 0−200 and 950−1500 ms following stimulus onset. Notably, the topographical distribution and source localization results suggested that increasing off-flavor intensity elicited progressively stronger neural activation, with the prefrontal cortex and right temporal lobe showing the most pronounced responses. By employing EEG for comparative analysis of sour off-flavor intensities in jumbo squid, this study provides novel insights into the neurophysiological mechanisms underlying off-flavor perception. Therefore, EEG is proved as a promising objective assessment tool for quantifying subtle flavor variations often missed by conventional sensory panels in seafood quality evaluation.

Key words: Squid; Sour off-flavor; Brain perception; Scalp electroencephalogram; Taste

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大豆分离蛋白对阿拉斯加鳕鱼肉挤压诱导质构化的协同作用：蛋白质构象转变和纤维结构的形成

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摘要：本研究使用高水分挤压技术，将阿拉斯加鳕鱼肉（APM）与大豆分离蛋白（SPI）混合挤压，探究了 APM-SPI 复合蛋白挤出物纤维结构形成的基本机理。从宏观微观结构、质构特征、纤维度、粘度、热力学性质、二级结构的变化等方面分析了挤出物的纤维结构特性及变化。研究表明，随着 SPI 含量的增加，挤出物颜色更深和更强的纤维度。适度的 SPI 加入会降低硬度和咀嚼性，同时提高表观粘度。结构分析表明，从 α-螺旋到 β-折叠构型的构象转变、二硫键的增加及高分子量蛋白质复合物的形成有利于纤维结构的形成。这些发现建立了一个理论框架，并为高水分挤压鱼肉产品的工业规模生产提供了技术指导，有可能推动可持续海鲜加工的创新，以满足消费者对优质营养替代品的需求。

关键词：高水分挤压；阿拉斯加鳕鱼肉；大豆分离蛋白；结构特性；物理化学性质

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微波辅助酶解制备罗非鱼皮抗氧化肽

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摘要：本研究以罗非鱼皮为原料，采用微波预处理辅助酶解技术制备抗氧化肽，旨在通过优化酶解工艺提升肽的得率与活性；阐明微波预处理促进酶解的机制并解析肽的结构与抗氧化活性间的构效关系。通过单因素与响应面法优化得到最佳工艺条件为：微波功率 440 W、温度 61℃、时间 20 min、酶解时间 6.2 h、加酶量 2.20%、料液比 1:40，该条件下肽的得率与 DPPH 自由基清除活性较未处理组分别提高了 8.23%和 54.89%。超滤分离获得四个组分，其中分子量<1kDa 的 MP4 组分抗氧化活性最高。进一步纯化 MP4 得到 F1-F4 四个亚组分，其中 F1、F2 和 F4 的 DPPH · IC50 值分别为(1.831±0.08)、(2.862±0.16)和(1.838±0.08) mg/mL，活性显著优于 F3。结果表明微波预处理能有效改善鱼皮质构特性，显著降低其硬度、胶粘性和咀嚼性，使胶原纤维结构变得疏松，从而促进酶解过程。同时证实小分子肽及富含组氨酸、苯丙氨酸、酪氨酸和半胱氨酸的肽段表现出更强的自由基清除能力。

关键词：罗非鱼皮；微波预处理；抗氧化肽；分离纯化；

基金项目：大连金石湾实验室项目（Dljswgj202404）；辽宁省自然科学基金项目（JYTQN2023136）；辽宁省教育厅面上项目（JYTMS20230460）。

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Exploring the Novel Pancreatic Lipase-Inhibitory Peptides in Chlorella pyrenoidosa: Preparation, Puriffcation, Identiffcation, and Molecular Docking

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Abstract: Obesity is a worldwide problem, and lowering pancreatic lipase (PL) activity is an effective strategy to counteract it. In this study, pancreatic lipase-inhibitory (PL-I) peptides were isolated and puriffed from Chlorella pyrenoidosa protein hydrolysates (CPPHs) using ultraffltration and Sephadex gel chromatography (Sephadex G-25). A total of 858 peptides were identiffed by liquid chromatography−tandem mass spectrometry (LC-MS/MS). Four novel PL-I peptides (FLSQPF, VWTPI, IVGPF, and IPYPL) were virtually screened using molecular docking and subsequently synthesized, with VWTPI exhibiting the inhibition. Moreover, the inhibition of the enzyme by VWTPI was a mixture of competitive and non-competitive inhibition, with an inhibition constant (Ki) of 7.27 mg/mL. Molecular docking showed that VWTPI interacts with the PL active center by hydrogen bonding, hydrophobic contacts, van der Waals forces, and π-π stacking. This study suggests that peptides from Chlorella pyrenoidosa could be used as lipid-lowering agents to prevent and cure obesity.

Key words: Chlorella pyrenoidosa; pancreatic lipase-inhibitory peptides; puriffcation; identiffcation; molecular docking

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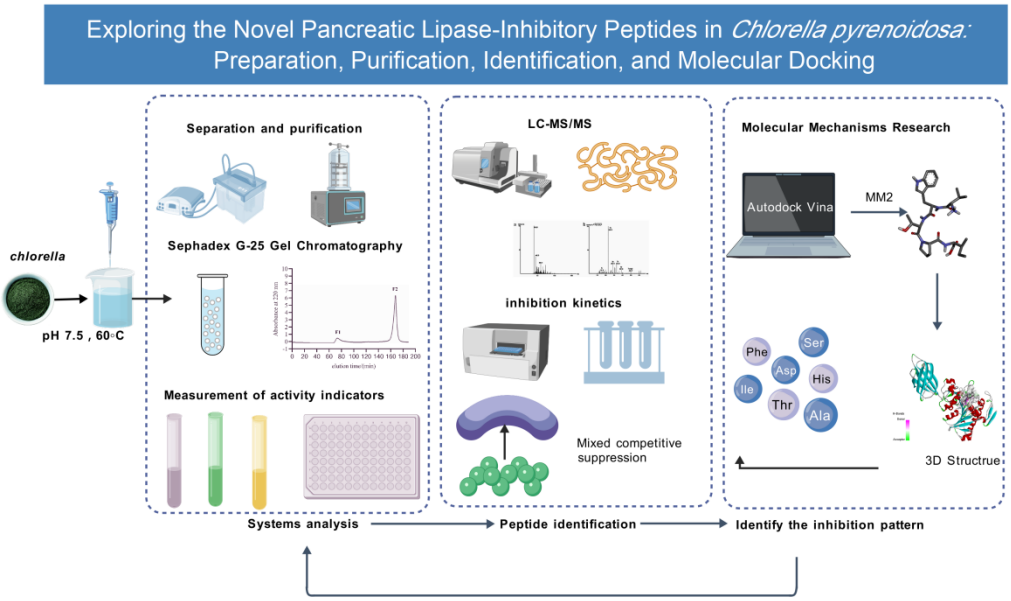
Figure 1



褐藻鱼丸凝胶工艺的优化及产品开发研究

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摘要：本研究以鲢鱼鱼糜和海带、裙带菜浆液为主要原料，优化褐藻鲢鱼鱼糜的工艺配方，制作裙带菜及海带鱼糜制品，研究不同加热方式对裙带菜鲢鱼鱼糜与海带鲢鱼鱼糜凝胶特性的影响并确定最优加热方式。结果表明，添加裙带菜鲢鱼鱼丸的最优加热方式为二段式水浴加热；海带鲢鱼鱼丸最优加热方式为二段式高压熟制，两种加热方式均显著优于其他几种热凝胶化方式。采用两种最优加热方式制备的褐藻鱼丸孔隙均匀平滑，凝胶网络结构紧密，持水效果好。

对不同贮藏温度下裙带菜和海带鲢鱼鱼丸的品质变化规律进行研究，建立相应的货架期预测模型。通过监测两种鱼丸在不同温度条件下贮藏期间各项品质指标的变化，结合 Pearson 相关性分析，确定关键品质指标，裙带菜鱼丸以 TVB-N 值为核心因子，海带鱼丸则以 TBA 值为关键参数。基于此建立的动力学模型能够有效预测两种产品的货架期，并得出相应的货架期预测方程。

关键词：褐藻；鱼丸；凝胶特性；加热方式；货架期

项目：国家重点研发计划项目（2023YFD2100600），国家藻类产业技术体系岗位科学家项目（CARS-50）

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Optimization of gelatinization process and development for brown algae fish ball product

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Abstract : This study used silver carp surimi and the liquid extracts of kelp and wakame as the main raw materials to optimize the formulation for brown algae silver carp surimi products. Both wakame-surimi and kelp-surimi products were prepared, and the effects of different heating methods on the gel properties of these products were investigated to determine the optimal heating conditions. The results indicated that two-stage water bath heating was the optimal method for wakame-surimi balls, while two-stage high-pressure cooking was optimal for kelp-surimi balls. Both methods were significantly superior to other thermal gelation methods evaluated. The brown algae-surimi balls prepared using these optimal heating methods exhibited uniform and smooth pores, a compact gel network structure, and effective water-holding capacity.

Furthermore, the quality changes of wakame-surimi and kelp-surimi balls stored at different temperatures were studied, and corresponding shelf-life prediction models were established. By monitoring the changes in various quality indicators during storage under different temperature conditions and combining with Pearson correlation analysis, the key quality indicators were identified. TVB-N value was determined as the core factor for wakame-surimi balls, while TBA value was the key parameter for kelp-surimi balls. Based on this, kinetic models were developed which effectively predicted the shelf life of both products, and the corresponding shelf-life prediction equations were derived.

Key words: Brown algae; Frozen surimi; Gel properties; Heating methods; Shelf life

基于 GC-IMS 与 ROAV 的海带挥发性风味特征及微生物脱腥研究

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摘要：本研究利用气相色谱–离子迁移谱（GC-IMS）结合相对气味活性值（ROAV），比较海带、裙带菜和笼目海带三种经济褐藻的挥发性风味特征，鉴定醛类和酮类为腥味主导组分，其中 1-辛烯-3-酮为最主要腥味标志物，贡献显著高于(E)-2-壬烯醛。鉴于传统盐渍海带脱腥方法存在营养流失和质构改变等问题，本研究以盐渍海带为对象，开展微生物发酵脱腥研究。生鲜盐渍海带经异常威克汉姆酵母发酵，1-辛烯-3-酮含量降低，并生成异戊醛和乙酸丙酯掩蔽腥味；乳酸菌–酵母复合发酵作用机制类似但稳定性较差。熟制盐渍海带经酿酒酵母发酵，1-辛烯-3-酮含量降低，伴随异戊醛等风味物质积累，感官品质改善。与市售产品对比，发酵样品以异戊醛为主要风味贡献物，1-戊烯-3-酮等异味成分显著减少。结果表明，微生物发酵可有效降低腥味并促进增香物质生成，为海带风味调控、标准化加工及高附加值产品开发提供理论依据。

关键词：盐渍海带；微生物；发酵脱腥；风味改善

项目：国家重点研发计划项目（2023YFD2100600），国家藻类产业技术体系岗位科学家项目（CARS-50）

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Volatile Flavor Characterization and Microbial Deodorization of Kelp Using GC-IMS and ROAV

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Abstract: In this study, the volatile flavor profiles of kelp, wakame, and caged kelp were compared using gas chromatography−ion mobility spectrometry (GC-IMS) coupled with relative odor activity value (ROAV). Aldehydes and ketones were identified as the dominant fishy components, with 1-octen-3-one recognized as the strongest fishy flavor marker, contributing significantly more than (E)-2-nonenal.

Considering the nutrient loss and texture changes associated with traditional deodorization methods for salted kelp, this study focused on microbial fermentation for targeted deodorization. Raw salted kelp fermented with anomalous Wickham’ s yeast exhibited a substantial reduction in 1-octen-3-one and produced isovaleraldehyde and propyl acetate to mask the fishy odor, while lactobacillus−yeast co-fermentation showed a similar mechanism but with lower stability. Fermentation of cooked salted kelp with brewer’ s yeast decreased 1-octen-3-one levels, accompanied by the accumulation of isovaleraldehyde and other flavor compounds, improving sensory quality. Compared with commercially available products, fermented samples were dominated by isovaleraldehyde, with off-flavor compounds such as 1-penten-3-one markedly reduced. These results demonstrate that microbial fermentation effectively mitigates fishy taste while promoting the formation of aroma-enhancing compounds, providing a theoretical basis for flavor modulation, standardized processing, and high-value product development of kelp.

Keywords: Salted kelp; Microorganisms; Fermentation deodorization; Flavor enhancement

产褐藻聚糖硫酸酯酶菌株诱变及酶蛋白序列分析

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摘要：【目的】为了增强褐藻聚糖硫酸酯酶酶解效率，满足后续褐藻多糖降解、低聚糖制备及相关食品领域应用的需求；【方法】本研究以 *Cobetia amphilecti* HN-25 为目标菌株提取褐藻聚糖硫酸酯酶，一方面通过紫外诱变，提高微生物菌株的产酶活，获得稳定性产酶菌株；另一方面纯化分离蛋白，通过 LC-MS 对电泳条带进行蛋白序列分析；【结果】通过紫外诱变实验，筛选出一株正向突变菌株，酶活性较原始菌株提高了 51%，具有传代稳定性；通过 SDS-PAGE 法与 Native-PAGE 实验，得到了分子量为 75kDa、48kDa、11kDa 的三个条带，并对其中的蛋白序列信息进行了分析与整合；【结论】通过实验获得了稳定产酶菌及纯化酶的蛋白序列，为褐藻聚糖硫酸酯酶后续的异源表达奠定信息基础。

关键词：科贝特氏菌；褐藻聚糖硫酸酯酶；紫外诱变；蛋白纯化

Mutagenesis of Fucoidanase producing strains and and Sequence Analysis of Fucoidanase

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Abstract:[Objective] In order to enhance the enzymatic efficiency of fucoidanase and meet the demands of fucoidan degradation, oligosaccharide preparation and related applications in the food field;[Methods] In this study, fucoidanase was extracted from Cobetia amphilecti HN-25 strain. Ultraviolet (UV) mutagenesis was used on the strain to improve the enzyme activity of the microbial strain and obtain a stable enzyme producing strain. Meanwhile the enzyme proteins were purified and sequenced by LC-MS;[Results] Through the UV mutagenesis experiments, one positive mutant strain was screened out with passage stability. And the enzyme activity was 51% higher than that of the original strain. Through the SDS-PAGE method and native-PAGE experiments, three bands with molecular weights of 75kDa, 48kDa, and 11kDa were obtained,

and the protein sequence information was analyzed and integrated [Conclusion] A stable enzyme-producing strain and the protein sequences of purified enzymes were obtained through experiments, laying an information foundation for the subsequent heterologous expression of fucoidanase.

Keywards: Cobetia amphilecti;Fucoidanase; Ultraviolet mutagenesis; Protein purification

核壳型载噬菌体微球的制备及其稳定性和释放行为的研究

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摘要：本研究旨在开发一种核-壳型载噬菌体微球替代抗生素用于养殖鱼类细菌性病害防控。实验以弗氏柠檬酸杆菌（Citrobacter freundii）噬菌体 LV-1 为模型，通过挤出滴落法耦合二次原位凝胶化反应，制备得到载噬菌体海藻酸钠/海藻酸钠-乳清蛋白共混凝胶（Alg/Alg-Whey）核-壳型微球，分析了微囊化噬菌体在模拟胃肠环境中的稳定性和释放行为，并考察了其贮藏稳定性。结果显示，噬菌体在包埋过程中活性稳定，平均包埋率约为 94%；微囊化噬菌体耐酸性显著提高，在 pH 2.4 的模拟胃液中孵育 2 h 后效价仅降低 0.53 lgPFU/g，在模拟肠液中

孵育 8 h 近乎完全释放；噬菌体在湿态微球中 4℃储存 7 周后活性无明显损失，具有良好的贮藏稳定性。本研究表明，核-壳型载噬菌体微球能保护噬菌体活性并在肠道中稳定释放，有望应用于养殖鱼类细菌性病害防控，为从源头解决水产品中的药物残留问题提供了可行方案。

关键词：噬菌体；微囊化；海藻酸钠/乳清蛋白共混凝胶；核-壳型微球

Preparation of Core-Shell Phage-Loaded Microspheres and Study of Their Stability and Release Behavior

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Abstract: This study aimed to develop a core-shell phage-loaded microsphere as an antibiotic alternative for the prevention and control of bacterial diseases in farmed fish. Using

Citrobacter freundii phage LV-1 as a model, core-shell alginate/alginate-whey protein (Alg/Alg-Whey) composite gel microspheres loaded with phage were prepared via the extrusion-dripping method coupled with secondary in-situ gelation. The stability and release behavior of the microencapsulated phage in simulated gastrointestinal environments were analyzed, and its storage

stability was investigated. The results showed that the phage remained stable during the encapsulation process, with an average encapsulation efficiency of approximately 94%. The acid resistance of the microencapsulated phage was significantly improved, with the titer decreasing by only 0.53 lg PFU/mL after 2 hours of incubation in simulated gastric fluid (pH 2.4). Nearly complete release was observed after 8 hours of incubation in simulated intestinal fluid. The phage retained significant activity without obvious loss after 7 weeks of storage in hydrated microspheres at 4° C, demonstrating good storage stability. This study indicates that the core-shell phage-loaded microspheres can protect phage viability and enable stable release in the intestine, showing promise for application in controlling bacterial diseases in farmed fish and offering a feasible strategy to mitigate drug residues in aquatic products at the source.

Key words: Phage; Microencapsulation;Sodium alginate/Whey protein composite gel; Core-shell microspher

基于 Nano-LC 联用 Orbitrap Fusion Lumos 三合一高分辨质谱技术比较分析不同海参酶解肽谱差异

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摘要：本研究以仿刺参（Apostichopus japonicus）与两种低值海参红极参（Cucumaria frondosa）和海地瓜（Acaudina molpadioides）为原料，选择碱性蛋白酶、木瓜蛋白酶进行酶解制备海参肽，并通过 NanoLC 联用 Orbitrap Fusion Lumos 三合一高分辨质谱技术比较分析仿刺参与

两种低值海参酶解肽谱的差异。结果显示，对同一海参原料，木瓜蛋白酶酶解产物释放肽段数量多于碱性蛋白酶；对 3 种不同海参原料，经碱性蛋白酶酶解，释放肽段数量依次为红极参>仿刺参>海地瓜，并鉴定出 717 条共有肽段；经木瓜蛋白酶酶解，释放肽段数量依次为仿刺参>红极参>海地瓜，并鉴定出 1510 条共有肽段；上述 6 个酶解产物中，共鉴定出 183 条共有肽段，其中有丰度信息的肽段 177 条；对高丰度肽段来源分析发现，释放肽段数量较多的母体蛋白为非肌肉型肌动蛋白、肌球蛋白重链、卵黄蛋白、胶原蛋白和细丝蛋白。研究表明三种海参体壁酶解产物中肽段的丰度和类型存在物种特异性，且受蛋白酶影响显著，这为海参肽制备原料和蛋白酶的选择提供了依据。

关键词：仿刺参，红极参，海地瓜，高分辨质谱，多肽组学

ComparativeAnalysis of Enzymatic Hydrolysate Peptide Profiles from Different Sea Cucumbers Using Nano-LC Coupled with Orbitrap Fusion Lumos Tribrid High-Resolution Mass Spectrometry

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Abstract: This study aimed to compare the peptide profiles of enzymatic hydrolysates from the Japanese sea cucumber (Apostichopus japonicus) and two lower-value species—the red sea cucumber (Cucumaria frondosa) and the sea potato (Acaudina molpadioides). Hydrolysis was performed using alkaline protease and papain, and the resulting peptide profiles were analyzed using nano-liquid chromatography coupled with an Orbitrap Fusion Lumos Tribrid high-resolution mass spectrometer (NanoLC-Orbitrap Fusion Lumos). The results indicated that for the same sea cucumber species, papain hydrolysis released a greater number of peptides than alkaline protease. Among the three species hydrolyzed with alkaline protease, the number of peptides released followed the order: C. frondosa > A. japonicus > A. molpadioides, with 717 common peptides identified. When hydrolyzed with papain, the order of peptide release was: A. japonicus > C. frondosa > A. molpadioides, with 1,510 common peptides identified. Across all six hydrolysates, a total of 183 common peptides were detected, 177 of which had quantifiable abundance data. Analysis of high-abundance peptides revealed that the predominant parent proteins included non-muscle actin, myosin heavy chain, vitellogenin, collagen, and filamin. The study demonstrated that the abundance and types of peptides in the body wall hydrolysates of the three sea cucumber species were both species-specific and significantly influenced by the protease used. These findings provided a scientific basis for the selection of appropriate raw materials and proteases in the production of sea cucumber-derived bioactive peptides.

Keywords: Apostichopus japonicus, Cucumaria frondosa, Acaudina molpadioides, high-resolution mass spectrometry, peptidomics

盐渍加工对采收期海带、裙带菜营养成分及铅含量影响的研究

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摘要：盐渍加工是褐藻（海带、裙带菜等）最主要的初加工方式，其加工过程对盐渍产品的品质有重要影响，进而影响全链条褐藻产品的品质。本研究以 7 天为一个周期将大连海域海带和裙带菜的采收期分别划分为 10 和 9 个阶段，采集各阶段的鲜菜、烫漂菜和盐渍菜，分别进行营养成分、重要生物活性物质及重金属铅、镉含量的检测，分析了周期性变化情况，解析了盐渍加工过程中营养成分等变化规律，揭示了重金属铅和镉变化与其他成分的关联性。研究结果为褐藻盐渍产品的安全性及品质提升提供数据支撑。

关键词：采收期；重金属；褐藻盐渍加工；营养成分

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Study on the Effects of Salting Processing on Nutritional Components and Lead Content of Laminaria japonica and Undaria pinnatifida at Harvest Period

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Abstract：Salting is the most important primary processing method for brown seaweeds (such as

Laminaria japonica and *Undaria pinnatifida*). Its processing process has a significant impact on the quality of salted products, which in turn affects the quality of brown seaweeds products throughout the entire supply chain.In this study, the harvest periods of *Laminaria japonica* and *Undaria pinnatifida* in the Dalian sea area were divided into 10 and 9 stages respectively, with seven-day intervals. Samples of fresh, blanched, and salted materials were collected at each stage, and the contents of nutritional components, important bioactive substances, and heavy metals (lead and cadmium) were detected respectively. The periodic variation was analyzed, the dynamic changes in nutritional components and other substances during the salting process were clarified, and the correlation between the changes of heavy metals (lead and cadmium) and other components was revealed. The research results provide a scientific basis and data support for the safety and quality improvement of brown seaweeds salted products.

Keywords: Harvest period; Heavy metals; Salting processing of brown algae; Nutritional components

即食海参加工过程中营养品质和食用品质的变化规律研究

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摘要：本研究旨在探究即食海参加工过程中营养品质和食用品质的变化规律。实验系统研究了即食海参煮制熟化和水发过程中蛋白质、多糖及微量元素等营养物质的流失规律，并综合运用质构剖面分析与体壁组织微观结构观察阐释加工过程中海参质构的变化；采用顶空固相微萃取-气质联用技术（HS-SPME-GC-MS）解析加工过程中挥发性气味物质的形成规律，并基于非靶向代谢组学比较了海参鲜料与加工产品间小分子代谢物质相对含量的差异。结果显示，煮制熟化时间对即食海参水发率及成品蛋白质、多糖及部分微量元素含量变化影响显著；海参体壁胶原纤维随煮制时间延长而断裂降解，由此导致质构软化；海参中特征性腥味物质（如酚类、醛类和醚类化合物等）在煮制熟化过程中逐渐流失，而酯类等典型挥发性香气物质逐渐增加；同时，即食海参中氨基酸、脂肪酸和核苷酸等小分子代谢物在煮制熟化、水发后显著下降。本研究表明即食海参加工过程中，煮制熟化时间是关键工艺参数，对海参加工特性、营养品质和食用品质影响显著，而水发工序主要影响成品的质构特征。

关键词：即食海参；营养品质；质构剖面分析；挥发性气味；非靶向代谢组学

Changes in nutritional and eating quality of ready-to-eat sea cucumber during processing

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Abstract: This study aimed to investigate the changes in nutritional and eating quality of ready-to-eat sea cucumber during processing. The loss patterns of nutrients, including proteins, polysaccharides, and trace elements, during boiling and rehydration were systematically examined.

Texture profile analysis (TPA) and microstructural observation of the body wall were employed to elucidate the textural changes during processing. Headspace solid-phase microextraction coupled with gas chromatography–mass spectrometry (HS-SPME–GC–MS) was used to analyze the evolution of volatile compounds, while non-targeted metabolomics was applied to compare the relative abundances of small-molecule metabolites between fresh and processed sea cucumbers. The results showed that boiling duration significantly influenced the rehydration yield and the contents of proteins, polysaccharides, and certain trace elements in the final product. Prolonged boiling led to the breakdown and degradation of collagen fibers in the body wall, resulting in texture softening. Characteristic off-flavor compounds, such as phenols, aldehydes, and ethers, decreased during boiling, while typical aroma-active esters increased. Additionally, significant reductions were observed in small-molecule metabolites, including amino acids, fatty acids, and nucleotides, after boiling and rehydration. This study demonstrated that boiling time served as a critical processing parameter, significantly affecting the processing characteristics, nutritional quality, and eating quality of ready-to-eat sea cucumber, whereas the rehydration process primarily determined the textural properties of the final product.

Keywords: Ready-to-eat sea cucumber; Nutritional Quality; Texture profile analysis (TPA); Volatile compounds; Non-targeted metabolomics

基于 GC-MS/GC-IMS 与 HPLC-PDA 对牡蛎不同组织中风味及滋味物质的比较分析

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摘要：本研究旨在探究牡蛎不同部位的风味物质与滋味成分差异。采用顶空气相色谱-离子迁移谱（HS-GC-IMS）和固相微萃取气相色谱-质谱（SPME-GC-MS）分析挥发性化合物，并结合 HPLC 测定游离氨基酸、风味核苷酸及有机酸组成。结果显示，外套膜、鳃、闭壳肌和内脏团呈现显著气味差异，整体风味以鱼腥、脂腥、青绿、黄瓜、蘑菇、杏仁及松木样气息为主。筛选出 10 种关键香气化合物，包括己醛、庚醛、壬醛、（E）-2-壬烯醛、1-辛烯-3-醇等。内脏团香气最浓烈，闭壳肌气味清淡。HPLC 结果表明，不同部位共含 16 种游离氨基酸、6 种风味核苷酸和 3 种有机酸，其中内脏团的 Glu、ATP、IMP 含量最高，为鲜味主导部位；闭壳肌的 AMP（TAV＞1）对鲜味贡献显著。综上，牡蛎不同部位风味物质与滋味组分差异显著，为牡蛎不同组织高质化加工利用提供理论依据。

关键词：太平洋牡蛎；不同部位；滋味；风味

Comparative analysis of flavors and flavor compounds in different tissues of oysters based on GC-MS/GC-IMS and HPLC-PDA

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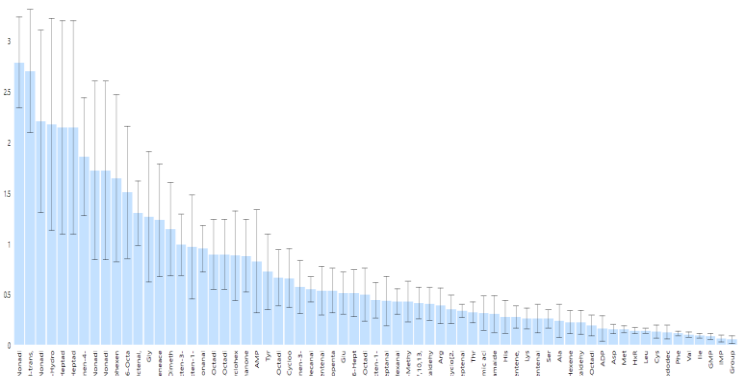
Abstract : This study aimed to investigate the differences in flavor substances and taste components among different parts of oysters. Headspace gas chromatography-ion mobility spectrometry (HS-GC-IMS) and solid-phase microextraction gas chromatography-mass spectrometry (SPME-GC-MS)

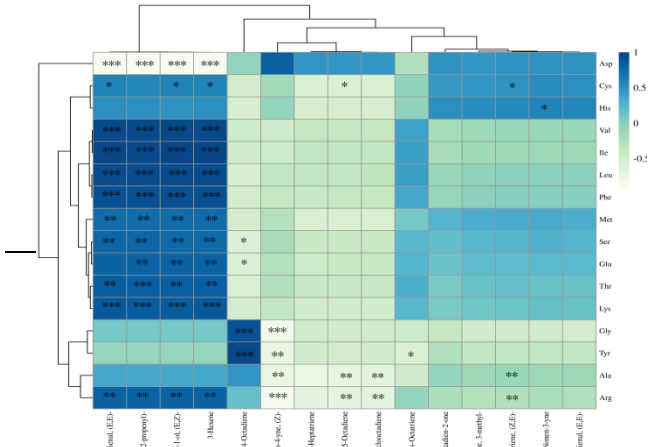
were used to analyze volatile compounds, while high-performance liquid chromatography (HPLC) was employed to determine the compositions of free amino acids, flavor nucleotides, and organic acids. The results showed that significant differences in odor were observed among the mantle, gill, adductor muscle, and visceral mass of oysters. The overall flavor was mainly characterized by fishy, fatty, green, cucumber-like, mushroom-like, almond-like, and pine-like aromas. Ten key aroma compounds were identified, including hexanal, heptanal, nonanal, (E)-2-nonenal, and 1-octen-3-ol. The visceral mass exhibited the strongest aroma, whereas the adductor muscle had a mild odor. HPLC analysis revealed that 16 free amino acids, 6 flavor nucleotides, and 3 organic acids were detected in different oyster parts. Among these, the visceral mass had the highest contents of glutamic acid (Glu), adenosine triphosphate (ATP), and inosine monophosphate (IMP), making it the primary umami-contributing part. The adenosine monophosphate (AMP) in the adductor muscle (with a taste activity value, TAV > 1) made a significant contribution to umami. In conclusion, there were significant differences in flavor substances and taste components among different oyster parts. This study provides a theoretical basis for the high-quality processing and utilization of different oyster tissues.

Key words: Pacific Oysters; Different Tissues; Taste; Flavor

Table 1. Free amino acid composition in different oyster tissues.

FAA	Concentration (mg/100g)				Threshold (mg/100g)	TAV			
	Mantle	Gill	Adductor	Viscera		A	B	C	D
Asp	27.78 ±0.61a	27.70 ±0.53a	23.27± 1.12b	16.34± 0.31c	100	0.28	0.28	0.23	0.16
Thr	27.03 ±4.28c	13.86 ±1.89b	10.05± 1.4b	43.48± 3.23a	260	0.10	0.05	0.04	0.17
Ser	12.70 ±1.31c	4.62± 0.68b	2.63± 0.16b	18.60± 1.74a	150	0.08	0.03	0.02	0.12
Glu	94.93 ±8.24c	62.47 ±5.2b	54.46± 1.12b	123.57 ±2.84a	30	3.16	2.08	1.82	4.12
Gly	60.51 ±6.95c	60.82 ±5.48c	260.75± 11.86a	145.09 ±6.96b	130	0.47	0.47	2.01	1.12
Ala	56.23 ±1.95b	48.34 ±3.83b	63.97± 2.45a	62.57± 2.43a	60	0.94	0.81	1.07	1.04
Cys	3.97± 0.47a	1.50± 0.11b	1.64± 0.09b	4.16± 0.24a	–	–	–	–	–
Val	3.16± 0.29b	1.88± 0.21b	1.59± 0.09b	8.01± 0.41a	40	0.08	0.05	0.04	0.20
Met	5.31± 0.29c	1.59± 0.24b	1.84± 0.29b	7.06± 0.65a	190	0.03	0.01	0.01	0.04
Ile	2.17± 0.18c	1.29± 0.16b	0.98± 0.14b	6.12± 0.19a	90	0.02	0.01	0.01	0.07
Leu	5.00± 0.48c	2.86± 0.32b	1.74± 0.18b	11.05± 0.38a	380	0.01	0.01	0.00	0.03
Tyr	25.40 ±0.68c	19.07 ±0.88c	91.74± 4.87a	39.63± 1.36b	91	0.28	0.21	1.01	0.44
Phe	3.82± 0.37c	2.17± 0.26b	1.69± 0.15b	7.72± 0.39a	90	0.04	0.02	0.02	0.09
Lys	27.78 ±0.61a	27.70 ±0.53a	23.27± 1.12b	16.34± 0.31c	50	0.38	0.17	0.16	0.61
His	27.03 ±4.28c	13.86 ±1.89b	10.05± 1.4b	43.48± 3.23a	20	0.74	0.25	0.23	0.72
Arg	12.70 ±1.31c	4.62± 0.68b	2.63± 0.16b	18.60± 1.74a	50	0.90	0.48	1.25	1.81





不同带电多糖对低盐鱼糜冻融循环中品质的影响

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摘要：本论文探究了羧甲基壳聚糖（CMCS）和壳聚糖季铵盐（QAC）对低盐鲢鱼鱼糜在冻融循环（FTC）过程中品质的影响。结果表明，这两种多糖能显著改善鱼糜的凝胶特性，提高其冻融稳定性。通过多尺度表征分析发现，多糖的添加有效增强了鱼糜的持水力（WHC），减缓了质构特性的下降，增加其凝胶强度，并保护了肌原纤维蛋白（MP）的二级和三级结构，减少了冰晶对蛋白质网络的机械损伤。分子模拟结果表明，多糖与肌球蛋白之间通过静电作用和氢键作用形成蛋白-多糖复合物，从而维持鱼糜结构的稳定性，为多糖作为抗冻剂的应用提供了理论支持。本研究为开发天然高效的抗冻剂提供理论依据，为实现低值水产品的高值化精深加工提供技术创新路径。

关键词：肌原纤维蛋白；分子模拟；静电相互作用；抗冻

The effect of various charged polysaccharides on the quality of low-salt surimi in silver carp during freeze-thaw cycles

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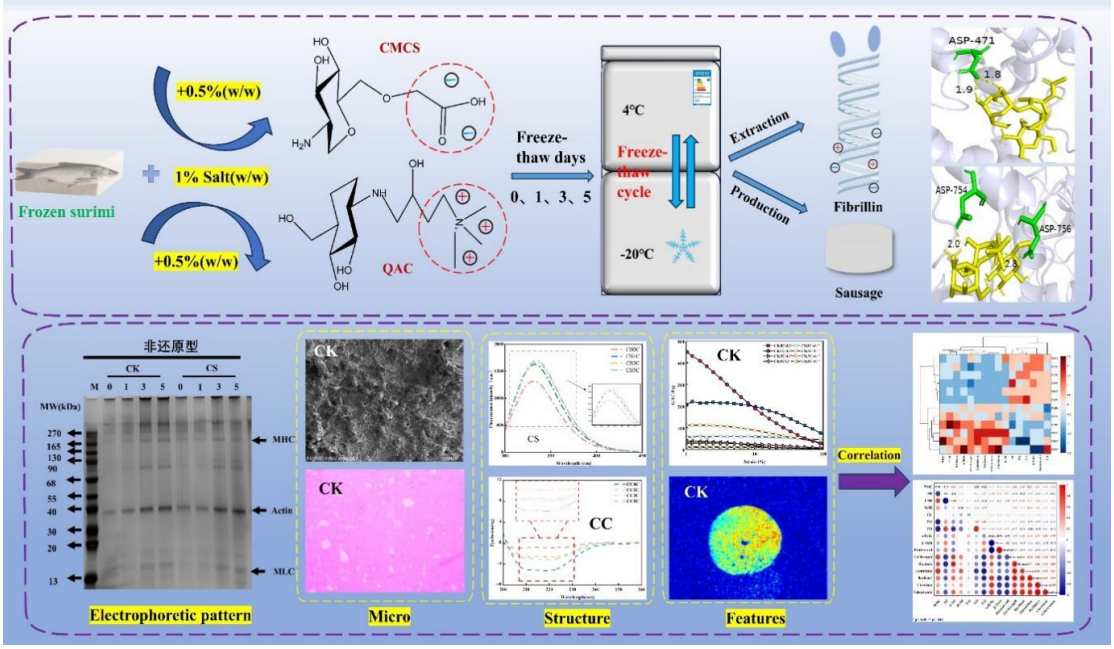
Abstract: This study investigated the effects of carboxymethyl chitosan (CMCS) and quaternary chitosan (QAC) on the quality of low-salt silver carp surimi during freeze-thaw cycle (FTC). The results indicate that polysaccharides significantly improve the gel properties of surimi and enhance its freeze-thaw stability. The incorporation of polysaccharides was found to enhance water-holding capacity (WHC), mitigate the decline in textural properties, and gel strength was enhanced. In addition, the secondary and tertiary structures of myofibrillar protein (MP) were preserved, thereby reducing structural disruption and ice crystal-induced damage. The structural stability of surimi is maintained through electrostatic and hydrogen-bonding interactions between polysaccharides and the myosin complex via molecular simulations, supporting their application as antifreeze agents.

This study provides a theoretical basis for natural antifreeze agents and a pathway for high-value processing of low-value aquatic products.

Keywords: Myofibrillar protein; Molecular simulation; Electrostatic interaction; Antifreeze



基于多维光谱技术解析不同来源磷脂对 HepG2 细胞脂质代谢的调控作用

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摘要：本研究探讨了毛鳞鱼籽磷脂（CPL）、蛋黄磷脂（EPL）和大豆磷脂（SPL）对油酸诱导的 HepG2 细胞脂质代谢紊乱的改善作用。结果表明，油酸导致细胞内甘油三酯、胆固醇、丙二醛、碳水化合物、核酸、 $-CH_2-$、 ν (C=O)/ν as (CH_2 + CH_3) 含量增加，细胞蛋白质含量降低，而 CPL、EPL 和 SPL 能显著抑制这些影响（$P < 0.05$）。基于傅里叶变换红外光谱（FT - IR）和化学计量学分析发现，CPL、EPL 和 SPL 处理可抑制细胞内的氧化应激和脂质过氧化，同时保护细胞内核酸结构，以维持正常的能量代谢途径。本研究为磷脂提取的进一步开发以及基于磷脂的功能化产品的创制指明了潜在方向。

关键词： 磷脂；脂质代谢；FT-IR；脂肪酸

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羊栖菜不同部位酚糖复合物提取、分离纯化研究及结构解析

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摘要：重要的经济褐藻资源羊栖菜藻体分为气囊、茎、假根三个部位，各部位因构造和功能不同导致其含有的酚糖复合物存在一定的差异。本研究对采用“石油醚脱脂-碱法破壁-醇沉富集”的分步优化工艺进行羊栖菜各部位多酚多糖复合物提取，结合单因素和正交实验对提取工艺进行针对性优化，运用 NKA － 9 柱层析法进行多糖多酚复合物分离纯化，利用高效液相色谱、傅里叶变换红外光谱、紫外光谱及核磁共振等技术表征其单糖组成、单酚组成、分子量分布等，并对各部位酚糖复合物体外抗氧化活性进行了测定。该结果为精准化海藻功能制品开发提供了理论支持。

关键词：羊栖菜；酚糖复合物；提取；纯化；抗氧化

项目：国家重点研发计划项目（2023YFD2100600），国家藻类产业技术体系岗位科学家项目（CARS-50）

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Extraction, Purification, and Structural Analysis of Phenolic-Polysaccharide Complexes from Different Parts of Hizikia fusiforme

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Abstract: As an important economic brown algal resource, Hizikia fusiformis thalli are divided into three parts: air bladders, stipes, and holdfasts. The structural and functional differences among these parts lead to variations in their phenolic-polysaccharide conjugate content. This study employed a stepwise optimized protocol—"defatting with petroleum ether, alkali-assisted cell wall disruption, and ethanol precipitation for enrichment"—to extract phenolic-polysaccharide conjugates from different sections of Hizikia fusiformis. The extraction process was systematically optimized using single-factor and orthogonal experimental designs. The resulting conjugates were subsequently isolated and purified via NKA-9 column chromatography. Their structural characteristics, including monosaccharide composition, phenolic constituent profile, and molecular weight distribution, were characterized using techniques such as high-performance liquid chromatography (HPLC), Fourier transform infrared spectroscopy (FT-IR), ultraviolet (UV) spectroscopy, and nuclear magnetic resonance (NMR). Furthermore, the in vitro antioxidant activities of the phenolic-polysaccharide conjugates from each algal part were evaluated.

These findings provide a theoretical foundation for the targeted development of functional seaweed-based products.

Key words:Hizikia fusiformis;Phenolic polysaccharide complexes;Extract;Purification;Oxidation resistance

大黄鱼鱼卵磷脂对肉糜凝胶特性的影响机制研究

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摘要：大黄鱼鱼卵磷脂（large yellow croaker roe phospholipids, LYPLs）是一种主要成分为磷脂型 n-3 多不饱和脂肪酸（n-3 polyunsaturated fatty acids, n-3 PUFA）的功能性脂质，可作为 n-3 PUFA 补充剂有效改善猪肉肉糜制品的凝胶特性，但其作用机制尚不明确。本研究以猪腰最长肌为原料，探究 LYPLs 对肉糜肌原纤维蛋白（myofibrillar protein, MP）的凝胶特性、分子间作用力和凝胶微观结构的影响，明确 LYPLs 对肉糜凝胶性的影响以及与 MP 凝胶结构变化的关系。进一步结合多光谱技术和分子动力学模拟（molecular dynamics simulation, MDS）技术，解析 LYPLs 中主要组分二十二碳六烯酸的磷脂酰胆碱（Phosphatidylcholine-DHA, PC-DHA）与肉糜中肌球蛋白的结合与互作机制，系统地构建“蛋白构象-氨基酸残基-α-C 原子运动变化”的逐步解析体系，为深入理解海洋磷脂调节肉制品品质的分子机制提供了理论支撑。

关键词：大黄鱼鱼卵磷脂；猪肉肉糜凝胶；n-3 多不饱和脂肪酸；分子动力学模拟

Effects of Large Yellow Croaker (Larimichthys Crocea) Roe Phospholipids on the Quality of Minced Gel and its Mechanism

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Abstract: Large yellow croaker roe phospholipids (LYPLs) are functional lipids mainly composed of phospholipid type n-3 polyunsaturated fatty acids (n-3 PUFA). LYPLs can effectively improve the gel properties of pork minced meat products as an n-3 PUFA supplement, but the mechanism of its action remains unclear. This study aims to use the longissimus dorsi muscle of pigs as raw material. First, starting from the minced pork system, this study investigated the effects of LYPLs on the gel properties, intermolecular forces, and microscopic gel structure of minced pork and its primary component, myofibrillar protein (MP), from the perspectives of macroscopic gel properties and microscopic protein molecular changes. The aim was to determine the influence of LYPLs on the gel properties of minced pork

and their relationship with changes in MP gel structure. Subsequently, multi-spectral technology and molecular dynamics simulation (MDS) techniques were used to explore the binding and interaction mechanisms between phosphatidylcholine (PC-DHA), the primary component of LYPLs, and myosin in pork mince. A systematic stepwise analytical framework was established, progressing from “protein conformation changes to amino acid residue changes and to α-C atom movement changes.” The research results provided theoretical support for a deeper understanding of the molecular mechanism by which marine phospholipids regulate the quality of meat products.

Key words: Large yellow croaker roe phospholipids; Minced pork gel; n-3 polyunsaturated fatty acids; Molecular dynamics simulations

静磁场辅助技术在南美白对虾冻融及温度波动贮藏中的品质保持作用

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摘 要:南美白对虾是我国重要的养殖品种,但在冷冻加工过程中,由于冰晶形成和蛋白质变性,易出现质构下降和营养损失,严重影响产品品质与产业价值。针对常规冷冻与解冻方式难以有效抑制品质劣化的问题,本研究系统探讨了静磁场对冻融及温度波动条件下虾仁品质的调控作用。结果表明,静磁场辅助冻融能够显著改善虾仁的物理和生化特性,具体表现为冰晶尺寸减小、肌肉结构更为致密、蛋白质总巯基含量和盐溶解度增加、表面疏水性和氧化水平降低以及β-折叠含量增加,从而有效抑制蛋白质氧化与构象破坏,并在贮藏过程中延缓持水性丧失和品质劣化。在模拟温度波动(-20 ℃～-10 ℃循环)条件下,随着循环次数的增加,虾仁品质逐渐下降,但自第 5 次循环起,静磁场处理显著提高了虾仁的硬度、咀嚼性和持水性,同时减轻了蛋白质疏水性增强和荧光强度升高,并保持更紧密的肌肉纤维结构和更轻的冰晶损伤。该研究揭示了静磁场在调控南美白对虾冻融及温度波动贮藏过程中的作用机制,证明其在维持肌原纤维蛋白稳定性和延缓品质劣化方面具有显著优势,为开发新型水产品冷冻加工保鲜技术提供了理论依据和应用参考,并对提升我国水产加工品品质与国际竞争力具有重要意义。

关键词:南美白对虾;静磁场;冻融;结构特性;蛋白质

魏华茂:男,宁波大学食品科学与工程学院副研究员,日本国立岩手大学博士。主要研究方向为水产品冷链物流与冻融品质智能调控技术,重点聚焦虾、蟹、贝类等典型海洋水产品在冷链全链条中的品质演变规律,系统揭示其在预冷处理、低温贮藏至终端销售环节的多尺度品质劣变机制。主持科研项目 3 项(含国家自然科学基金青年项目),以第一作者或通讯作者发表论文 24 篇,申请专利 6 项。现任宁波市“科技副总”。

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基于“兼性”电荷效应的抗冻多糖/多肽资源挖掘

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摘　要：天然多糖、多肽等新型抗冻配方的使用，可有效抑制高蛋白食品在冻藏、运输、加工过程中的冷冻变性。多糖、多肽等食品配料的电荷状态是影响其诸多功能特性的重要结构基础；然而，带何种电荷的多糖/多肽才是理想的高性能食品抗冻剂，尚缺乏理论与实践研究。受自然界中极地动植物体内具有高浓度的兼性电荷物质这一现象启发，本研究分别以羧甲基壳聚糖（CMCO）和豆类蛋白水解产物（CPH）作为兼性电荷多糖和多肽的代表，通过调控两者正负电荷的多寡/类型，并结合分子模拟和实验表征技术，探究其冷冻保护机制。结果表明，CMCO 通过静电作用与蛋白结合，可提高蛋白的分子刚性，稳定其二、三级结构，而 CPH 则主要通过诱导热致效应，实现冷冻保护。值得注意的是：两者的冷冻保护行为均具有明显的电荷响应特征，即均衡的正负电荷比例可显著提高其抗冻效率。最后，分别以面团、鱼糜、酵母、乳制品等冷冻食品为模型，系统展示了基于“兼性电荷效应”设计高性能抗冻配料的应用范例。

关键词：兼性电荷；冷冻保护；高效；抗冻资源；多糖；多肽

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祝祥威：男，堪萨斯州立大学博士毕业，华中科技大学化学与化工学院博士后，现为湖北工业大学食品科学与工程系副教授，主要研究方向为基于电荷效应的食品高分子相互作用及其低温冷冻保护研究，主要对象包括冷冻鱼制品、冷冻面制品和冷冻发酵制品。

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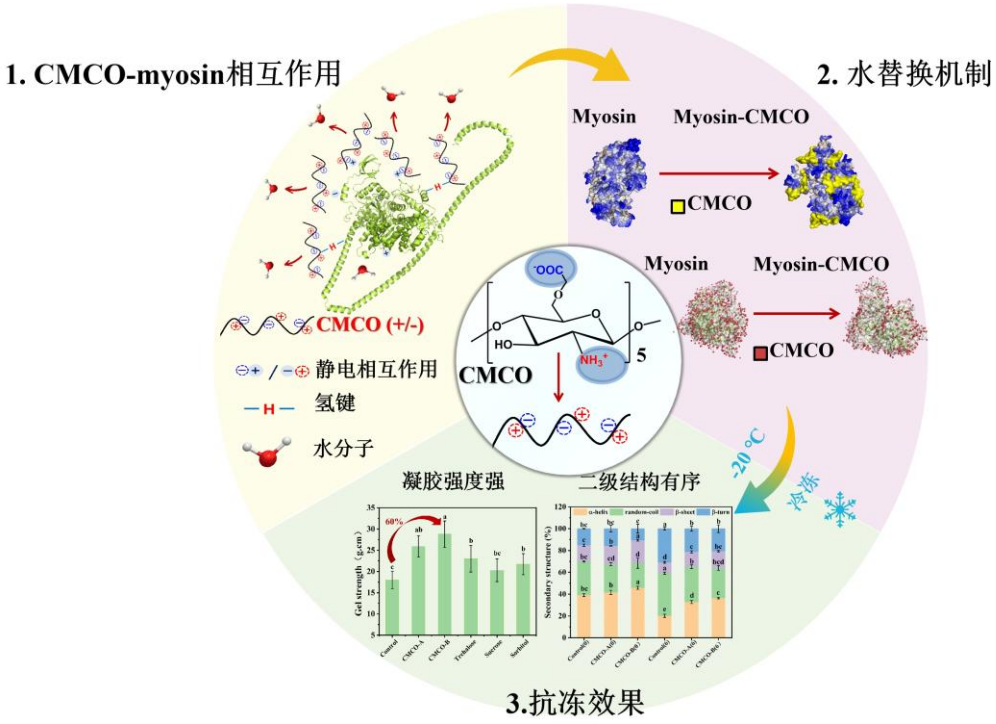

植物乳杆菌发酵苹果汁改善风味特性并增强益生潜力

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摘要：发酵苹果汁是一种营养密集的饮品，富含多种维生素，具有多重健康益处，包括改善消化、促进脂肪代谢，以及在降低热量摄入的同时提供持续能量。为推进富含益生菌的风味功能果汁的开发，本研究确立了植物乳杆菌作为一种安全有效的苹果汁发酵剂。所选菌株的生物胺合成量极低，仅产生腐胺 30.55 ± 1.2 mg/L 和尸胺 0.59 ± 0.55 mg/L，且未检出组胺和酪胺；同时，该菌株无溶血活性，并表现出强大的生物膜形成能力，进一步印证了其适用于发酵应用。电子鼻分析表明，植物乳杆菌显著丰富了发酵苹果汁的挥发性化合物谱，从而优化了其风味特性。该菌株在苹果汁基质中也展现出优异的生长适应性，进一步提升了发酵效率和感官品质。重要的是，16S rRNA 测序分析证实，发酵苹果汁能特异性重塑肥胖个体的肠道微生物群，显著提升包括肠球菌属、副拟杆菌属和双歧杆菌属在内的有益菌属的相对丰度。同时，发酵苹果汁增强了糖酵解活性，提示其在代谢调节中具有潜在作用。综上所述，本研究证实，经植物乳杆菌发酵的苹果汁兼具良好的感官特性、安全性，以及通过调节肠道微生物群和激活代谢通路而实现的抗肥胖潜力。此项研究为开发具有特定健康效益的新一代功能性发酵饮料提供了重要的科学依据。

关键词：肥胖；植物乳杆菌；发酵苹果汁；风味；肠道微生物群

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大黄鱼加工副产物碳点荧光特性的研究

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摘要：本研究利用大黄鱼加工副产物制备碳点（CDs），系统评估其自发荧光与环境稳定性，并探讨其应用潜力。以鱼头、鱼骨等大黄鱼副产物为前驱体，经绿色一步水热法制备出水溶性 CDs，通过 UV－Vis、荧光光谱、FT-IR 对其光学特性进行表征，并在不同 pH、盐度及多种金属离子环境下评估其荧光性能。结果显示，CDs 经特定波长激发后发出蓝色荧光，并具有激发波长依赖性。其在中性 pH 下荧光稳定，而强酸强碱环境下荧光强度逐渐减弱。另外，盐度升高也会引起 CDs 的荧光猝灭。常见生理离子对 CDs 荧光影响较小，仅在以 Fe3+、Cu2+为代表的过渡金属离子存在下显著猝灭。本研究实现了水产副产物的高值化利用，所得 CDs 兼具优良荧光性能与环境稳定性，并对特定金属离子具有识别性，展现出在生物成像与离子传感方面的应用前景。

关键词：大黄鱼；碳点；荧光稳定性；废弃物高值化

Fluorescence Properties of Carbon Dots Derived from Large Yellow Croaker Processing By-products

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Abstract: This study synthesized carbon dots (CDs) from large yellow croaker processing by-products using a one-step green hydrothermal method and systematically evaluated their photoluminescence stability under various environmental conditions. The optical and surface properties of the CDs were characterized by UV–Vis absorption spectroscopy, photoluminescence spectroscopy, and FT-IR spectroscopy. The fluorescence behavior of CDs was evaluated under varying conditions, including pH levels, salinity concrntrations, and exposure to representative metal ions. The water-dispersible CDs emitted blue fluorescence under appropriate excitation and displayed excitation-dependent emission. It exhibits stable fluorescence at neutral pH, but the fluorescence intensity gradually decreased under acidic or alkaline environments. Additionally, increased salinity leads to fluorescence quenching. Common physiological cations exerted minimal effects on CDs fluorescence, while transition metal ions, such as Fe3+ and Cu2+, induced pronounced quenching. These findings present a novel approach for the high-value utilization of aquatic by-products. The obtained CDs exhibit excellent fluorescence performance with environmental stability, and selectivity responses to specific metal ions, suggesting promising applications in bioimaging and ion sensing.

Key words: large yellow croaker; carbon dots; fluorescence stability; waste utilization

枯草芽孢杆菌与植物乳杆菌分步发酵提升海带功能性

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摘要：本研究旨在开发一种基于枯草芽孢杆菌与植物乳杆菌顺序发酵技术的高效海带加工策略。研究采用分阶段发酵：首先用枯草芽孢杆菌进行好氧发酵，初步降解海带的细胞壁与多糖，再接种植物乳杆菌进行厌氧乳酸发酵。监测发酵过程中 pH 值、总酸、还原糖等理化指标，并评估发酵产物的抗氧化、降血糖、降血压及降血脂活性。结果表明，该顺序发酵工艺显著优于单菌及混菌发酵，表现出显著协同效应，预期产物中活性肽得率及褐藻寡糖含量均显著提升，且其抗氧化活性提升至未发酵样品的 1.7 倍。本研究证实，该时序发酵策略能有效利用两菌株的代谢协同作用，显著提升海带的生物活性与功能成分，为开发高附加值海带制品提供了新途径。

关键词：海带；分步发酵；生物活性；高附加值

Enhancement of Seaweed Functionality by Sequential Fermentation with Bacillus subtilis and Lactiplantibacillus plantarum

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Abstract: This study aimed to develop an efficient processing strategy for seaweed using sequential fermentation with Bacillus subtilis and Lactiplantibacillus plantarum. A two-stage fermentation process was employed, an initial aerobic fermentation by B. subtilis to degrade the algal cell wall and polysaccharides, followed by anaerobic lactic acid fermentation with L. plantarum. Key physicochemical parameters (pH, total acidity, reducing sugars, etc.) were monitored, and the bioactivities of the products, including antioxidant, anti-hyperglycemic, anti-hypertensive, and lipid-lowering activities, were evaluated. Results demonstrated that the sequential fermentation process was significantly superior to single-strain or mixed-culture fermentation, exhibiting a notable synergistic effect. The yield of bioactive peptides and alginate oligosaccharides were pronounced increased, and antioxidant activity reached 1.7 times than that of unfermented samples. This study confirms that the temporal fermentation strategy effectively leverages the metabolic synergism between the two bacterial strains, significantly improving the bioactivity and functional components of seaweed, thereby providing a novel approach for developing high-value seaweed products.

Key words: Seaweed; Sequential Fermentation; Bioactivity; High value-added

抑菌性海带碳点的制备及表征

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摘要：本研究以海带为前驱体制备具有抑菌活性的碳点(CDs)，并探究其理化特性。采用一步水热法分别制备海带 CDs 与海带-柠檬酸 CDs，通过最低抑菌浓度评估其对大肠杆菌和金黄色葡萄球菌的抑菌活性，并利用透射电子显微镜(TEM)、X 射线光电子能谱(XPS)、X 射线衍射(XRD)、傅里叶变换红外光谱(FT-IR)、UV－Vis 与荧光光谱等对所制备的 CDs 进行表征。结果显示，相较于未改性的海带 CDs，海带－柠檬酸 CDs 表现出更强的抑菌活性，可有效抑制以大肠杆菌和金黄色葡萄球菌为代表的革兰氏阴性菌与阳性菌的生长。海带-柠檬酸 CDs 由 C、N、O 构成，表面富含 O-H、C-O 等含氧官能团，呈自发荧光并具激发依赖性。研究结果为藻类资源的高值化利用提供可行方案。

关键词：海带；碳点；表面改性；抑菌活性；废弃物高值化

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Preparation and Characterization of Antibacterial Kelp-Derived Carbon Dots

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Abstract: This study utilizes kelp as a renewable precursor to synthesize antibacterial carbon dots (CDs), and characterizing their physicochemical properties. Kelp CDs and kelp-citric acid CDs were synthesized via a one-step hydrothermal method. Antibacterial activity against Escherichia coli and Staphylococcus aureus was evaluated using minimum inhibitory concentration (MIC) assays. The kelp-citric acid CDs were characterized by transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), UV–Vis absorption, and photoluminescence spectroscopy. The results indicate that the kelp-citric acid CDs consist of C, N, and O, with enriched oxygen containing surfaces groups (e.g., O–H, C–O), display visible-range emission with excitation-dependent photoluminescence, and exhibit enhanced antibacterial activity compared to unmodified kelp CDs, effectively inhibiting the growth of representative Gram-negative and Gram-positive bacteria strains. These results provide a viable approach for the high-value utilization of algal

resources.

Key words: kelp; carbon dots; surface modification; antibacterial activity; waste valorization

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制备条件对大黄鱼碳点理化特性影响的研究

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摘要：本研究以大黄鱼加工副产物为碳源，采用水热法合成生物质荧光碳点，探究不同水热反应温度与时间对碳点理化特性的影响。通过紫外-可见吸收光谱、透射电子显微镜（TEM）、X 射线光电子能谱(XPS)、傅里叶变换红外光谱（FT-IR）等对所制备的碳点进行表征分析。结果表明，各条件下所制备的大黄鱼碳点均具有良好的单分散性，平均粒径随水热反应温度升高和时间延长呈现先增大后减小的趋势。其中，在 200℃水热反应 6 h 条件下制备的碳点具有最优的分散性和稳定性，Zeta 电位为-18.87±1.15 mV。XPS 与 FT-IR 分析表明所制备的大黄鱼碳点主要由 C、O、N 元素组成并富含多种表面官能团。本研究为揭示生物质碳点的形成机制提供参考依据，并为大黄鱼废弃物的高值化利用提供了新途径。

关键词：大黄鱼；碳点；水热法；理化特性

鲟鱼子酱苦味物质的形成途径与调控机制研究

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摘要：我国鲟鱼子酱产销量连续十年世界第一。然而，加工及贮藏过程鲟鱼子酱感官品质的劣变带来了严重的经济损失。通过简单描述分析，明确了“奶油味”、“坚果味”、“鲜味”、“苦味”、“腥味”和“金属味”是鱼子酱滋味描述词。显著差异代谢物与苦味数据库 BitterX 和 BitterSweet 对比后，共筛选出棕榈酸乙酯、蓖麻油酸、葫芦素 D 等 19 种潜在苦味物质。葫芦素 D、蓖麻油酸和棕榈酸乙酯与苦味受体 T2R46 结合最紧密，RMSD 分别为 0.3625、0.3697 和 0.3473 nm，氢键作用和疏水相互作用是主要结合作用力。苦味鱼子酱中棕榈酸乙酯、蓖麻油酸、葫芦素 D 含量分别为 73.35 μg/mL、312.83 μg/mL、3.97 μg/mL，显著高于正常鱼子酱。初步探究了 5’-单磷酸腺苷、β-乳球蛋白、γ-氨基丁酸三种苦味掩蔽剂对鱼子酱苦味模拟溶液的苦味掩蔽效果，为鲟鱼子酱苦味抑制技术与方法选择提供了理论依据。

关键词：鲟鱼子酱；苦味；苦味感知；苦味掩蔽

The Formation Pathway and Regulatory Mechanism of Bitter Substances in Sturgeon Caviar

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Abstract : China has ranked first in the world in terms of the production and sales of sturgeon caviar for ten consecutive years. However, the deterioration of the sensory quality of sturgeon caviar during processing and storage has caused serious economic losses. The simple descriptive analysis identified ‘creamy’, ‘nutty’, ‘fresh’, “bitter”, ‘fishy’ and ‘metallic’ are representative descriptors of caviar taste. Significantly differential metabolites were compared with the bitter databases BitterX and BitterSweet, and a total of 19 potentially bitter compounds such as ethyl hexadecanoate, ricinoleic acid, cucurbitacin D were screened out. Cucurbitacin D, ricinoleic acid and ethyl hexadecanoate were the most tightly bound to the bitter taste receptor T2R46 with RMSDs of 0.3625, 0.3697 and 0.3473 nm, respectively, and hydrogen bonding interactions and hydrophobic interactions were the main forces for their binding. The quantitative analysis of the three compounds showed that the contents of ethyl hexadecanoate, ricinoleic acid, and cucurbitacin D in bitter caviar were 73.35 μg/mL, 312.83 μg/mL, and 3.97 μg/mL, respectively, which were significantly higher than those in the normal caviar. The present study also initially explored the bitter masking effects of three bitter masking agents, namely, adenosine monophosphate (AMP), β-lactoglobulin, and γ-aminobutyric acid on the bitter simulation solution of caviar, and the electronic tongue results showed that AMP could completely mask the bitterness of the standard bitter mixing solution. These results provided a theoretical basis for a comprehensive analysis of caviar taste perception, and a preliminary investigation into the practical application of masking

bitter caviar.

Key words: Sturgeon caviar; Bitterness; Bitter perception; Bitterness masking

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流化冰对罗氏沼虾的保鲜效果研究

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摘要：为探究流化冰在罗氏沼虾保鲜中的应用，本研究将罗氏沼虾分为活虾组（L 组）、刚死亡组（D 组）、-1 ℃流化冰降温组（-1 组）、-6 ℃流化冰贮藏组（-6 组），于贮藏 0、1、3、5、7、9 d 测定感官品质、虾肉微观结构及 pH 值、ATP 等指标。结果显示，L 组 ATP 含量高于 D 组，蒸煮损失率低 5.5%，其余指标无显著差异；-6 组外观、感官评价优于-1 组，冷却速率更快，pH 变化更平稳，蒸煮损失率更低，ATP 降解更慢，0 d 时 ATP 达 L 组 85%且高于 D 组；贮藏 7 d 时，-6 组肌原纤维排列紧密，微观结构更优。基于 K 值的鲜度评价中，-6 组评分全程高于 D 组且接近 L 组，0 d 达 L 组 98%。综上，-6 ℃流化冰能有效延缓罗氏沼虾品质劣变，保持鲜度与感官品质，为优化其供应链提供支撑。

关键词：流化冰；罗氏沼虾；保鲜；微冻

Effects of Partial Freezing Storage on the Freshness and Muscle Microstructure of *Macrobrachium rosenbergii*

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Abstract：To explore the application of fluidized ice in the preservation of Macrobrachium rosenbergii, this study divided the prawns into four groups: live prawn group (Group L), freshly dead group (Group D), -1 ° C fluidized ice cooling group (Group -1), and -6 ° C fluidized ice storage group (Group -6). Sensory quality, microstructure of prawn meat, and chemical indicators including pH value and ATP were determined on days 0, 1, 3, 5, 7, and 9 of storage. Results showed that Group L had a higher ATP content than Group D, with a cooking loss rate 5.5% lower than that of Group D, while no significant differences were observed in other indicators. Group -6 outperformed Group -1 in appearance and sensory evaluation, with a faster cooling rate, more stable m pH change, lower cooking loss rate, and slower ATP degradation. On day 0, the ATP content of Group -6 reached 85% of that in Group L, which was significantly higher than that in Group D. On day 7 of storage, the myofibrils in Group -6 remained tightly arranged and coherent, showing a significantly better microstructure than Group -1. Freshness evaluation based on K-value indicated that the scores of Group -6 were higher than those of Group D throughout the storage period and close to those of Group L, reaching 98% of Group L's score on day 0. In conclusion, -6 ° C fluidized ice can effectively delay the quality deterioration of Macrobrachium rosenbergii and maintain its freshness and sensory quality, providing support for optimizing its supply chain.

Keywords：Slurry Ice; Macrobrachium rosenbergii; Preservation; Partial freezing

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调味鲅鱼排的品质及风味研究

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摘要：对调味鲅鱼排的配方和加工工艺进行了优化及对添加 L-半胱氨酸的调味鲅鱼排品质及其风味特性进行研究。调味鲅鱼排的食盐添加量为 1%，酱油添加量为 2.5%，白胡椒粉添加量为 1%，料酒添加量为 3%；微波功率 800 W，微波时间 50 s、油炸温度 180℃、油炸时间为 2 min。添加 L-半胱氨酸可显著增强鱼排的抗氧化性能，DPPH 自由基清除率由 56.08%上升到 72.18%，$ABTS^{+}$ 自由基清除率由 59.24%上升到 74.34%；添加 L-半胱氨酸在提升鲜味、调节挥发性风味组成方面具有积极作用，可显著提高 IMP 和 AMP 等呈味核苷酸含量。本研究为进一步促进鲅鱼深加工与品质调控提供了参考。

关键词：鲅鱼排；L-半胱氨酸；品质；风味分析

Study on the Quality and Flavor of Seasoned Mackerel Fillets

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Abstract:. The formulation and processing technology of seasoned mackerel fish steak were optimized, and the quality and flavor characteristics of seasoned mackerel fish steak with the addition of L-cysteine were investigated. The optimal formulation for the seasoned mackerel fish steak consisted of 1% salt, 2.5% soy sauce, 1% white pepper, and 3% cooking wine. The optimal processing parameters were microwave power of 800 W, microwave time of 50 s, frying temperature of 180° C, and frying time of 2 min. The addition of L-cysteine significantly enhanced the antioxidant properties of the fish steak. The DPPH radical scavenging rate increased from 56.08% to 72.18%, and the $ABTS^{+}$ radical scavenging rate increased from 59.24% to 74.34%. The addition of L-cysteine played a positive role in enhancing the umami taste and regulating the composition of volatile flavors, significantly increasing the content of taste-presenting nucleotides such as IMP and AMP. This study provides references for further improving the deep processing and quality control of mackerel.

Key words: Seasoned mackerel fish steak; L-Cysteine; quality; flavor analysis

Correlation between flavor quality evolution and lipid oxidation of sea urchin during refrigeration based on GC-IMS

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Abstract: This study focused on the flavor changes of sea urchin during refrigeration, aiming to analyze the dynamic changes of flavor substances during their storage period through multivariate correlation analysis, and explore the role of lipid and protein oxidation in it. By measuring the changes in lipids and proteins of sea urchin during the storage period of 0 to 72 hours, and combining gas chromatography-ion mobility spectrometry (GC-IMS) technology for untargeted analysis of volatile flavor compounds. Principal Component Analysis (PCA) and Relative Odor Activity Value (ROAV) were used to screen and evaluate key flavor compounds. As a result, it was found that with the extension of refrigeration time, the oxidation degree of sea urchin significantly deepened, manifested as the continuous accumulation of primary and secondary lipid oxidation products and the oxidation of protein thiol groups. The GC-IMS clearly showed the dynamic changes in volatile flavor compounds: the content of aldehydes (such as pentanal) representing fresh flavors decreased, while flavor compounds related to quality deterioration (such as trimethylamine and isoamyl alcohol) significantly increased. Through ROAV analysis, it was further confirmed that 3-methylbutanal and trimethylamine were key contributors to the overall flavor during the later stages of storage. The study identified 24 hours as a critical point for significant changes in flavor quality. According to correlation analysis, it was found that the formation of various flavor compounds related to quality deterioration was significantly positively correlated with lipid oxidation indicators.

Keywords: sea urchin; GC-IMS; flavor changes; principal component analysis

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扇贝裙边肽 IPP 对软骨细胞氧化损伤与衰老的抑制作用

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摘要：扇贝裙边作为富含生物活性成分的海洋副产物，是潜在的抗氧化肽来源。抑制活性氧与炎症因子诱导的软骨细胞氧化损伤及衰老是骨关节炎防治的关键。本研究通过超声辅助酶解制备扇贝裙边蛋白水解物，筛选抗软骨细胞氧化与衰老活性肽并探究作用机制。结果显示：390W 超声预处理（SMPH390）可显著提高水解物的组氨酸及可溶性肽含量，增加表面疏水性与水解度，并增强 $ABTS^{+}$·和 DPPH·自由基清除能力（$P<0.05$）；质谱鉴定 SMPH390 含 31 条肽段，选取合成 Peptide Ranker 评分最高的 PAPPP、IPGLP、IPPPF（IPP）进行体外验证，发现 IPP 在 5~15 μg/mL 浓度下可剂量依赖性改善 H_2O_2诱导的软骨细胞活力下降，抑制 ROS 积累，效果优于其他肽段；IPP 通过维持线粒体膜电位、增强 SOD 活性、降低 MDA 含量，减少衰老标志物 β-半乳糖苷酶生成；qPCR 结果显示其可显著上调抗氧化基因（*CAT*、*SOD*、*GPX*）及软骨基质合成基因（*SOX9*、*ACAN*）表达，同时抑制基质降解基因（*MMP13*、*ADAMTS5*）及衰老基因（*P21*、*P16*）（$P<0.05$）；靶蛋白预测提示 IPP 可能通过结合膜表面 A 类 G 蛋白偶联受体发挥作用。本研究从扇贝裙边中筛选出活性肽 IPP，其可抑制氧化应激下软骨细胞损伤与衰老，为开发海洋源骨关节炎功能肽提供参考。

关键词：扇贝裙边；活性肽；骨关节炎；软骨细胞衰老；抗氧化

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摘 要：本文以菲律宾蛤仔肉为蛋白原料，无水氯化钙为钙源，优化菲律宾蛤仔肽及其钙螯合物的制备工艺。采用红外光谱、紫外光谱和扫描电镜（SEM）等手段对菲律宾蛤仔肽及其钙螯合物进行结构表征。分子对接表明肽钙主要通过配位键、疏水相互作用和氢键进行结合，结合位点以C-末端羧基氧原子和氨基酸侧链为主；酸性氨基酸和疏水性氨基酸均可为螯合反应提供配位点，螯合模式为双齿模式。菲律宾蛤仔肽钙螯合物具有良好的稳定性，尤其是在中性和弱碱性条件。钙离子转运试验表明，菲律宾蛤仔肽钙螯合物的钙转运能力显著高于无机钙。研制了一款菲律宾蛤仔肽钙螯合钙片剂产品，为菲律宾蛤仔高值化利用提供一定的参考。

关 键 词 ：菲律宾蛤仔；肽钙螯合物；分子对接；促钙吸收；片剂

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高压均质调控三文鱼肌原纤维蛋白乳化及吞咽特性的构效关系与机制解析

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摘　要　人口老龄化加剧了对吞咽障碍食品的需求，该类食品需兼具适宜的流变质地与良好营养。三文鱼富含优质蛋白及ω-3 不饱和脂肪酸，是开发高营养价值吞咽食品的理想基质，如何通过适度加工精准调控其蛋白的成乳性与最终产品的吞咽特性，仍需深入研究。　本研究采用高压均质技术处理三文鱼肌原纤维蛋白，系统分析了高压均质对其分子结构的多尺度影响。进而以其为乳化剂构建了富含ω-3 的三文鱼油的乳液体系（ϕ=0.3-0.6），并表征了乳液的乳化特性、流变学性质及吞咽特性。　结果表明，两步高压均质处理(50 MPa)能显著改善蛋白的乳化活性与稳定性，乳液平均粒径降低了 90%，并形成具有优异粘弹性的蛋白凝胶网络。IDDSI 测试表明乳液体系含油量为 50%与 60%时，可达 Level 4，适合老年吞咽困难人群食用。高压均质诱导的蛋白适度变性、疏水基团暴露及结构展开，是增强其界面吸附能力与膜强度的关键；而由此形成的更细小、稳定的胶束结构，则是实现优异流变特性和润滑性能，从而改善吞咽功能的核心机制。本研究不仅解析了高压均质调控蛋白功能特性的分子机制，也为开发基于海洋资源的高性能特殊膳食食品提供了创新的技术方案与坚实的理论支撑。

关键词　三文鱼蛋白；高压均质；乳液凝胶；蛋白胶束；界面特性；吞咽障碍；

Structure-Function Mechanism of High-Pressure Homogenized Salmon Myofibrillar Protein in Emulsification and Swallowing Properties

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Abstract　The growing aging population worldwide is driving demand for dysphagia foods that combine suitable texture with high nutritional value. Salmon, rich in high-quality protein and ω-3 fatty acids, is an ideal base for such foods, though precise modulation of its emulsification and swallowing properties via processing remains challenging. This study employed high-pressure homogenization (HPH) to modify salmon myofibrillar protein and systematically examined its structural changes. The modified protein was utilized as an emulsifier to stabilize ω-3-rich salmon oil (φ = 0.3–0.6), and the emulsion was characterized for its stability, rheological behavior, and swallowing characteristics. Results demonstrated that two-step HPH treatment (50 MPa) significantly enhanced emulsification, reducing average droplet size by 90% and forming a gel network with high viscoelasticity. Emulsions with 50% and 60% oil attained IDDSI Level 4, confirming suitability for dysphagia diets. Mechanistic analysis indicates that HPH induced moderate protein denaturation, hydrophobic exposure, and structural unfolding, which enhances interfacial

adsorption and film strength. The resulting fine and stable micellar structure contributed to improved rheological properties and lubricity, thereby facilitating swallowing. This work elucidates the molecular mechanism underlying HPH-induced functional enhancements in salmon protein, providing a theoretical and technical foundation for developing high-performance marine-based dietary products for dysphagia populations.

Keywords Salmon protein; High-pressure homogenization; Emulsion gel; Protein micelle; Interfacial property; Dysphagia diet

基于脑电图研究不同酸异味程度的秘鲁鱿鱼(Dosidicus gigas)对脑部感知的影响及其潜在机制

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摘要：秘鲁鱿鱼（*Dosidicus gigas*）的市场价值受到其强烈的酸异味显著限制，其本身固有的酸异味严重影响了消费者的接受度。本研究采用了多模态方法，结合脑电图（EEG）、电子感官技术和传统的感官评估，以表征不同酸异味强度下的感知属性及神经相关性，旨在探讨其潜在机制。感官分析表明，巨型鱿鱼的酸异味主要由酸味、苦味及后味共同作用所致。平均 EEG 信号的频谱表明，δ 波和 α 波频段中表现出显著的响应。不同强度的酸异味引发了明显不同的时间响应，感知差异在刺激开始后的 0-200 毫秒和 950-1500 毫秒内逐渐显现。拓扑分布和源定位结果表明，前额皮层和右颞叶是酸异味的主要响应区域。因此，EEG 被证明是一种有前景的客观评估工具，能够量化常规感官评估面板通常忽略的微妙味觉变化，为水产品品质评估提供了新的思路。

关键词：秘鲁鱿鱼；酸异味；脑部感知；头皮脑电图；味觉

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Effects of different sour off-flavor in jumbo squid (Dosidicus gigas) on brain perceptions via scalp electroencephalogram and the underlying mechanisms

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Abstract: The commercial utilization of jumbo squid (*Dosidicus gigas*) faces significant constraints due to its pronounced sour off-flavor. This investigation employed a multimodal approach combining

electroencephalography (EEG), electronic sensing technology, and conventional sensory evaluation to characterize the perceptual attributes and neural correlates of varying off-flavor intensities, aiming to explore the underlying mechanisms. Sensory profiling indicated that sour off-flavor of jumbo squid was mainly attributed to the combined effects of sourness, bitterness, and persistent aftertaste. Further analysis using the electronic tongue and electronic nose clarified the distinct characteristics of the squid sour off-flavor at varying intensities. The spectrum analysis of averaged EEG signals revealed robust neural activation patterns, with particularly prominent responses in the δ and α frequency bands. Distinct levels of sour off-flavor elicited clearly different temporal dynamics, with perceptual distinctions emerging within the 0–200 and 950–1500 ms following stimulus onset. Notably, the topographical distribution and source localization results suggested that increasing off-flavor intensity elicited progressively stronger neural activation, with the prefrontal cortex and right temporal lobe showing the most pronounced responses. By employing EEG for comparative analysis of sour off-flavor intensities in jumbo squid, this study provides novel insights into the neurophysiological mechanisms underlying off-flavor perception. Therefore, EEG is proved as a promising objective assessment tool for quantifying subtle flavor variations often missed by conventional sensory panels in seafood quality evaluation.

Key words: Squid; Sour off-flavor; Brain perception; Scalp electroencephalogram; Taste

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无水保活过程中虾夷扇贝活力品质的研究

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摘要：探索不同贮藏方式对活品虾夷扇贝活力与风味之间的内在联系，是提高扇贝品质，解决“活而不鲜”问题的有效策略。将新鲜扇贝分成 6 个不同的包装组，测定其在 4℃干藏 4 d 中的活力、呈味物质和挥发性风味物质的变化。结果表明，第 4 d，充氧加覆盖湿海绵结合组扇贝在冷藏过程中失重率和缩边率较低，持水率较高；充氧包装和充氧加捆绑结合包装组中糖原和 ATP 含量较高。此外，谷氨酸和甘氨酸含量降低是干藏扇贝风味变质的重要因素。采用气相色谱-离子迁移谱法（GC-IMS）结合化学计量学分析，最终筛选出乙醇、丙酮和二甲基硫化物作为评价扇贝风味的潜在生物标志物。因此，充氧加捆绑能有效地保持活贝在干藏过程中的活力和风味品质。

关键词：干藏；活力；风味品质；虾夷扇贝；GC-IMS

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海水鱼优势腐败菌产生物胺能力比较及生物消减技术研究

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摘要：本研究旨在比较分析海水鱼中不同腐败微生物产生物胺能力，并探索利用食用益生菌降解生物胺的可行性。实验以鲭科鱼类典型代表鲐鲅（*Scomber japonicus*）为原料，分离鉴定其冷藏过程中的优势腐败菌，并对不同微生物的产生物胺能力进行比较分析；在此基础上，从食用微生物中筛选具有降解生物胺能力的特定菌株，探索其消减生物胺的可行性。结果显示，从鲐鲅中共分离出 17 株腐败菌，其中 5 株具有产胺能力，分别为海洋冷杆菌（*Psychrobacter maritimus*）、莓实假单胞菌 （*Pseudomonas fragi*）、海藻希瓦氏菌（*Shewanella algae*）、恶臭假单胞菌（*P. crudilactis*）和弯曲芽孢杆菌（*Bacillus flexus*），主要产生组胺、腐胺、尸胺和苯乙胺，其中菌株 *S. algae* YY1 的产胺能力最强，其中组胺产生量可达 55.15 mg/kg。靶向筛选出一株兼具高效降解生物胺（精胺降解率 95.3%）与亚硝酸盐（降解率 98.2%）能力的枯草芽孢杆菌 *B. subtilis* NK1，其耐盐性达 8%；在腌干鲐鲅加工中应用 *B. subtilis* NK1，可使组胺最大降解率近 100%。研究表明，不同致腐微生物产生物胺的特征存在差异，枯草芽孢杆菌株 *B. subtilis* NK1 具有高效降解生物胺及亚硝酸盐能力，有望应用于腌制水产品的加工。

关键词：生物胺；生物消减；枯草芽孢杆菌；鲐鲅

Comparison of Biogenic Amine-Producing Capabilities Among Dominant Spoilage Bacteria in Marine Fish and Its Biological Reduction Technology

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Abstract： This study aimed to compare and analyze the biogenic amine-producing capabilities of different spoilage microorganisms in marine fish and to explore the feasibility of using edible probiotics for biogenic amine degradation. The experiment used *Scomber japonicus*, a typical representative of scombroid fish, as the raw material to isolate and identify the dominant spoilage bacteria during refrigerated storage, and to conduct a comparative analysis of the biogenic amine-producing capabilities of different microbial strains. On this basis, specific strains with the ability to degrade biogenic amines were screened from edible microorganisms, and the feasibility of their application in reducing biogenic amine levels was explored. On this basis, specific strains with the ability to degrade biogenic amines were screened from edible microorganisms, and their potential for reducing biogenic amine levels was

investigated.The results showed that a total of 17 spoilage bacterial strains were isolated from *S. japonicus*, among which five exhibited amine-producing ability. These included *Psychrobacter maritimus, Pseudomonas fragi, Shewanella algae, P crudilactis*, and *Bacillus flexus*. The main biogenic amines produced were histamine, putrescine, cadaverine, and phenylethylamine. Among them, strain *S. algae* YY1 exhibited the strongest amine-producing capability, with histamine production reaching up to 55.15 mg/kg. A *B. subtilis* strain, designated NK1, was selectively screened for its dual capacity to efficiently degrade biogenic amines (with a spermine degradation rate of 95.3%) and nitrite (with a degradation rate of 98.2%), and it demonstrated a salt tolerance of up to 8%. Application of *B. subtilis* NK1 in the processing of dried and salted *S. japonicus* resulted in a maximum histamine degradation rate of nearly 100%.The findings indicate that different spoilage microorganisms exhibit distinct patterns of biogenic amine production. The *B. subtilis* strain NK1, with its high efficiency in degrading both biogenic amines and nitrite, shows promise for application in the processing of cured aquatic products.

Key words: Biogenic amines; Biological reduction; Bacillus subtilis; *Scomber japonicus*

应用噬菌体防治养殖大菱鲆弗氏柠檬酸杆菌感染的研究

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摘要：本研究旨在评估噬菌体对养殖大菱鲆（*Scophthalmus maximus*）弗氏柠檬酸杆菌感染的防治潜力。实验以弗氏柠檬酸杆菌 HZ-F 为宿主菌，分离获得一株烈性噬菌体 LV-1，并系统分析其形态特征、一步生长曲线、基因组结构以及体内外裂解活性。扫描电镜观察显示，该噬菌体属于肌尾病毒科；一步生长曲线表明其潜伏期为 20 分钟，裂解量为 34；基因组分析结果显示，LV-1 为双链线性 DNA 病毒，基因组全长约 168 kb，G+C 含量为 38.6%，共预测到 280 个基因，其中 45 个为已知功能基因，并编码 4 个 tRNA，未检出整合酶、毒力因子及抗生素抗性基因。体外裂解实验显示，LV-1 在 15°C 海水中对弗氏柠檬酸杆菌具有最佳裂解效果。在体内攻毒保护实验中，以 MOI=1 的剂量腹腔注射噬菌体，能够将感染大菱鲆的累计死亡率从 66.7%降低至 0%，显示出较好保护效果。可见，噬菌体具备作为抗生素替代品用于防治大菱鲆细菌性疾病的潜力，为从源头控制养殖水产品药物残留提供了可行策略。

关键词：大菱鲆；弗氏柠檬酸杆菌；噬菌体

Application of bacteriophages to control Citrobacter freundii infection in farmed turbot (Scophthalmus maximus)

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Abstract : This study aimed to evaluate the therapeutic potential of bacteriophages against C. freundii infection in cultured S. maximus. Using C. freundii strain HZ-F as the host bacterium, a lytic phage, designated LV-1, was isolated and systematically characterized in terms of its morphological features, one-step growth curve, genomic structure, and lytic activity both in vitro and in vivo. Scanning electron microscopy (SEM) observations revealed that the phage belongs to the Myoviridae family. One-step growth analysis indicated a latent period of 20 minutes and a burst size of 34. Genomic analysis showed that LV-1 is a double-stranded linear DNA virus with a genome approximately 168 kb in length and a G+C content of 38.6%. A total of 280 open reading frames were predicted, including 45 genes with known functions and 4 tRNA-coding genes. No integrase, virulence factors, or antibiotic resistance genes were detected. In vitro lytic assays demonstrated optimal bacteriolytic activity of LV-1 against C. freundii in seawater at 15°C. In in vivo challenge-protection experiments, intraperitoneal injection of

phage at an MOI of 1 reduced the cumulative mortality of infected turbot from 66.7% to 0%, indicating significant protective efficacy. These results suggest that phages have promising potential as alternatives to antibiotics for controlling bacterial diseases in turbot, providing a feasible strategy for reducing drug residues in aquaculture products from the source.

Keywords: *Scophthalmus maximus; Citrobacter freundii;* Bacteriophage

海葡萄酸性多糖的成骨作用：结构-活性关系及分子机制

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摘要：本研究聚焦海葡萄酸性多糖（*Caulerpa lentillifera* acidic polysaccharides，CLAP）的结构特性，并对其成骨效应及潜在机制进行了研究。通过傅里叶变换红外光谱、单糖组成和分子量测定等方面，对 CLAP 的结构特征进行分析。采用体外模型量化成骨效应指标：碱性磷酸酶活性、矿化结节形成、骨相关基因表达。结合斑马鱼胚胎模型，通过染色，荧光半定量，ELISA 定量等方法验证 CLAP 对骨再生的促进作用。探究其通过调控 PI3K-AKT 信号通路影响成骨细胞分化的分子机制，明确关键靶点。体外实验表明，CLAP 显著促进了成骨细胞的增殖、分化和矿化。体内实验表明，CLAP 可以增强斑马鱼的矿化能力，促进软骨的形成，增加骨钙素的合成。综上，CLAP 作为一种天然多糖，具有显著的骨再生促进作用，为骨组织工程提供了潜在的生物活性材料。

关键词：海葡萄酸性多糖；结构表征；成骨活性；PI3K-AKT 信号通路

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Unraveling the osteogenic activity of Caulerpa lentillifera acidic polysaccharides: from structural features to molecular targets

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Abstract: This study focused on the structural characteristics of *Caulerpa lentillifera* acidic polysaccharides (CLAP) and investigated their osteogenic effects and potential mechanisms. The structural features of CLAP were analyzed by Fourier transform infrared spectroscopy (FTIR), monosaccharide composition analysis, and molecular weight determination. In vitro assays were employed to assess osteogenic indicators, including alkaline phosphatase (ALP) activity, mineralized nodule formation, and expression

of bone-related genes. In vivo osteogenesis was examined in zebrafish embryos using staining, fluorescence quantification, and ELISA-based analysis. The involvement of the PI3K-AKT signaling pathway in CLAP-driven osteoblast differentiation was investigated, and potential molecular targets were identified. In vitro results demonstrated that CLAP significantly promoted osteoblast proliferation, differentiation, and mineralization. In vivo findings revealed that CLAP enhanced zebrafish skeletal mineralization, cartilage formation, and osteocalcin synthesis. Collectively, these results indicate that CLAP, as a natural polysaccharide, exhibits significant osteogenic-promoting properties and holds promise as a bioactive material for bone tissue engineering applications.

Key words: *Caulerpa lentillifera* acidic polysaccharides; Structural characterization; Osteogenic activity; PI3K-AKT signaling pathway

鲜切三倍体虹鳟鱼物理场绿色保鲜关键技术研究

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摘要：本研究探讨了低温等离子体活化乳酸（PALA）协同高浓度 CO_2 包装保鲜、低温等离子体协同莱菔子提取物保鲜及新鲜度检测智能食品指示标签（BWA-PVA-CNF）等技术在鲜切三倍体虹鳟鱼保鲜方面的应用。研究发现，低温等离子体活化乳酸（PALA）协同高浓度 CO_2 包装等绿色物理场保鲜技术可有效抑制了虹鳟鱼 TVC、TBARS、TVB-N 的增长，延缓鱼肉硬度、弹性和色泽的劣变，并将汁液流失率控制在最低水平。LF-NMR 分析表明，物理场处理组 T_{22}弛豫时间变化最小，能有效抑制不易流动水向自由水转化。FT-IR 分析显示，物理场处理后酰胺 I 带和 II 带变化最小，有效抑制了蛋白质的氧化变性与结构降解。此外，BWA-PVA-CNF 智能标签具备良好的气体敏感性和 pH 响应性能，在酸/碱性气体环境中灵敏度 SRGB 分别达到 28.26%和 39.17%，对虹鳟鱼新鲜度的实时可视化监测具有较好的应用效果。

关键词：小虹鳟鱼；物理场；贮藏品质；指示标签;

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Modification of myofibrillar protein using combined chicken breast and soybean protein isolate for improving gel properties: protein structure and intermolecular interactions

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Abstract:

Objective: The silver carp surimi gel suffered from the disadvantages of loose structure, low strength, and easy to deteriorate. Chicken breast and soybean protein isolate (SPI) have been employed to ameliorate on the surimi gel properties. This study was designed to investigate the effect and potential mechanism of the combined modification of chicken myofibrillar protein (CMP) and SPI on the improvement of fish myofibrillar protein (FMP) gel quality properties.

Methods: The analysis of physicochemical properties, protein structure, and conformation revealed that the composite addition of CMP and SPI increased the solubility of proteins, induced the change of proteins conformation and the exposure of hydrophobic groups, and facilitated the aggregation and interaction of proteins.

Results: The apparent viscosity, storage modulus, and thermal stability of MP sols with the combined addition of CMP and SPI were improved, and the intermolecular interactions in the gel system were enhanced. The stronger interactions contributed to the formation of a denser network structure, ultimately leading to improved gel quality properties. The identification of the binding sites between CMP and SPI with FMP by molecular docking and dynamics revealed that the main interaction forces between the molecules were hydrophobic interactions, hydrogen bonds, and ionic bonds, and several residues (CMP with FMP: Lys-451, Lys-205, Lys-204, and SPI with FMP: Tyr-309, Asn-307, Ser-676) identified as the binding sites.

Conclusion: This work revealed the relationship between MP conformation and gel properties mediated by the complex addition of CMP and SPI and provided a reference and theoretical guidance for the development of new silver carp protein gel products.

Keywords: myofibrillar protein, silver carp, soy protein isolate, chicken breast, gelation, protein-protein interaction

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预制时间调控虾糜凝胶蛋白构象及其冷冻稳定性的机制研究

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摘要：目的 基于“预凝胶化-冻藏-再加热”的新型加工体系，本研究探究了在 30 ℃ 下预制不同时间（0-90 min）对冻藏虾糜凝胶品质的影响。**方法** 测定虾糜凝胶的凝胶强度、质构特性、汁液损失、色泽、动态粘弹性、化学作用力、总巯基与二硫键含量、水分分布及红外光谱特征。**结果** 随预制时间延长，化学作用力、α-螺旋和 β-折叠含量及质地特性均呈先升高后降低的变化趋势。在冻藏过程中，冰晶形成破坏蛋白结构，导致动态黏弹性降低、凝胶网络松散、无规卷曲增加，进而加剧汁液损失。预制 15 min 时，虾糜蛋白充分展开，氢键和疏水相互作用有效维持凝胶构象稳定，显著改善凝胶质构并使黏弹性达到峰值。**结论** 预制 15 min 能有效地抑制虾糜凝胶冻藏期间的凝胶劣变，提升产品品质。

关键词：虾糜凝胶；预制时间；冷冻储藏；凝胶特性

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水母胶原蛋白抗菌敷帖的制备及其性能研究

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摘要：本研究旨在开发一种基于水母胶原蛋白的新型抗菌敷贴。实验采用胃蛋白酶低温酶解法从水母中提取胶原蛋白，通过冷冻干燥法制备出具有多孔结构的海藻糖/水母胶原蛋白复合抗菌敷帖，并对胶原蛋白及敷贴的理化与结构特征进行表征，利用质构仪对敷料的拉伸强度及断裂伸长率进行了测定，并基于斑马鱼胚胎模型评价水母胶原蛋白的生物修护活性，通过体外模拟皮肤组织实验，评估了抗菌敷贴对金黄色葡萄球菌的抑制效果。结果显示，本研究提取的水母胶原蛋白为类I 型（或称之为0 型），具有良好的组织修护活性；所制备的胶原蛋白抗菌敷贴力学性能优良，且对模拟皮肤组织上的金黄色葡萄球菌具有显著抑制作用，模拟皮肤组织经抗菌敷贴处理48 h，金黄色葡萄球菌活菌数降低至检测限以下（>4 log CFU）。本研究表明，水母胶原蛋白抗菌敷贴具有良好抗菌和修复作用，在感染性创面修复领域具有潜在应用前景。

关键词：水母；胶原蛋白；抗菌敷帖；创面修复

Preparation and Performance Study of Jellyfish Collagen Antibacterial Dressings

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Abstract:This study aimed to develop a novel antibacterial dressing based on jellyfish collagen. Collagen was extracted from jellyfish using pepsin-assisted low-temperature enzymatic hydrolysis, and a trehalose/jellyfish collagen composite antibacterial dressing with a porous structure was prepared via freeze-drying. The physicochemical and structural characteristics of both the collagen and the dressing were systematically characterized. The mechanical properties of the dressing, including tensile strength and elongation at break, were determined using a texture analyzer. The biorepair activity of the jellyfish collagen was evaluated using a zebrafish embryo model, while the antibacterial efficacy of the dressing against Staphylococcus aureus was assessed through an in vitro simulated skin tissue model. Results indicated that the extracted collagen was type I-like and

exhibited favorable tissue repair activity. The prepared collagen-based antibacterial dressing demonstrated excellent mechanical properties and significantly inhibited Staphylococcus aureus on simulated skin tissue. After 48 hours of treatment, the viable count of S. aureus was reduced below the detection limit (representing a reduction of >4 $\log_{10}$ CFU). This study demonstrates that the jellyfish collagen-based antibacterial dressing possesses effective antibacterial and tissue-repair functions, showing promising potential for application in infected wound repair.

Key words:jellyfish; collagen; antibacterial dressing; wound repair

南极磷虾中新型咸味增强肽的鉴定及其分子机制研究

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摘要： 本研究旨在从南极磷虾中鉴定新型咸味增强肽，并研究其增强咸味感知的分子机制。利用虚拟筛选从脱脂南极磷虾粉酶解物中筛选潜在咸味增强肽。感官评价和电子舌结果表明，EDLEY、WDDDP、EDYEF、 ERDY 和 DRPWE 具有显著的咸味增强作用（$P < 0.05$）。分子对接结果表明，该五条肽段可以进入咸味受体 TMC4 的结合口袋，其中氢键为主要作用力，Tyr318、Arg422、Pro529 和 Arg580 为关键结合位点。多肽的咸味增强作用与氢键比例呈极强正相关（$r = 0.99$, $r = 0.95$），与疏水相互作用比例呈极强负相关（$r = -0.90$, $r = -0.88$）（$P < 0.05$）。分子动力学模拟结果表明，该五条肽段与 TMC4 形成了稳定的复合物。本研究为咸味增强肽的构效关系研究提供了新见解。

关键词：脱脂南极磷虾粉；咸味增强肽；虚拟筛选；分子对接；分子动力学模拟

资助项目： 国家重点研发计划（2024YFD2101200）

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静磁场辅助冷藏对大黄鱼品质影响研究

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摘要：水产品因富含蛋白质与水分，贮藏过程中极易受微生物及内源酶作用而腐败。本研究以大黄鱼为对象，系统考察 5 mT 静磁场对冷藏期品质的影响，并揭示其作用机制。结果表明，该处理显著降低菌落总数、嗜冷菌及优势腐败菌数，减缓 TVB-N 与 TBA 含量上升，维持较好色泽与质构特性。蛋白质分析显示，处理组溶解度与巯基含量增加，疏水性与羰基含量降低；FT-IR 及透射电镜结果表明静磁场有助于稳定蛋白构象，保持肌原纤维完整； SDS-PAGE 证实肌球蛋白重链和肌动蛋白降解延缓。低场核磁共振结果显示静磁场显著抑制结合水向自由水迁移，提高持水力，减轻组织损伤。综上，静磁场通过抑菌、延缓蛋白质氧化降解及调控水分迁移实现品质保持，具备作为水产品保鲜辅助技术的应用潜力。

关键词：静磁场；大黄鱼；冷藏；品质；蛋白质特性；水分迁移

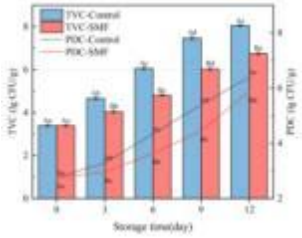
项目：磁场辅助冷藏提升大黄鱼品质关键技术研究（2024S126）

通讯作者：欧昌荣，男，博士，教授，水产品加工与贮藏，13777086117，ouchangrong@nbu.edu.cn

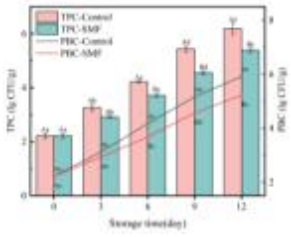
图表附录：

1.感官评定

2.微生物变化

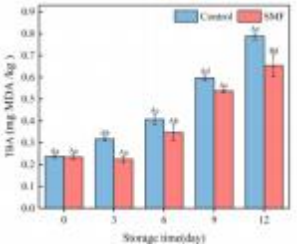


冷藏期间大黄鱼菌落总数(TVC)及假单胞菌数(PDC)的变化

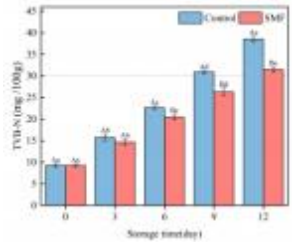


冷藏期间大黄鱼嗜冷菌数(TPC)及产 H2S 细菌数(PBC)的变化

3.品质变化

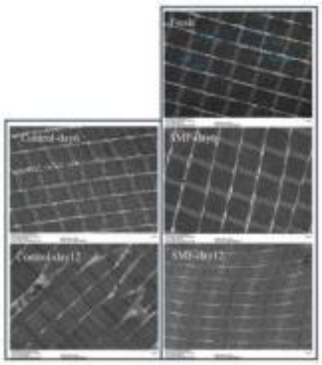


冷藏期间大黄鱼TBA 的变化

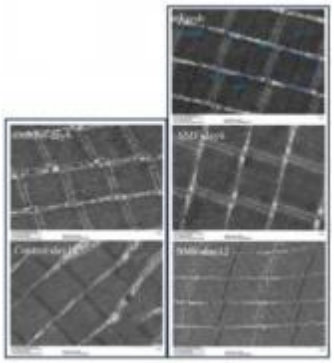


冷藏期间大黄鱼 TVB-N 的变化

4.蛋白质变化

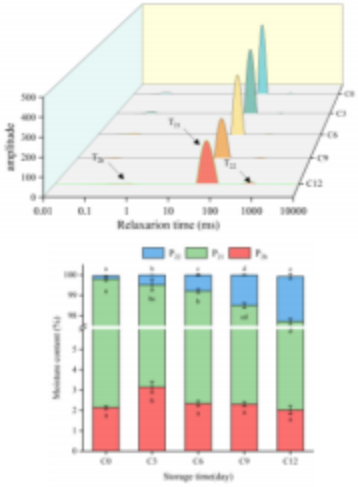


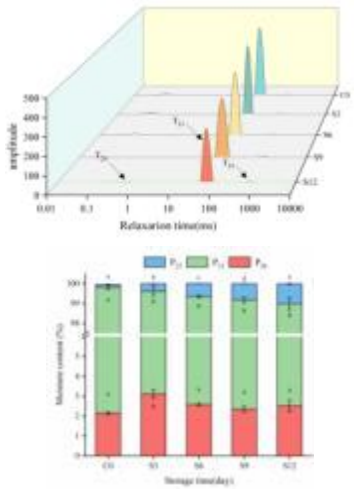
冷藏期间大黄鱼肌肉超微结构变化（4000×）



冷藏期间大黄鱼肌肉超微结构变化（8000×）

5.水分迁移变化





冷藏期间大黄鱼的水分分布（A:control 和 B:SMF）及水分含量变化（C:control 和D:SMF）P2b、P21 和P22 的变化分别表示结合水、固定水和自由水的含量

蜂蜡基鱼油油凝胶增强猪肉肌原纤维蛋白-油凝胶界面的乳化功能和体外消化行为

沈丽平

广东海洋大学

摘要：鱼油富含对人体健康有益的ω-3 多不饱和脂肪酸，但由于其氧化性和低消化率，在食品工业中的应用受到限制。鱼油的糊化可以提高鱼油的抗氧化性能和生物利用率。本文使用蜂蜡基鱼油油凝胶代替动物脂肪，研究了高蜂蜡和鱼油油凝胶添加量对液-固界面稳定性的影响。结果表明，添加适量的鱼油油凝胶(FOG) (10 wt%)可以促进肌原纤维蛋白(MP)结构的解折叠，减小粒径，促进界面膜的形成，提高乳状液的稳定性和消化性能。因此，BW 和 FOG 都可以调节 MP 的空间构象和界面稳定性，从而改善 MP 乳液的稳定性和消化特性。

小龙虾肉松的制备及包装方式对其品质特性的影响研究

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摘　要：小龙虾是我国重要的淡水养殖物种之一，加工产品存在形式单一、风味流失和货架期短的问题，而肉松作为可常温贮藏运输、风味独特、营养丰富的休闲食品，在小龙虾高值化加工利用中具有开发潜力。本研究以小龙虾虾肉为原料，设计炒松和炒酥结合的二次炒制工艺制备肉松产品。在此基础上，研究风味添加物（紫苏汁、生姜汁、酵母抽提物）对肉松产品风味的改善，阐明风味添加物对于腥味化合物的掩蔽作用，进一步利用三种常见的市售包装方式（铝箔袋、塑料罐、气调）对肉松包装，探索其对于风味和贮藏特性的影响。该研究为开发以小龙虾为原料的高附加值休闲水产食品提供了基础理论和技术支持。

Abstract: Crayfish is one of the most important freshwater aquaculture species in China, yet its processed products often suffer from limited product forms, flavor loss, and short shelf life. Meat floss, as a convenient snack food with distinctive flavor, rich nutrition, and suitability for ambient storage and transportation, holds great potential for the high-value utilization of crayfish. In this study, crayfish meat was used as the raw material, and a dual frying process combining “stir-frying to loose” and “stir-frying to crisp” was designed to prepare crayfish meat floss. On this basis, the effects of flavor additives (perilla juice, ginger juice, and yeast extract) on improving the flavor quality of the product were investigated, with emphasis on their masking effects against off-flavor compounds. Furthermore, three common commercial packaging methods (aluminum foil pouches, plastic jars, and modified atmosphere packaging) were applied to explore their influence on flavor retention and storage characteristics. This study provides fundamental theoretical insights and technical support for the development of high value-added crayfish-based snack foods.

EGCG/TGase 对节水漂洗鱼糜凝胶理化特性及体外动态消化行为的影响

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摘　要: 本研究探讨了表没食子儿茶素没食子酸酯（EGCG）与转谷氨酰胺酶（TGase）对节水漂洗鱼糜凝胶的理化特性及体外动态消化行为的影响。结果表明，EGCG 与 TGase 联合处理可显著降低肌动蛋白的表面疏水性、总巯基含量与活性巯基含量、二硫键含量及 α -螺旋含量（从 23.93%降至 5.63%），同时增大其粒径与浊度，并促使 β -折叠结构的形成（从 14.03%升至 68.37%）。EGCG/TGase 显著提升了节水漂洗鱼糜的凝胶性能，单次漂洗鱼糜凝胶强度值可达 864.17 g • cm。在体外动态消化过程中，必需氨基酸/总氨基酸比例始终保持在 60%以上（超过 40%的参考标准）。胃及胃肠消化阶段的消化动力学均符合 Logistic 模型。综上所述，EGCG 与 TGase 协同增强了节水漂洗鱼糜的凝胶品质，且未损害其营养价值。

Abstract: This study investigated the effects of epigallocatechin gallate (EGCG) and transglutaminase (TGase) on the physicochemical properties and in vitro dynamic digestion characteristics of water-saving rinsed surimi gels. The results showed that the combined application of EGCG and TGase reduced the surface hydrophobicity, total sulfhydryl group, reactive sulfhydryl group, disulfide bond contents, and α-helix content (from 23.93% to 5.63%) of myosin while increasing its particle size, turbidity, and β-sheet content (from 14.03% to 68.37%). The EGCG/TGase significantly improved the gel strength of water-saving rinsed surimi, with value reaching 864.17 g·cm for once-rinsed surimi gels. Meanwhile, essential amino acids/total amino acids ratio remained above 60% (exceeding the 40% standard) at the end of the in vitro dynamic digestion. The digestion curves for both gastric and gastrointestinal phases followed the logistic model. Overall, EGCG and TGase synergistically enhanced the gel properties of water-saving rinsed surimi without affecting its nutritional quality.

漆酶/原花青素交联对鲢鱼源胶原水凝胶理化性能影响及其生物相容性评价研究

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摘　要：本研究基于胶原蛋白的自组装行为，运用光谱学、能谱学和显微技术等方法首先考察了不同酚羟基含量原花青素以及漆酶催化后不同酚羟基原花青素处理鲢鱼皮胶原水凝胶的结构特性和稳定性影响；然后从溶液态运用流变学的方法进一步分析漆酶/原花青素对胶原蛋白自组装行为的影响，探究其分子机理以及最佳交联剂浓度；最后运用细胞模型，评估胶原水凝胶浸提液的细胞相容性及其生物活性。本研究提供了一种更绿色安全的生物医学材料，同时也为低机械性能的鱼源胶原蛋白拓展应用前景提供了理论基础。

Abstract: Based on the self-assembly behavior of collagen, this study first investigated the structural characteristics and stability effects of proanthocyanidins with different phenolic hydroxyl contents and proanthocyanidins with different phenolic hydroxyl groups treated by lassinase on the original hydrogel of silver carp skin glue by means of spectroscopy, energy spectroscopy and microscopic techniques. Then, the effect of laccase/proanthocyanidin on the self-assembly behavior of collagen was further analyzed from the solution state using rheological methods, and its molecular mechanism and the optimal concentration of crosslinking agent were explored. Finally, the cell model was used to evaluate the cytocompatibility and biological activity of the collagen hydrogel extract. This study provides a greener and safer biomedical material, and also offers a theoretical basis for the expanded application prospects of fish-derived collagen with low mechanical properties.

基于 3D 打印的模拟小龙虾肉：龙虾油乳液对鱼糜凝胶特性的影响

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摘　要: 针对小龙虾副产品中小龙虾油利用率低的问题，本研究旨在从小龙虾副产品中提取油脂，并将其应用于鱼糜凝胶生产新型产品。研究重点是明胶（GeL）与黄原胶（XG）的不同体积比对皮克林乳液稳定性和 3D 打印鱼糜产品质量的影响。研究结果表明，当明胶（GeL）与黄原胶（XG）的体积比为 2:1 时，得到的 Pickering 乳液的粒径较小，为 23.97 μm，Zeta 电位绝对值最大为 28.30 mV，从而使小龙虾油乳液体系更加稳定。随后的微流变分析表明，GeL/XG（2:1）稳定乳液的 MVI 值最高（85000 秒时为 0.59 nm -2），这表明它在长期稳定性方面可能更占优势。此外，在用于 3D 打印的鱼糜中添加稳定的小龙虾油乳液可提高鱼糜成品的质量。研究发现，当乳液添加量为 5%时，获得的鱼糜混合物具有更高的打印精度（86.00%）和打印稳定性（98.64%），硬度为 660.35 g，弹力为 0.8750，咀嚼度为 384.82 g，持水力 93.10%。这项工作可为小龙虾副产品油的提取和利用以及小龙虾肉的 3D 打印，特别是在质量、质地和颜色方面提供有价值的理论和方法见解。

Abstract: To address the low utilization of crayfish oil in crayfish by-products, this study aimed to extract oil from crayfish by-products and apply it to surimi gels to produce novel products. The investigation focused on the impact of various volume ratios of gelatin (GeL) to xanthan gum (XG) on Pickering emulsion stability and the quality of surimi 3D-printed products. The findings indicated that when the ratio of GeL to XG was 2:1, the Pickering emulsion obtained had a smaller particle size of 23.97 μm and a maximum absolute zeta-potential of 28.30 mV, which could make the crayfish oil emulsion system more stable. Subsequently, the micro-rheological analysis indicated that GeL/XG (2:1) stabilized emulsion had the highest MVI value (0.59 nm -2·s at 85000 s), suggesting it may be more dominant during long-term stability. In addition, the addition of stabilized crayfish oil emulsion to surimi for 3D printing improved the quality of the surimi final product. It was found that when the emulsion was added at an amount of 5%, the obtained surimi mixture had higher printing accuracy (86.00%) and printing stability (98.64%), with a hardness of 660.35 g, a springiness of 0.8750, a chewiness of 384.82 g, and a water holding capacity of 93.10%. This work could provide valuable theoretical and methodological insights into the extraction and utilization of crayfish by-product oils as well as 3D printing of crayfish meat, especially in terms of quality, texture and color