水产品加工和综合利用学术年会

2026年学术年会

智汇蓝色粮仓 链动未来健康

论文摘要集

2026年10月15日-17日

中国·宁波

目录

A method for improving the quality of grass carp (Ctenopharyngodon idellus): A comprehensive evaluation of clear water depuration based on sensory and nutritional aspects 12

Accelerated Chemotaxonomic Discrimination of Marine Fish Surimi Based on Tri-step FT-IR Spectroscopy and Electronic Sensory 13

Ameliorative effect and mechanism of fucoxanthin on lipopolysaccharide-induced acute liver injury 15

Ameliorative Effects and Mechanisms of Marine Structured Lipids on Parkinson's Disease 17

Anti-obesity effects of fucoxanthin and conjugated linoleic acid complex liposomes in high-fat diet mice through regulation of AMPK signaling pathway 19

Citrus Juice Marination Improves the Flavor of Fish: A Case Study of Sea Bass (*Lateolabrax japonicus*) 20

Combined Protective Effects of Rohu Fish Maw Enzymatic Hydrolysate and *Astragalus membranaceus* Extract against Cyclophosphamide-Induced Premature Ovarian Insufficiency 22

Comparison of Flocculation Methods for Sodium Alginate and Characterization of Its Structure and Properties 24

Cryoprotective properties of betaine-based natural deep eutectic solvents and their regulatory mechanisms on the quality of frozen shrimp surimi 25

Dynamic Evolution of Muscle Quality and Metabolic Response Mechanisms in *Lvpan abalone* During Waterless Preservation* 27

Effect of Low-Salt Composite Tenderization on Texture and Flavor of Rainbow Trout: Process Optimization and GC-IMS Analysis 29

Effects of alkaline pH-shifting combined with arginine and lysine on the properties of grass carp myofibrillar protein emulsion gels under low-salt conditions 31

Effects of Combined Treatment with Chlorine Dioxide and Ginger Juice on Freshness Preservation and Protein Oxidation of Longsnout Catfish 32

Effects of intestinal contents on muscle quality and protein degradation of red shrimp (*Solenocera crassicornis*) during cold storage 34

Effects of oil type on the gelation characteristics and in vitro curcumin release behavior of tilapia

myofibrillar protein/κ-carrageenan oligosaccharide emulsion gels 37
Effects of Organic Acid Curing on Physicochemical Properties and Quality of Semi-Dried Grass Carp Fillets 39
Effects of slaughter methods on energy metabolism, oxidative stress, apoptosis, and postmortem quality of brown-marbled grouper (*Epinephelus fuscoguttatus*) during cold storage 40
Enhancement of Gelation and Protein Interactions in Low-Salt Shrimp Gels via Static Magnetic Field Coordinated with Microcrystalline Cellulose 42
Enhancing the flavor profiles of sheep bone soup by supplementing Solen grandis meat 44
Environmental salinity shapes nutritional quality and taste components of mud crab *Scylla paramamosain* from two natural habitats in eastern Guangdong of China 46
Flavor formation and metabolic transformation during mixed microbial fermentation of rapidly fermented low-salt fish sauce from mandarin fish viscera 48
FPVGR-Pn3G 协同复合物抑制 DPP-IV 的作用机制及其消化吸收特性 49
Fractional Extraction and Lipid Profile Characterization of *Procambarus clarkii* Oil via Non-targeted Lipidomics 50
From internal degradation to quality deterioration: Lipid peroxidation-induced protein changes in sea bass (Lateolabrax japonicus) during storage revealed by multi-omics 52
Fucoidan oligosaccharides from *Kjellmaniella crassifolia* ameliorate ulcerative colitis by regulating the TLR4 and NF-κB signaling pathway and modulating gut microbiota 54
Glycosylated fish collagen peptides with different degrees of modification: effects on gelation properties and volatile flavor of tilapia surimi 56
Green and efficient extraction of fish oil: Quality optimization based on a deep eutectic solvent method 58
Halogenated Natural Products in Various Tropical Reef Fish Species 60
Improving the Quality of Surimi Powder Produced by an Innovative Low-temperature Spray-drying Process Using Thermal Protectants: A Comparative Evaluation of Protein Structure and Gel Properties 61
Influence of Fermented Feed on the Volatile Flavor Profile of *Procambarus clarkii* (Crawfish) through Alterations in Nutritional Components and Fatty Acid Metabolism 63
Interaction Mechanism of Protein Changes and Microbial Metabolism in Chinese hook snout carp

(*Opsariichthys bidens*) during Refrigerated Transport Simulating Natural Conditions..... 65
κ-卡拉胶-大豆分离蛋白乳液膜的性质调控及其在冷冻虾滑中的应用 67
κ-卡拉胶在不同基质中对小鼠肠道黏膜屏障及肠道菌群调控的研究..... 68
Low-molecular-weight fucoidan alleviates DSS-induced colitis in mice through modulation of the NF-κB and MAPK pathways-related mRNA and protein expression..... 71
Maternal n-3 PUFA availability modifies gestational cadmium toxicity across the maternal–placental–fetal axis..... 73
Metabolite composition and taste quality of *Eriocheir sinensis* under different steaming methods 75
Moderate reactive oxygen species enhance antimicrobial activity and quality preservation of oyster meat by ozone micro-nano bubble water 77
Modification of shrimp tropomyosin properties for improved functional performance: TGase modification and polyphenol-beta-glucan modification 79
Molecular mapping of off-odor in post harvest golden pompano (*Trachinotus ovatus*): From microbial succession to TAAR5/OR2W1 receptor recognition 80
Nanoparticles prepared from different plant protein isolates using alkali-heat synergistic pH-shifting method to stabilize Antarctic krill oil-loaded high internal phase emulsions 82
Nutritional and Flavor Profile Differences Among Three Venerid Clam Species: A Multi-Dimensional Quality Approach..... 84
O-B 改性淀粉乳液作为新型添加剂提升巨型鱿鱼鱼糜凝胶的 3D 打印适配性与品质..... 86
Omics insights into the mechanisms of flavor changes in Eriocheir sinensis under different restraint methods during live transportation..... 87
Phosphorylation dynamics of myofibrillar and sarcoplasmic proteins associated with quality changes in large yellow croaker (*Larimichthys crocea*) during early cold storage..... 89
Postmortem Quality Changes in Grass Carp during Chilled Storage: Dynamic Association with the Lysosomal-Mitochondrial Apoptotic Pathway..... 91
Preparation and Characterization of Shikonin-Incorporated Gelatin Films with Antibacterial and Antioxidant Activities and Their Application in Beef Preservation..... 92
Preparation, Characterization, and pH-Responsive Intestinal Release Properties of Gel Beads Encapsulating Sea Cucumber Mouthpart Peptides 93

Preservative efficacy of slightly acidicelectrolyzed water on refrigerated large yellow croaker: Insights into quality deterioration, flavor migration, and shelf-life extension 95
Quality Analysis of Refrigerated Dried Shrimp (*Acetes chinensis*) via Physical Chemistry and Non-Targeted Metabolomics: Advancing Product Development 97
Rapid Analytical and Quantitative Evaluation of Formaldehyde in Squid Based on Tri-step IR and Partial Least Squares 99
Screening and Characterization of a Pufferfish-Skin-Derived Keratin Repair Peptide, LGGF (LG4), for Damaged Human Hair 101
Seafood: processing, preservation, nutrition, marketing, and policy 103
Structural and functional responses of myofibrillar proteins from yellow croaker to plasma-activated buffer: evidence from a simulated PAW system 104
Synergistic Cryoprotection of Carboxymethylated Propylene Glycol Alginate and Carboxymethylated Artemisia Sphaerocephala Krasch gum in Shrimp Gel 106
Synergistic regulation of heat-induced gelation in golden pompano (*Trachinotus ovatus*) myofibrillar proteins by Na^+/K^+ ratio: Structural evolution and water migration 107
The effects of low molecular weight fucoidan on the quality of frozen *Litopenaeus vannamei* ... 109
Ultrasonication during acid-heat fibrillation tailors soy protein isolate architecture for high internal phase emulsion gels: Linking fibril structure to astaxanthin stability and bioaccessibility 111
Ultrasound-assisted phosphate soaking improves the quality of frozen shrimp: Insights into gel properties and proteomic profiling 113
Unveiling the hidden benefits of integrated multi-trophic aquaculture (IMTA) in estuarine ecosystems: Beyond growth performance to nutritional enhancement 115
Valorization of *Eriocheir sinensis* Processing By-Products into ACE Inhibitory Peptides: Mechanisms and Application Potential 117
V 型淀粉在罗非鱼鱼糜制品中的应用：凝胶品质改善与关键腥味物质吸附 119
2-苯乙醇对木糖葡萄球菌的特异性代谢调控：与发酵鱼中乳杆菌的对比分析 120
2-Phenylethanol triggers species-selective metabolic reprogramming in Staphylococcus xylosus: A comparative paradigm to lactobacilli in fermented fish 121
3 种热加工工艺对鲭鱼冷藏期间品质的影响 122
阿魏酸交联花青素-鱼明胶基智能水凝胶与指示膜的制备及虾新鲜度监测应用 124

靶向耐冷性摩根菌 LuxS/AI-2 群体感应系统的抑制剂筛选及其抑腐作用研究 125
白兰花活性物质在水产品保鲜中的应用 127
鲍鱼内脏多糖制备及降血糖活性研究 129
鲍鱼内脏黄嘌呤氧化酶抑制肽酶解制备工艺优化及其酶解产物活性研究 131
鲍鱼内脏活性成分开发及高值化利用 133
鲍鱼内脏降血糖活性肽制备及其作用机理研究 134
包装材料、贮藏温度及品质改良剂对牡蛎预调理制品贮藏品质的影响 136
丙烯醛对金鲳鱼肌原纤维蛋白氧化修饰、构象变化、交联聚集及 TGase 诱导凝胶特性的影响 138
不同加工工艺对裙带菜岩藻黄素色泽、含量及结构的影响 140
不同加工形态裙带菜对吐司品质特性的影响 141
不同结构鱼肉蛋白肽乳化剂的理性制备及乳化性质分析 143
不同静磁场辅助冷冻阶段对凡纳滨对虾冰晶形态与肌肉品质的影响 144
不同热前处理对鱼骨浆加工特性、蛋白质结构及风味特性的影响：从组织破碎到风味形成的关联分析 146
不同糖源糖基化鱼明胶的消化抗氧化特性及体外肠道菌群调节作用 148
不同腌制方式对干制双斑东方鲀鱼片品质的影响 150
不同预处理对坛紫菜蛋白提取与功能特性的影响 152
长棘海星皂苷提取物的制备及其抗肿瘤活性机制研究 153
超声辅助 BBR@HMSN 介导的光动力灭活副溶血性弧菌及其在黄鳍金枪鱼保藏中的应用 155
超声辅助磷酸化对鱼明胶消化-发酵特性的影响 157
超声辅助柠檬酸处理的“释放–螯合”效应对坛紫菜重金属去除效率的影响 159
超声辅助漂洗对鱼糜风味的影响机制 161
超声改性火麻仁蛋白对金线鱼鱼糜凝胶特性的影响 162
超声和酶解预处理诱导豌豆蛋白形成新型原纤维以实现虾青素的高效递送 164
陈化干鲍来源糖肽的分离及其对 RAW264.7 巨噬细胞免疫稳态的调节作用 166
臭氧微纳米气泡介导的卵形鲳鲹捕后减菌与脱腥干预：微生态-风味代谢网络的解析 167
从海洋蛋白资源到功能性食品配料：南极磷虾源生物活性肽的研究进展与挑战 168
从热加工产物到营养活性代谢物：5-HMF 经 5-HMFA 调控机体铁稳态的机制 170

从中华草龟龟甲到创伤护理：具有止血性能的壳聚糖-龟甲胶原复合海绵的制备与表征 172
脆肉与普通罗非鱼复配对鱼糜凝胶品质的影响 173
等离子体活化乳酸协同高浓度 CO_2 气调包装对虹鳟鱼贮藏品质的影响 174
等离子体活化水暂养对鲫风味及品质的影响 176
低分子量褐藻聚糖硫酸酯的结构分析及其体外抗氧化和抗炎活性的研究 177
低聚糖调控鳄鱼蛋白肽美拉德反应产物的风味与抗氧化特性研究 178
低温真空慢煮对鲣鱼品质特性的影响及其贮藏过程中微生物群落与风味变化研究 179
电场食品保鲜技术研究进展及开发 181
典型甲壳类水产动物蛋白的消化规律与标志性代谢物鉴定研究 182
电子鼻、电子舌、HS-SPME-GC-MS 和机器学习的综合方法解析风干带鱼中气味和滋味协同效应及风味前体 183
丁香油和薄荷油对克氏原螯虾有水保活后肌肉品质的影响 185
冻藏复热烤金鲳鱼中腥味与过熟异味的挥发性物质组成及呈味特性差异研究 187
冻融对凡纳滨对虾冷藏黑变及血淋巴酚氧化酶系统的影响 188
冻融过程中肌球蛋白质基脂肪球超分子动态组装机制 189
冻融模式对预制烤鱼复热前后杂环胺与晚期糖基化终末产物生成的影响 190
短期冻藏扇贝闭壳肌凝胶波动特性的外源调控及作用机制 192
多层界面构建对虾青素乳液稳定性及抗氧化活性的影响 194
二十碳五烯酸乙酯逐层封装微胶囊的制备及表征 196
凡纳滨对虾空气暴露下滋味品质调控：从 AMPK 代谢重塑到 HSF1 上游调控 197
风味组学与机器学习关联三文鱼加工副产物美拉德反应体系的挥发性物质谱与感官属性 199
复合保水剂浸泡预处理优化及其对蒸制鱿鱼足嫩化效果的影响 201
复合生物保鲜剂对即食蟹肉产品保鲜影响及货架期预测 202
复合诱变选育高产脱腥酶菌株及海带脱腥效果研究 203
负载河鲀鱼皮蛋白水解物乳液的制备及其修复受损头发作用研究 205
负载绿原酸的纳米淀粉/壳聚糖复合水凝胶的制备及其对凡纳滨对虾黑变的抑制作用 207
钙离子-阿魏酸稳态化花色苷智能膜构建及其对水产品储运品质衰变的预测应用 209
干式发酵大黄鱼品质与风味演变及调控研究 211
甘油一酯的酶法制备及其对复合凝聚鱼油微胶囊理化特性的影响 212
干燥方式对淡水鱼鱼鳔理化特性及品质的影响 213

高压脉冲电场对皱纹盘鲍冷藏期间品质的影响 215
龟甲抗氧化肽的酶解制备及其体外抗氧化活性与理化特性 217
过热蒸汽技术在水产加工中的应用 218
海蓬子植物盐的感官特性、风味感知及其在鲟鱼子酱中的减钠替代与品质调控研究 219
海葡萄酸性多糖的成骨作用：结构-活性关系及分子机制 221
海洋生物活性物质抗过敏作用机制研究 223
海洋食品功能因子精准挖掘与生物制造及靶向营养健康应用 226
褐藻-白菜复配泡菜的发酵品质特征及机制研究 228
褐藻表面黏液多糖制备、表征及对 炎症性肠病小鼠的保护作用 229
褐藻聚糖硫酸酯配伍中药制剂改善 T2DM 小鼠胰岛素抵抗的研究 231
褐藻盐渍加工与熟制过程中颜色变化规律及机制研究 233
胡椒碱复合液通过氧化损伤与膜破坏抑制热氏假单胞菌的效应研究 235
华贵栉孔扇贝酶解蛋白粉对小麦面团体系多尺度调控效应 237
花胶肽功能性凝胶软糖的研制及降糖活性评估 240
花青素基智能双层膜的制备及其对池沼公鱼保鲜与新鲜度指示研究 241
化学改性坛紫菜多糖的 α-淀粉酶抑制活性分析及结构表征 242
黄渤海海洋牧场增殖与网箱养殖许氏平鲉营养品质及风味特征比较 243
肌球蛋白 Pickering 乳液纳微球构建及其组分的相互作用 244
基于 COMSOL 的凡纳滨对虾液氮速冻工艺优化：品质保持与液氮消耗协同调控 245
基于 Fe_3O_4@PDA 磁性材料富集鲛鳚鱼内源性肽及其功能鉴定 247
基于分子对接和光谱技术探究酚类物质对金鲳鱼脂氧合酶（LOX）的抑制作用 248
基于空位修饰 $Ti_3C_2T_x$ 量子点@SnS_2 肖特基异质结用于电化学发光检测黄曲霉毒素 B_1 250
基于喹醛酰氯衍生化策略的超高效液相色谱-高分辨质谱法检测鱼南极磷虾油中的氯丙醇酯 252
基于氯化胆碱-乳酸低共熔溶剂的南美白对虾虾头总脂质提取工艺优化及组成分析 253
基于美拉德反应增强鲍鱼肌肉蛋白-菊粉共轭物的油-水界面行为和乳化性能 255
基于羟丙基壳聚糖多功能纳米载体实现微藻油双靶向递送以缓解结肠炎症 258
基于虾壳钙资源的柠檬酸接枝酪蛋白磷酸肽-钙螯合物的构建及其结构与稳定性研究 259
基于纤维素纳米材料稳定的草果精油 Pickering 乳液的制备及表征 260
基于相关性网络和差异代谢通路探究多菌株接力发酵对高盐鱼露风味和品质的改善机制 262

基于虚拟筛选制备鲣鱼暗色肉来源的 α-淀粉酶与 α-葡萄糖苷酶双抑制肽 263
基于鱼骨颗粒制备鱼油基 Pickering 乳液：一种资源回收的双重增值策略 264
基于预糊化和油脂填充调控面糊多相胶体网络：对油炸裹糊文蛤品质的提升作用 266
减盐水产凝胶食品的基质结构重构与风味协同调控 269
交变磁场处理降低中华绒螯蟹原肌球蛋白 IgE 结合活性并保持蟹肉品质 271
交变磁场频率对罗非鱼片冻融过程及贮藏品质的影响 272
胶原蛋白肽-壳寡糖复合物的构建及表征 274
胶原蛋白肽通过 AMPK/PGC-1α 与 NRF2/HO-1 双通路改善能量代谢和氧化损伤的抗疲劳机制研究 275
胶原蛋白源 Fe^{2+}结合活性肽：结合 Fe^{2+}的关键氨基酸及其提高细胞 Fe^{2+}生物利用度的机制 277
交直流电场协同对微冻凡纳滨对虾的保鲜效果及作用机制 279
介质阻挡放电低温等离子改善三角帆蚌肌原纤维蛋白乳液冻融稳定性：结构修饰及其内在机制 280
静磁场辅助液氮与鼓风速冻对罗非鱼品质及蛋白氧化的影响 281
抗冻抗氧化型天然低共熔溶剂通过调控冰晶和脂质/蛋白质氧化保护冻融循环中的金鲳鱼鱼糜 283
壳聚糖表面改性对复合凝胶球再生性能的强化及海藻浓缩汁品质保护效应研究 285
壳聚糖-芳香醛席夫碱的合成、表征及其在磁场辅助金鲳鱼冷藏保鲜中的应用 287
壳聚糖-聚乙烯亚胺功能材料对碘离子的高效吸附：作用机制及其在海藻浓缩汁中的应用 289
壳聚糖-酪蛋白 Pickering 乳液的构建及稳定机制 291
可食用微载体机械信号介导鱼类细胞快速扩增和分化效应研究 293
克氏原螯虾头降尿酸肽的挖掘与功效机制研究 295
空间电场辅助制冷减轻鲍鱼肌肉质量恶化：微生物演替和代谢重塑的多维视角 297
快速发酵无盐虾头副产物的品质分析与风味变化 299
来源于 *Flammeovirga yaeyamensis* 的新型 PL24 家族石蒜多糖裂解酶 Uly24Fy 的克隆表达与性质表征 301
冷等离子体沉淀肌浆蛋白的高值化改性：羧甲基纤维素改性纤维在碱性贮藏过程中的结构与功能变化 303
冷等离子体辅助蟹壳甲壳质资源转化及分子调控 304
冷冻方式与预处理对花青素降解动力学的影响及水产品锁鲜应用 305

冷冻干燥与喷雾干燥对皱肋文蛤酶解粉风味特性的影响 307
笼目海带酚糖复合物提取、结构解析及抗衰老活性研究 310
卵形鲳鲹低温暂养的保活工艺及生理代谢特征 312
罗非鱼品种差异对营养品质及蛋白质结构功能特性差异的影响 314
毛鳞鱼鱼籽磷脂重塑高脂膳食小鼠脂肪酸谱并缓解肝脏氧化应激与脂质沉积 316
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 318
木聚糖链长与化学取代对六方冰晶面生长抑制的分子动力学研究 320
牡蛎抗疲劳肽的酶法制备及其体内外活性评价研究 322
牡蛎源多肽和糖肽缓解脂质积累及结构表征 324
纳米颗粒稳定的精油皮克林乳液/壳聚糖膜对虾的保鲜效果研究 326
南海特色海参脂质改善高尿酸血症小鼠肾损伤的比较研究 327
南极磷虾可溶性蛋白抗冻组分的分离筛选及其对保加利亚乳杆菌的冷冻保护作用 329
南极磷虾蒸煮分离液中水溶性蛋白的回收及理化特性分析 330
泥蚶铁蛋白-抗坏血酸纳米颗粒的构建及其铁吸收机制研究 331
烹饪方式对卤制中华鳖食用品质的影响 333
热带水果果皮多酚-壳聚糖复合膜的构建及对石斑鱼保鲜效果的研究 335
热加工方式调控海带强化牦牛肉体系消化行为及活性肽释放机制研究 336
热熏鲟鱼片品质变化的机制解析：超高压条件下腐败菌群动态研究 338
溶菌酶-壳聚糖复合颗粒的构建及其对典型水产腐败菌的协同抑菌机理 339
山苍子精油包埋产物的比较及其复合膜对石斑鱼的保鲜应用 342
山苍子精油复合膜的制备及其对点篮子鱼的保鲜性能研究 343
生、熟鲍鱼内脏酱油的发酵工艺及品质的比较研究 345
食用昆虫在水产食品加工与饲料领域的功能特性研究进展 348
双频超声辅助腌制对烤制鲳鱼肉品质的影响 350
双氧水处理对鲣鱼鱼糜凝胶脱腥的作用机理研究 352
水产品组胺降解菌的筛选鉴定及酶学性质研究 353
四种鱼鳔酸溶性胶原蛋白理化性质及结构特点的比较研究 355
酸预处理与碱消化工艺对巨藻 LF 和泡叶藻褐藻胶提取率及品质的差异化调控 357
坛紫菜纯化多糖的结构解析及其对冻藏凡纳滨对虾虾仁的品质维持 358

糖基化鱼明胶乳液凝胶对带鱼鱼糜凝胶品质及结构的影响 359
溏心干鲍品质评价方法的初步构建与应用 360
同轴电喷雾法制备二十碳五烯酸乙酯核壳微胶囊 361
微刻蚀与虫胶涂层联用构建活性 PVA/CMC/海藻酸钠复合膜及其在水产品保鲜中的应用 362
微拟球藻 ACE 抑制肽的定向制备、结构特征及其活性评价 364
微藻蛋白界面网络调控食品泡沫与乳液稳定性的多尺度机制 367
五种鲢鱼副产物组织来源对明胶结构、理化性质及乳化性能的影响 369
硒化卡拉胶的工艺优化及结构表征 371
虾加工副产物作为可持续资源用于可生物降解活性食品包装膜的研究进展 372
暹罗鳄加工副产物的高值化利用：油脂提取与酶法改性 375
小龙虾各部位脂质提取特征比较及抗氧化能力评价 377
新鲜与冷冻罗非鱼片不同部位 营养品质的比较 379
星辉互映启发的新型交织式金纳米阵列 SERS 平台用于食品危害物检测 381
鲟鱼皮胶原水解物在冻融循环中对鱼糜的冷冻保护作用及其抗冻肽的构效关系 383
鲟鱼子酱自生微生物 *Stenotrophomonas rhizophila* SR-1 延缓冷藏鲟鱼子酱贮藏品质劣变的作用及机制 385
羊栖菜中无机砷提取及脱除工艺研究 386
贻贝肽-低聚半乳糖美拉德复合物的结构表征与促锌吸收机制研究 388
益生元介导美拉德反应改善鲢鱼蛋白水解物品质及其肠道免疫调节作用 390
“一夜埕”金鲳鱼低钠复合盐配方优化及品质与风味特性研究 391
鱿鱼新型甲醛清除剂开发及其保鲜研究 393
油炸温度和时间对面包虾理化特性和挥发性风味的影响 397
鱼胶水发工艺优化及机理研究 399
鱼胶原蛋白基皮克林乳液的构建及其在功能性沙拉酱中的应用 400
玉米纤维胶对带鱼肌原纤维蛋白功能特性及鱼丸品质的影响 402
鱼子酱碳点的抑菌特性研究及其在鲟鱼子酱冷藏保鲜中的应用 404
原花青素调控冷藏草鱼肌肉脂质氧化与代谢：基于脂质组学的解析 406
栅栏因子结合含气调理低强度杀菌技术调控即食海带品质的研究 409
整合多传感器追踪与代谢组学揭示豹纹鳃棘鲈（*Plectropomus leopardus*）在运输过程中的环境应激及代谢机制 411

植物提取物协同等离子体及无氧气调包装对虹鳟冷藏保鲜和品质的调控 413
贮藏鲟鱼子酱关键膜磷脂结构重塑的多尺度表征 415

A method for improving the quality of grass carp (Ctenopharyngodon idellus): A comprehensive evaluation of clear water depuration based on sensory and nutritional aspects

Xinyang Li [a],1, Chenyang Zhao [a],[1], Lin Xu [a], Yuxiang Wang [a], Jin Yu [c], Xudong Weng [d],[**], Ting Ye [e], Xiaoguo Ying [a],[*], Yang Gao [b],[*]

[a] Zhejiang Provincial Key Laboratory of Health Risk Factors for Seafood, Collaborative Innovation Center of Seafood Deep Processing, College of Food and Pharmacy,Zhejiang Ocean University, Zhoushan, China

[b] College of Fishery, Zhejiang Ocean University, Zhoushan, China

[c] Longyou Aquaculture Development Center, Agricultural and Rural Bureau of Longyou County, Quzhou, China

[d] Zhejiang Yulaoda Agricultural Technology Co., Ltd., Quzhou, China

[e] Quzhou Aquatic Technology Extension Centre, Quzhou, China

Abstract： This study investigates the effects of clear water depuration farming on grass carp muscle quality, nutrition, and flavor. Results show that clear water depuration significantly reduces off-flavor compounds while improving muscle texture and sensory traits. After three months, fish muscle hardness, chewiness, and whiteness increased, while drip and freezing loss decreased. Low-density farming better preserved essential amino acids and unsat- urated fatty acids, enhancing nutritional value. Glycine, histidine, and alanine were the main free amino acids with elevated levels. Volatile analysis showed nonanal, hexanal, and 1-octen-3-ol levels declined with time, especially under low-density conditions. Muscle texture improvements correlated positively with mono-unsaturated fatty acids, protein, and collagen, and negatively with moisture, pH, and polyunsaturated fatty acids. Clear water depuration may also promote collagen synthesis. Overall, a three-month depuration under low-density conditions is optimal for improving grass carp's sensory and nutritional quality without negatively affecting texture and taste.

Keywords: Fasting，Muscle texture，Flavor，Fatty acid，Amino acid

通讯作者：应晓国，男，博士、副教授。研究方向为冷链物流。联系电话 15158157652。

该研究由主要产业计划资助舟山技术研发（2023C03006）。

Accelerated Chemotaxonomic Discrimination of Marine Fish Surimi Based on Tri-step FT-IR Spectroscopy and Electronic Sensory

Ran Zhou[1], Wei Wei[1], Wei Hu[1], Changhua Xu[1, 2*]

1.College of Food Science & Technology, Shanghai Ocean University, Shanghai 201306, PR China; 2. National R&D Branch Center for Freshwater Aquatic Products Processing Technology (Shanghai), Shanghai 201306, China;

Abstract: To develop a rapid and reliable method for discrimination of marine fish surimi using Tri-step Fourier transform infrared spectroscopy combined with electronic sensory analysis. Four types of marine fish surimi were characterized by FT-IR spectroscopy, second-derivative infrared spectroscopy and two-dimensional correlation infrared spectroscopy. Principal component analysis was used for classification, while electronic eye and electronic nose systems were employed to evaluate differences in color and odor. Distinct differences among the surimi samples were observed in lipid- and protein-related spectral features, and characteristic fingerprints were obtained in the region of 1800–1500 cm^{-1}. Two hundred surimi samples were effectively classified by PCA, and 20 unknown samples were successfully identified. The discrimination indexes of the electronic eye and electronic nose were 98 and 82, respectively. Tri-step FT-IR spectroscopy combined with electronic sensory analysis provides a rapid and comprehensive approach for discriminating marine fish surimi and has potential for species authentication and quality control.

Key words: Surimi; Fourier transform infrared spectroscopy; Electronic sensory; Chemotaxonomic discrimination; Species identification

Funding: National Natural Science Foundation of China (No. 31401571); Natural Science Foundation of Shanghai (No. 14ZR1420000); Key Projects in the National Science & Technology Pillar Program during the Twelfth Five-year Plan Period (Nos. 2015BAD17B01 and 2015BAD17B02); Shanghai Young Teachers Training Program (No. ZZZZHY15009).

Corresponding author: Changhua Xu, male, Ph.D., Professor. Research interests: rapid food testing.

Tel.: 18516275495. E-mail: chxu@shou.edu.cn

Ameliorative effect and mechanism of fucoxanthin on lipopolysaccharide-induced acute liver injury

Qing-yan Zou[1,2], Yu-hong Yang[2], Lei Du[3]

1. College of Food Science and Engineering, Ocean University of China, Qingdao, 266404, Shandong;

2. School of Food Science and Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan, 250353, Shandong;

3. Department of Nutrition and Food Hygiene, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, 250012, Shandong;

Abstract:

Acute liver injury (ALI) induced by lipopolysaccharide (LPS) represents a critical clinical challenge due to its high mortality and limited therapeutic options. Fucoxanthin (Fx), a marine-derived xanthophyll carotenoid, exerts hepatoprotective potential owing to its strong anti-inflammatory and antioxidant properties. However, its pro-tective role against LPS-induced ALI remains poorly understood. This study elucidated the protective effect and underlying mechanism of Fx against LPS-induced ALI in both a mouse model and a hepatocyte-macrophage co-culture system. Oral administration of 50 or 200 mg/kg body weight Fx once daily for 7 consecutive days notably attenuated LPS-induced increase in serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels, and improved pathological changes in mouse livers. In the co-culture system of AML12 hepatocytes and RAW264.7 macrophages, Fx treatment dose-dependently alleviated LPS-induced damage to AML12 cells, as evidenced by reduced lactate dehydrogenase (LDH) release and maintained cell viability. Mechanistically, Fx significantly suppressed macrophage overactivation-mediated hepatic inflammatory responses and oxidative stress induced by LPS. Specifically, Fx downregulated pro-inflammatory molecules, such as tumor necrosis factor-alpha (TNF-α), interleukin-1beta (IL-1β), IL-6, IL-18, and inducible nitric oxide synthase (iNOS), as well as inhibited intracellular reactive oxygen species (ROS) generation. These effects collectively suppressed excessive hepatocyte apoptosis via blocking the intrinsic apoptotic signaling

pathway and inhibited massive hepatocyte pyroptosis through inactivating the NOD-like receptor family pyrin domain containing 3 (NLRP3)/caspase-1/

gasdermin D (GSDMD)-mediated pyroptosis pathway. Collectively, these findings suggest that Fx may serve as a promising functional ingredient for preventing ALI.

Key words: Fucoxanthin; Acute liver injury; Hepatocyte; Apoptosis; Pyroptosis;

通讯作者：

杜磊，男，博士研究生，副教授，E-mail:dulei@sdu.edu.cn

研究方向：健康老龄化的营养干预策略

资助项目：

本研究得到齐鲁工业大学（山东省科学院）科教产融合重大创新试点项目（2025ZDZX15）、国家自然科学基金（82473617、32202023）、山东省自然科学基金（ZR2024MH074、ZR2021QC177）以及山东省重点研发计划（2023CXGC010713）的资助。

Ameliorative Effects and Mechanisms of Marine Structured Lipids on Parkinson's Disease

Yi-Fei Ning [1], Yi-Wen Wang[1], Lei Ma[1], Xian-Shu Wang[1], Yu-Ming Wang[1, 2], Cheng-Cheng Wang[1,*], and Tian-Tian Zhang[1,*]

1. College of Food Science and Engineering, Ocean University of China, Qingdao, 266404, Shandong;

2. Sanya Institute of Oceanography, Ocean University of China, Sanya, 572000, Hainan;

Abstract:

Parkinson's disease (PD) involves dopaminergic impairment associated with iron dyshomeostasis and oxidative injury. DHA-enriched phosphatidylglucoside (DHA-PG) was produced by replacing the choline head group of marine DHA-enriched phosphatidylcholine with glucose and evaluated in MPTP-treated mice. DHA-PG improved motor performance and mitigated the loss of striatal TH immunoreactivity and TH protein expression. It also reduced striatal iron deposition, partially normalized changes in FPN1, TfR1, and FTH1, and strengthened GPX4/xCT-related antioxidant defense, as reflected by increased GPX4 and xCT protein expression and GSH-PX activity. DHA-PG significantly restored Bcl-2 mRNA expression. Although the changes in Caspase-3 mRNA expression, the ND4/ND1 ratio, and MAO activity did not reach statistical significance, all shifted toward control values. These findings indicate that DHA-PG attenuates MPTP-induced dopaminergic dysfunction in association with improved iron homeostasis, antioxidant defense, and downstream injury-related processes, supporting glucose head-group modification as a potential strategy for developing functional marine DHA phospholipids.

Key words: DHA-Enriched Phosphatidylglucoside; Parkinson's Disease; Iron Homeostasis; Ferroptosis

通讯作者：

1、张恬恬，女，博士研究生，教授，E-mail: zhangtiantian@ouc.edu.cn

研究方向：（1）海洋食品全生命周期主动健康营养理论（2）特定健康需求的功效成分制备与功能评价（3）基于海陆结合理念的主动健康精准营养产品创制

2、王成成，男，博士研究生，副教授，E-mail: wangchengcheng@ouc.edu.cn

研究方向：（1）基于表观遗传的海洋食品时序营养学机制；（2）基于血脑屏障的活性脂质营养健康机制；（3）基于多成分-多靶点的精准营养食品创制理论与技术

资助项目：

2024YFD2401600，国家重点研项目，《水产特色营养食品绿色高效制造的理论与技术研究》，

Anti-obesity effects of fucoxanthin and conjugated linoleic acid complex liposomes in high-fat diet mice through regulation of AMPK signaling pathway

Jiyan Sun[a#], Yanxiaofan Sun[a#], Yuxin Shi[a], Xuhui Lei[a], Zhiying Xu[a], Yichao Ma[a,b,c], Shu Liu[a,b,c], Yunhai He[a,b,c], Qiukuan Wang[a,b,c], Dandan Ren[a,b,c*]

1.College of Food Science and Engineering, Dalian Ocean University, Dalian, PR China;

2.National R & D Branch Center for Seaweed Processing, Dalian, PR China;

3.Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian, PR China

*Corresponding author: Prof. Dandan Ren (rendandan@hotmail.com ORCID:0000-0002-9346-0502)

The authors shared the co-first authorship.

Abstract

Solving the problem of obesity has been globally recognized as a crucial public health challenge. Recent studies have shown that fucoxanthin and conjugated linoleic acid could work together to exert an anti-obesity effect. In this study, sodium alginate- and chitosan-modified fucoxanthin and conjugated linoleic acid complex liposome (S-C-L) was prepared and characterized. The anti-obesity effect and mechanism of action of S-C-L were evaluated by establishing an obese mouse model. The results indicated that S-C-L reduced the weight and fat content of obese mice and improved their oxidative stress state. It regulated the expression levels of mRNA and protein by activating the AMPK signaling pathway, thereby enhancing energy expenditure and inhibiting the differentiation of adipocytes, confirming its anti-obesity properties. Comprehensive analysis indicated that S-C-L had broad application potential in the development of anti-obesity foods and health products.

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

Citrus Juice Marination Improves the Flavor of Fish: A Case Study of Sea Bass (*Lateolabrax japonicus*)

Yuxiang Wang[1], Chenyang Zhao[1], Jixiang Zhang[1], Xiaoguo Ying[1,*], Shanggui Deng[1], Lukai Ma[2,*]

1 Key Laboratory of Health Risk Factors for Seafood of Zhejiang Province, College of Food Science and Pharmacy, Zhejiang Ocean University, Zhoushan 316022, China

2 Key Laboratory of Green Processing and Intelligent Manufacturing of Lingnan Specialty Food, Ministry of Agriculture and Rural Affairs, Guangdong Provincial Key Laboratory of Lingnan Specialty Food Science and Technology, College of Food Science and Technology, Zhongkai University of Agriculture and Engineering, Guangzhou 510225, China

Abstract: Although aquatic products are abundant in premium proteins and other vital nutrients, their unique fishy smell often restricts public acceptance and the development of related products. Therefore, pre-marinating is usually used to improve sensory quality and mitigate fishy smell; In this study, sea bass filets were marinated for 1 h at a solid–liquid ratio of 3:5 (w/w) using 15% orange juice, 15% grapefruit juice, and 10% lemon juice. Subsequently, their effects on the flavor and sensory quality of sea bass were examined; The results of gas chromatography-ion mobility spectrometry (GC-IMS) showed that marinating the filets in citrus juice led to a notable increase in volatile compounds, including esters with fruity flavor such as ethyl butyrate and terpenes with pleasant citrus aromas such as limonene. The results of texture profile analysis (TPA) showed that pre-marinading with orange juice and grapefruit juice significantly reduced the hardness of fish and resulted in higher sensory evaluation scores ($p < 0.05$). Lemon juice treatment produced the most noticeable whitening effect ($p < 0.05$); These findings suggest that citrus juices can be effectively incorporated as marinade ingredients for sea bass, providing both theoretical insight and practical guidance for improving the marinating technology for aquatic products.

Keywords: sea bass; citrus juice; flavor; volatile compounds; quality improvement

通讯作者：

应晓国，男，博士，副教授，主要从事冷链物流相关方面的研究，电话：15158157652

马路凯，男，博士，副教授，主要从事油脂营养与安全相关方面的研究，Email: malukai@zhku.edu.cn

资助项目：本研究由广东省重点领域项目（2023B0202080003）、广东省重点建设学科科研能力提升项目（X202411347192）、舟山市级重大产业科技攻关项目（2023C03006）、舟山市定海区科技计划项目（2024C0101）以及大宗水产品预制菜加工关键技术研发项目（2023C03006）资助。

Combined Protective Effects of Rohu Fish Maw Enzymatic Hydrolysate and *Astragalus membranaceus* Extract against Cyclophosphamide-Induced Premature Ovarian Insufficiency

Ran-Ran Pei[1], Cheng-Cheng Wang[1], Yu-Ming Wang[1], and Tian-Tian Zhang[1,*]

1. College of Food Science and Engineering, Ocean University of China, Qingdao, 266404, Shandong.

Abstract

[Objective]: This study investigated the combined protective effects of rohu fish maw enzymatic hydrolysate (RFM) and *Astragalus membranaceus* extract (AM) against cyclophosphamide-induced ovarian insufficiency.

[Methods]: Eight-week-old female ICR mice were assigned to five groups: normal control (NC), premature ovarian insufficiency model (POI), RFM, AM, and RFM+AM groups (n = 7 per group). The experiment lasted for 21 days. Dietary intervention was provided throughout the experiment. RFM and AM were added to the AIN-93G diet at 1% and 0.1%, respectively. The combined diet contained both ingredients. During the second week, mice in the POI and intervention groups received intraperitoneal injections of cyclophosphamide at 75 mg/kg once daily for seven days. The NC group received an equal volume of normal saline. Reproductive organ indices, estrous cycles, ovarian morphology, serum hormones, and related gene expression were evaluated. KGN cells were exposed to 15 μM 4-hydroxycyclophosphamide (4-HC) for 48 h. RFM and AM were added simultaneously with 4-HC. KGN cell apoptosis was quantified by flow cytometry, and estradiol secretion in the culture supernatant was measured.

[Results]: Cyclophosphamide reduced body weight and reproductive organ indices. It prolonged the estrous cycle and damaged ovarian morphology. It also reduced serum progesterone and estradiol levels and increased follicle-stimulating hormone levels. RFM and AM alleviated these changes. The combined intervention generally produced the greatest improvement. It better preserved follicular structure and granulosa cell survival. In KGN cells, 15 μM 4-HC reduced estradiol

secretion by approximately 40% without markedly affecting cell viability. RFM and AM increased estradiol secretion in 4-HC-treated cells. The combined treatment produced the largest increase. The interventions also altered the expression profiles of genes associated with follicular development and steroid hormone synthesis.

[Conclusion]: RFM and AM alleviated cyclophosphamide-induced ovarian injury and improved ovarian endocrine function. Their effects were associated with preserved follicular morphology and improved estradiol secretion by granulosa cells. The combined intervention showed a greater overall protective effect than either treatment alone.

Key words: premature ovarian insufficiency; fish maw; *Astragalus membranaceus*; granulosa cells; cyclophosphamide

通讯作者：

张恬恬，女，博士研究生，教授，E-mail: zhangtiantian@ouc.edu.cn

研究方向：（1）海洋食品全生命周期主动健康营养理论（2）特定健康需求的功效成分制备与功能评价（3）基于海陆结合理念的主动健康精准营养产品创制

资助项目：

2024YFD2401600，国家重点研发项目，《水产特色营养食品绿色高效制造的理论与技术研究》

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

Yuxin Shi [1,†], Mingna Dong [1,†], Xuhui Lei [1], Zhiying Xu [1], Jiyan Sun [1], Yingying Zhao [1], Yichao Ma [1,2,3], Hui Zhou [1,2,3], Shu Liu [1,2,3], Yunhai He [1,2,3], Qiukuan Wang [1,2,3] and Dandan Ren [1,2,3,*]

1 College of Food Science and Engineering, Dalian Ocean University, Dalian 116023, China; 15836713449@163.com (M.D.); xuzhiying1214@163.com (Z.X.); 19819752650@163.com (Y.Z.)

2 National R&D Branch Center for Seaweed Processing, Dalian 116023, China

3 Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian 116023, China

* Correspondence: rdd@dlou.edu.cn

† These authors contributed equally to this work.

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 weredetermined to be a 2% sodium carbonate concentration, a duration of 4 h, a material-toliquid ratio of 1:40, and a temperature of 60 ℃, 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

Cryoprotective properties of betaine-based natural deep eutectic solvents and their regulatory mechanisms on the quality of frozen shrimp surimi

Yan Li[1], Wenzheng Shi[1*]

1. College of Food Science and Technology, Shanghai Ocean University, Shanghai, 201306, China

Abstract: Natural deep eutectic solvents (NADESs) have emerged as promising candidates in the field of cryoprotection owing to their non-toxicity, excellent biocompatibility, and structural designability. In this study, three betaine-based NADESs (betaine:glycerol (Bet:Gly), betaine:sorbitol, and betaine:glucose), were selected to systematically investigate their cryoprotective properties, as well as their protective effects and underlying mechanisms on frozen shrimp surimi. Visual observation of freezing behavior and DSC analysis revealed that the betaine-based NADESs exhibited lower freezing points compared with water and 50% sucrose solution, and that the pure NADESs remained unfrozen even at -80 ℃. Ice recrystallization inhibition assays indicated that the presence of NADESs effectively retarded ice nucleation and growth, and suppressed recrystallization, with Bet:Gly showing the most pronounced effect. After five FT cycles, the gel treated with 4 wt% Bet:Gly retained 89% of its original gel strength, which was 35% and 22.80% higher than that of the control group and the commercial cryoprotectant group, respectively. Moreover, the 4 wt% Bet:Gly-treated group maintained the highest water-holding capacity (76.18%) after five FT cycles. In addition, Bet:Gly effectively inhibited protein oxidation and denaturation, as evidenced by reduced loss of sulfhydryl groups, decreased surface hydrophobicity, and suppressed aggregation of myofibrillar proteins. Molecular docking results further revealed that Bet:Gly could capture water molecules via hydrogen bonds, and stabilize myofibrillar proteins through hydrogen bonding, van der Waals forces, and salt-bridge interactions. Collectively, these findings suggest that Bet:Gly holds great promise as a cryoprotectant for the food industry.

Keywords: Natural deep eutectic solvent; ice recrystallization inhibition; shrimp surimi; freeze-thaw stability;

cryoprotection mechanism

Acknowledgements: The National Key Research and Development Program of China (2023YFD2401502).

***Corresponding authors:** Wenzheng Shi, Ph.D., aquatic product processing and storage, wzshi@shou.edu.cn.

Dynamic Evolution of Muscle Quality and Metabolic Response Mechanisms in *Lvpan abalone* During Waterless Preservation*

Sun Yaxin [1, 2], Wang Shanyu [1, 2],Liu Qi [2], Sun Yong [2], Cao Rong [2, ①]

(*1. School of Food Science and Engineering, Ocean University of China, Shandong Qingdao 266003, China;*

2. *Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao 266071,China*)

Abstract:[Objective]To elucidate the dynamic changes in muscle quality and physiological metabolism of Haliotis discus hannai during sealed, oxygenated, low-temperature waterless live storage.[Methods]Female *Haliotis discus hannai* × male *H. fulgens* were used as the research subject. Waterless storage was conducted at 3℃ for 0–7 days. Basic nutritional components, glycogen and lactic acid levels, antioxidant enzyme activities, and malondialdehyde content were measured. Muscle quality and flavor profile were further evaluated by analyzing nucleotides, free amino acids, free fatty acids, texture, histology, electronic tongue, and electronic nose. Orthogonal partial least squares discriminant analysis (OPLS-DA) was used to construct a flavor metabolite network and screen for key biomarkers of quality transformation. [Results]As the storage time increased, moisture, crude protein, and crude fat contents decreased overall, while ash content increased relatively. Glycogen content decreased, and lactic acid showed a rise-then-fall trend. Activities of superoxide dismutase and catalase first increased then decreased, while malondialdehyde accumulated continuously, indicating antioxidant defense activation in the early phase and progressively aggravated oxidative damage later. Muscle texture parameters generally declined. Histological analysis revealed enlarged inter-fiber spaces, looser arrangement, and impaired structural integrity in the late storage period. Taste analysis showed significant decreases in umami and richness ($p < 0.05$), with increased bitterness. The largest odor profile difference was observed between day 0 and day 7 groups based on electronic nose results, and the day 5 group was clearly separated from the day 6–7 groups, suggesting day 5 may be a key node for odor quality change. OPLS-DA identified 11 key compounds as biomarkers of quality transformation, and a flavor metabolite network was constructed. The study further revealed an intrinsic link between the depletion of non-volatile taste

*基金项目：国家重点研发计划（2024YFD2401901），中国水产科学研究院基本科研业务费（2023TD72）资助[This work was supported by the National Key R & ientific Institution Basal Research Fund, CAFS (NO.2023TD72)]

compounds and the generation of volatile aroma compounds, proposing a unified metabolic mechanism for flavor deterioration. [Conclusion] In the early stage of storage, *lvpan abalone* mainly maintains homeostasis through energy regulation and antioxidant defense; after 5 days, oxidative damage, tissue deterioration, and flavor deviation become evident. Eleven key biomarkers can be used as indicators of quality transformation. This work shifts the focus from mere survival rate to the maintenance of sensory shelf life, providing a mechanistic framework for optimizing aquatic product logistics.

Keywords: Lvpan abalone; Waterless preservation; Energy metabolism; Oxidative stress; Muscle quality

Effect of Low-Salt Composite Tenderization on Texture and Flavor of Rainbow Trout: Process Optimization and GC-IMS Analysis

Jiaxin Gan[1,2]，Huan Xiang[2]，Shengjun Chen[1,2*]

1 College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China；

2 Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs, National R&D Center for Aquatic Product Processing, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, China

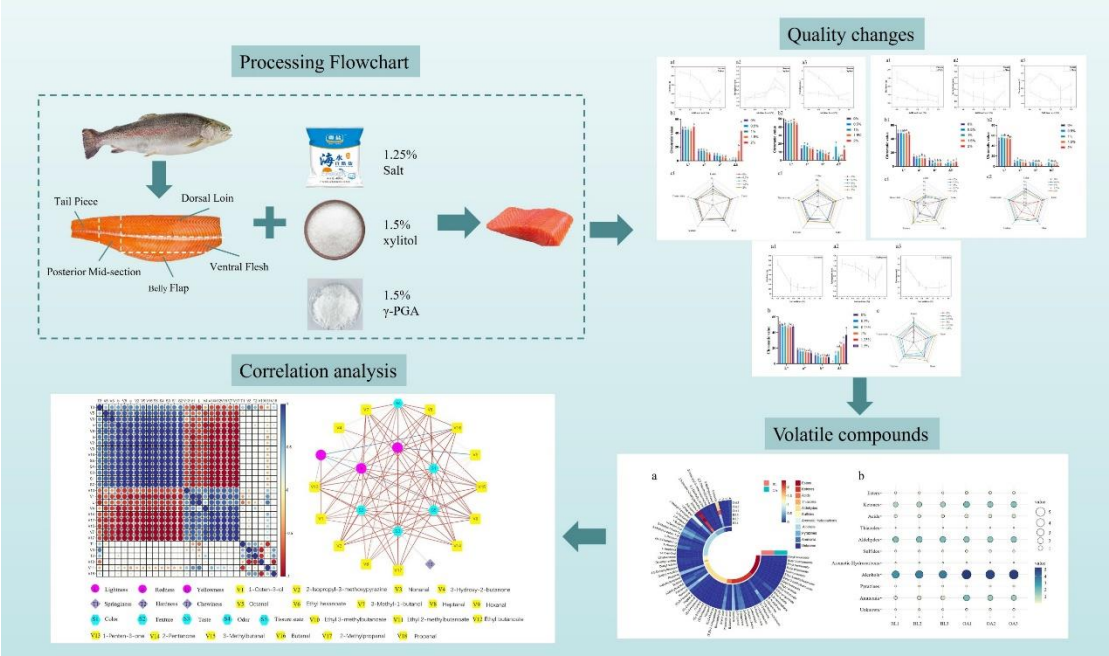
Abstract： To improve the processing quality and market competitiveness of rainbow trout (*Oncorhynchus mykiss*) by addressing issues such as tough texture, dry mouthfeel, and monotonous flavor caused by heating and other factors, this study utilized rainbow trout meat to conduct single-factor experiments. This study investigated the effects of salt, white sugar, xylitol, papain, and γ-polyglutamic acid on fish texture, color, and sensory properties. Subsequently, the tenderizing technique was optimized. Volatile flavor compounds in the optimal treatment group (OA) and the untreated control group (BL) were compared using gas chromatography-ion mobility spectrometry (GC-IMS), and key flavor compounds were identified. Furthermore, correlation network analysis revealed intrinsic relationships among the quality indicators. The optimal curing process for rainbow trout fillets was identified based on the significant enhancement of texture and the highest sensory score. A total of 75 volatile compounds were detected in 11 classes, including aldehydes, alcohols, and ketones. Treatment with OA led to an increase in the total concentration of volatile compounds from 7.10 to 7.96 mg/kg, facilitating the generation of desirable compounds, such as 3-hydroxy-2-butanone, 2-methylpropanal, and ethyl butyrate, while effectively inhibiting the buildup of straight-chain aldehydes, such as hexanal and octanal. Furthermore, it completely eradicated 2-isopropyl-3-methoxypyrazine, a compound known to impart strong grassy flavors. This study introduced an optimized low-salt composite tenderization process to enhance the texture and taste of rainbow trout meat, elucidating the mechanism of quality improvement through flavor chemistry and multi-indicator correlation analyses. The findings offer reliable process parameters and a scientific

foundation for the industrial processing of rainbow trout.

Key words: rainbow trout; tenderization process; gas chromatography-ion mobility spectrometry (GC-IMS); volatile flavor compounds; correlation analysis

Acknowledgements： The authors are grateful for the financial support from the Full-Chain Research Project of the Chinese Academy of Fishery Sciences （2025XT0105）; the Earmarked fund for CARS (CARS- 46); Guangdong Basic and Applied Basic Research Foundation (2023A1515111155); Central Public-interest Scientific Institution Basal Research Fund, South China Sea Fisheries Research Institute, CAFS (2023TD74); the Guangdong Provincial Special Fund for Modern Agriculture Industry Technology Innovation Teams (2024CXTD26).

Correspondence：陈胜军（1973-），男，博士，研究员，研究方向：水产品加工与质量安全控制，E-mail：chenshengjun@scsfri.ac.cn



Effects of alkaline pH-shifting combined with arginine and lysine on the properties of grass carp myofibrillar protein emulsion gels under low-salt conditions

*Haipeng Wu，Ruiying Ran，Yi Xie，Guoping Wu，Chan Zhong**

College of Food Science and Engineering, Jiangxi Agricultural University, Nanchang, 330045, Jiangxi, China

Abstract: Myofibrillar proteins (MPs) from grass carp exhibit low solubility and inferior interfacial activity under low-salt conditions, severely limiting their application in low-fat and low-salt emulsion gel products. In this study, grass carp MPs were modified via alkaline pH-shifting combined with arginine or lysine at concentrations of 0%, 0.1%, 0.5%, and 1.0% (w/v). The protein conformational changes, thermal stability, and emulsifying properties of emulsion gels fabricated with camellia oil, safflower seed oil, and perilla seed oil were evaluated. Both amino acids induced the partial unfolding of MPs, converting α-helix and β-sheet structures into β-turns, which effectively improved protein solubility and thermal stability. The optimal modification efficacy was obtained at 0.5%, with the solubility of arginine- and lysine-modified MPs reaching 62.78% and 62.89%, respectively. At the optimal concentration, all three oil-based emulsion gels presented enhanced emulsifying activity, greater absolute zeta potentials, smaller and more uniformly dispersed oil droplets, and denser interfacial protein films, along with substantially suppressed lipid oxidation. By contrast, the 1.0% amino acid treatment triggered competitive adsorption between free amino acids and MPs at the oil-water interface, which exacerbated oil droplet flocculation and impaired the overall emulsion performance. These findings demonstrate that alkaline pH-shifting combined with a moderate concentration of arginine or lysine can synergistically enhance the physical stability and oxidative stability of low-salt MP emulsion gels by regulating protein conformation to optimize interfacial adsorption behavior, providing a theoretical basis for the development of low-salt fish protein-based emulsion products.

Key words: Myofibrillar protein; Alkaline pH-shifting; Arginine and lysine; Emulsion gel; Low-salt

基金项目：国家自然科学基金项目（32260610，32460618）；江西省农业农村厅名特优水产品产业技术体系专项基金（JXARS-15）

Effects of Combined Treatment with Chlorine Dioxide and Ginger Juice on Freshness Preservation and Protein Oxidation of Longsnout Catfish

Junyi Yang[1,#], Peng Shi[1,#], Jun Mei[1,*], Jing Xie[1,2,3,4,5,6,*]

(1 College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

2 Key Laboratory of Aquatic Products High Quality Utilization, Storage and Transportation (Co-construction by Ministry and Province), Ministry of Agriculture and Rural Affairs

3 National Experimental Teaching Demonstration Center for Food Science and Engineering Shanghai Ocean University, Shanghai 201306, China

4 Shanghai Engineering Research Center of Aquatic Product Processing and Preservation, Shanghai 201306, China

5 Shanghai Professional Technology Service Platform on Cold Chain Equipment Performance and Energy Saving Evaluation, Shanghai 201306, China

6 Marine Biomedical Science and Technology Innovation Platform of Lin-gang Special Area, Shanghai, China)

** Correspondence: jxie@shou.edu.cn (J.X.); jmei@shou.edu.cn (J.M.)*

Tel.: +86-21-61900351 (J.X.);

Abstract: This study investigated the combined effects of chlorine dioxide (ClO_2) and ginger juice on the preservation and protein oxidation of longsnout catfish stored under modified atmosphere packaging at 4°C. Fish samples were divided into five groups: control (CK), modified atmosphere packaging alone (Q), 48 mg/L ClO_2 (CI), 125 mL/L ginger juice (J), and their combination (ClJ). Microbial counts, pH, K value, TVB-N, and myofibrillar protein structural changes—including secondary and tertiary structures, Ca^{2+}-ATPase activity, and carbonyl and total sulfhydryl contents—were monitored over 15 days. The CIJ treatment showed the strongest preservation effect, significantly inhibiting microbial growth, delaying increases in K value and TVB-N. Although ClO_2 alone induced oxidative damage, as evidenced by lower Ca^{2+}-ATPase activity and higher carbonyl levels, the antioxidant components in ginger juice effectively counteracted this oxidation and

preserved protein structure. At day 15, the CIJ group retained 46.98% α-helix content and the highest total sulfhydryl levels. The synergistic action of ClO_2 (bactericidal) and ginger juice (antioxidant and deodorizing) extended shelf life by at least 3 days compared with individual treatments. This combined approach offers a practical strategy for preserving aquatic.

Keywords: ClO_2, Ginger juice, Longsnout catfish, Protein oxidation

资助项目：国家重点研发计划项目“养殖鱼类加工与质量安全控制关键技术与装备”课题 2“养殖鱼类生态保鲜保活与物流品质监控关键技术研究”（2023YFD2401402）

通讯作者：谢晶，女，博士，教授，水产品保鲜，15692165513，jxie@shou.edu.cn

梅俊，男，博士，教授，水产品保鲜，jmei@shou.edu.cn

Effects of intestinal contents on muscle quality and protein degradation of red shrimp (*Solenocera crassicornis*) during cold storage

Feili Zhan [a,b], Renda Yu [d], Wenxiong Zheng [a], Soottawat Benjakul[c], Daodong Pan[b], Bin Zhang [a*]

1. College of Food Science and Pharmacy, Zhejiang Ocean University, Zhoushan, 316022, Zhejiang;

2. College of Food Science and Engineering, Ningbo University, Ningbo,315211, Zhejiang;

3. International Center of Excellence in Seafood Science and Innovation, Faculty of Agro-Industry, Prince of Songkla University, 90112, Songkhla,Thailand;

4. College of Food Science and Technology, Henan Agricultural University, 450002, Zhengzhou 450002

Abstract: This study explored the effects of intestinal components on muscle quality deterioration and protein degradation of red shrimp during refrigerated storage. This study investigates the impact of intestinal contents and intestinal microbial metabolites on muscle quality and protein degradation by measuring muscle quality, endogenous enzyme activity, and physicochemical parameters related to muscle protein degradation, combined with metagenomic analysis to elucidate the composition and function of the gut microbiota.The results demonstrated that refrigeration induced continuous quality degradation and muscle protein breakdown in red shrimp, whereas eliminating intestinal tissues effectively retarded muscle spoilage and protein degradation and optimized muscle texture. The intestinal microorganisms capable of secreting extracellular proteases to promote muscle protein degradation were primarily *Vibrio*, *Bacillus*, *Pseudomonas*, *Photobacterium*, and *Shewanella*. These microorganisms promote protein degradation by secreting zinc proteases, serine proteases, and aspartyl proteases. This study elucidates the molecular mechanisms of intestinal microbial metabolism influences the muscle protein degradation of red shrimp during refrigeration. The findings provide a theoretical foundation for precise regulation of intestinal-targeted microorganisms, thereby maintaining the optimal quality of shrimps during refrigeration.

Keywords: Red shrimp; myofibrillar proteins; non-targeted metabolomics; metagenomics;

refrigeration

Corresponding author: Bin Zhang, man, DR.The research area is freshness and quality of aquatic products. Tel: +86-0580-255-4781, E-mail: zhangbin@zjou.edu.cn, ORCID: 0000-0003-4696-9098, No.1, Haida South Road, Lincheng Changzhi Island, Zhoushan, Zhejiang province, 316022 P. R. China.

Figures

Fig.1

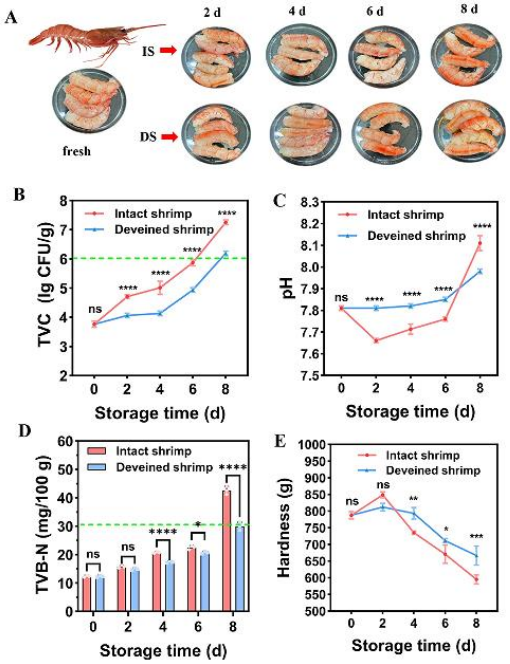


Fig.2

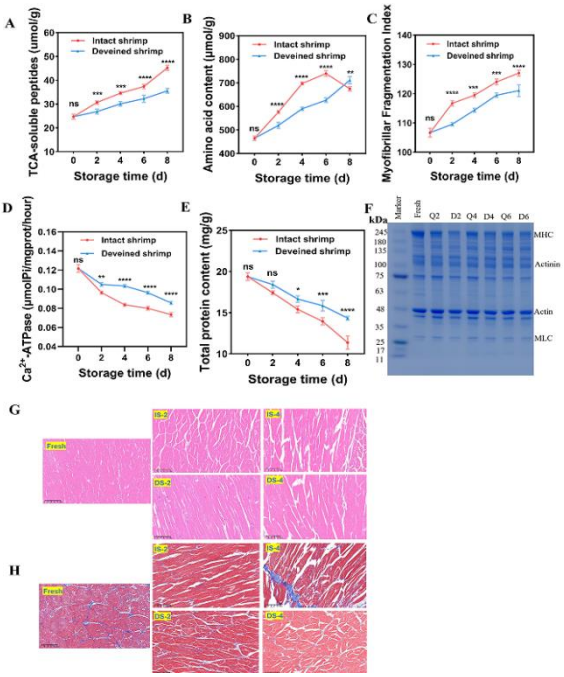
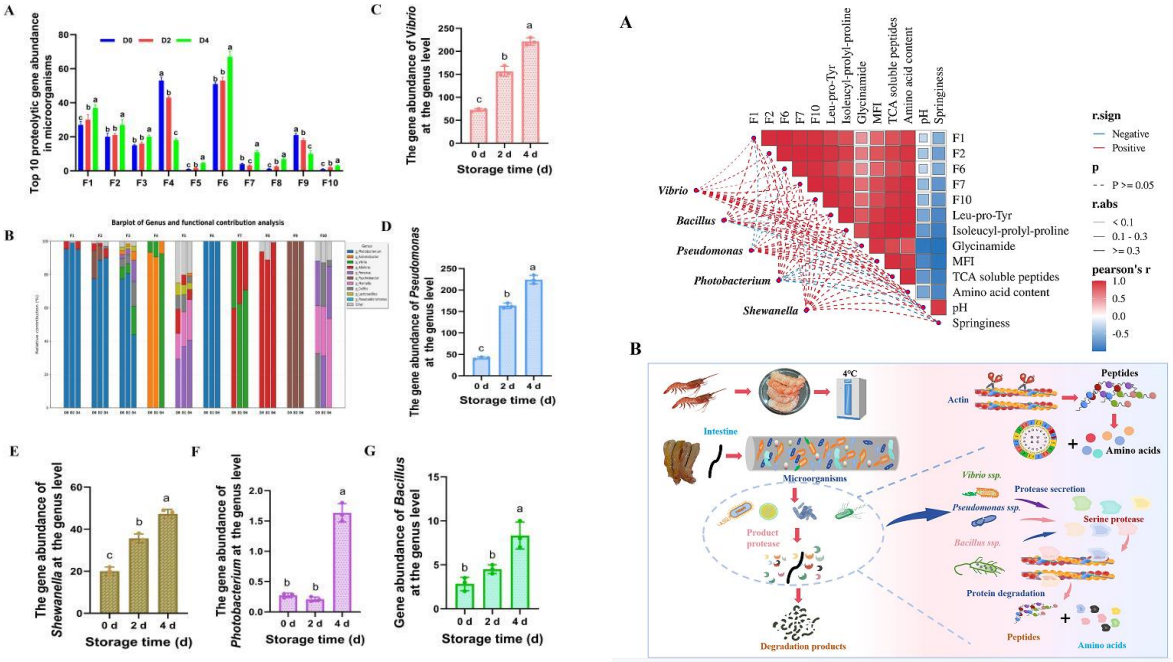


Fig.4


A
Top 10 proteolytic gene abundance in microorganisms
D0
D2
D4
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
C
The gene abundance of Vibrio at the genus level
Storage time (d)
B
Barplot of Genus and functional contribution analysis
D
The gene abundance of Pseudomonas at the genus level
Storage time (d)
E
The gene abundance of Shewanella at the genus level
Storage time (d)
F
The gene abundance of Photobacterium at the genus level
Storage time (d)
G
Gene abundance of Bacillus at the genus level
Storage time (d)

A
F1
F2
F6
F7
F10
Leu-pro-Tyr
Isoleucyl-prolyl-proline
Glycinamide
MFI
TCA soluble peptides
Amino acid content
pH
Springiness
Vibrio
Bacillus
Pseudomonas
Photobacterium
Shewanella
r.sign
Negative
Positive
p
P >= 0.05
r.abs
< 0.1
0.1 - 0.3
>= 0.3
pearson's r
1.0
0.5
0.0
-0.5
B
4℃
Intestine
Microorganisms
Product protease
Degradation products
Actin
Peptides
Amino acids
Vibrio ssp.
Protease secretion
Pseudomonas ssp.
Serine protease
Bacillus ssp.
Protein degradation
Peptides
Amino acids

Effects of oil type on the gelation characteristics and in vitro curcumin release behavior of tilapia myofibrillar protein/κ-carrageenan oligosaccharide emulsion gels

Li-Jing Xu[a], Yu-Zhen Qiu[a], Sai-Yi Zhong[a,b] Rui Li[a,*]

[a] College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Guangdong Province Engineering Laboratory for Marine Biological Products, Guangdong Provincial Engineering Technology Research Center of Seafood, Guangdong Provincial Engineering Technology Research Center of Prefabricated Seafood Processing and Quality Control, Guangdong Provincial Science and Technology Innovation Center for Subtropical Fruit and Vegetable Processing, Zhanjiang 524088, China

[b] Shenzhen Research Institute, Guangdong Ocean University, Shenzhen 518120, China

Abstract: Emulsion gels are theoretically ideal carriers for liposoluble bioactives. However, their potential has been limited by a lack of systematic comparisons of the interactions between oligosaccharide-modified proteins with different oil types. Therefore, this study fabricated tilapia myofibrillar protein (TMP)/κ-carrageenan oligosaccharide (κCOS) complex-stabilized emulsion gels and assessed them for curcumin (CUR) encapsulation and in vitro release. The effects on curcumin stability and bioavailability were investigated using oils differing in carbon chain length and unsaturation degree. Namely, medium-chain triglycerides, MCT; flaxseed oil, FO; Engraulis japonicus oil, EJO were chosen and yielded oil-in-water emulsion gels. As the oil volume fraction (φ) increased from 0.60 to 0.75, the storage modulus showed an increasing trend, whereas the optimal gel strength was achieved at φ = 0.7. At this φ, the CUR encapsulation efficiency ranked as CUR-MCT (95.92 ± 1.47%) > CUR-FO (93.10 ± 1.62%) > CUR-EJO (91.12 ± 1.03%). CUR-MCT exhibited superior photostability and thermal stability, evidenced by the highest retention rates of 47.15 ± 2.18% and 83.86 ± 1.24%, respectively. Curcumin bioavailability exhibited the same trend as free fatty acid release across the in vitro digestion process: CUR-MCT (52.20 ± 0.37%, 44.49 ±

1.63%) > CUR-FO (26.82 ± 0.63%, 27.92 ± 1.32%) > CUR-EJO (16.03 ± 0.18%, 20.27 ± 1.21%). Overall, the MCT-based emulsion gel demonstrated the best performance and is the optimal oil for TMP/κCOS complex-stabilized emulsion gel fabrication and curcumin delivery. This study provides theoretical insights towards the use of tilapia proteins and oligosaccharides and selection of oil for lipophilic bioactive delivery.

Key words: Delivery system; In vitro digestion; Oil type; Stability; Lipophilic bioactive

资助项目：

广东省基础与应用基础研究项目（2026A1515011668）

广东省高校重点研究项目（2025ZDZX2029）

通讯作者：

李瑞，女，博士，教授，研究方向：海洋生物制品研发及应用，13707552195，E-mail: lirui@gdou.edu.cn

Effects of Organic Acid Curing on Physicochemical Properties and Quality of Semi-Dried Grass Carp Fillets

Wan-jun HU[1], Rui-ying Lv[1], Ming-yu YIN[1], Xi-chang WANG[1], Qing-qing JIANG[1]*

1.College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

Abstract: This study investigated the effects of organic acid type and curing pH on the quality attributes of semi-dried grass carp fillets. L-Ascorbic acid, L-malic acid, and citric acid were used to adjust the pH of a glucose-containing NaCl curing solution to 6.0, 4.5, and 3.0, respectively. Grass carp fillets were cured in these solutions, then steamed and vacuum-dried. Compared with the control group, organic acid curing significantly decreased the pH, a^* value, and water activity, while significantly increasing the L^* value, salt content, and hardness of the semi-dried grass carp fillets ($p < 0.05$). Hardness generally decreased with decreasing curing pH, and protein solubility was lowest at pH 4.5. All organic acid treatments effectively inhibited lipid oxidation during curing and drying. A total of 36 volatile compounds were identified, including 13 esters, 4 alcohols, 5 aldehydes, 6 ketones, and 8 other compounds. However, the overall composition of volatile flavor compounds did not differ significantly among the curing pH treatments ($p > 0.05$). At a given pH, citric acid treatment resulted in higher contents of taste-active nucleotides and free amino acids and exhibited a more favorable volatile flavor profile. Overall, citric acid curing at pH 4.5 provided a favorable balance among product quality and flavor development. This study provides a basis for the application of organic acid curing in the processing and quality control of semi-dried grass carp products.

Key words: grass carp; organic acid; semi-dried product; physicochemical properties; flavor

资助项目：“十四五”国家重点研发计划（2022YFD2100902）

通讯作者：姜晴晴，女，博士，副教授，主要研究方向为水产品高质化加工与利用。联系电话 19821257396，邮箱 qqjiang@shou.edu.cn。

Effects of slaughter methods on energy metabolism, oxidative stress, apoptosis, and postmortem quality of brown-marbled grouper (*Epinephelus fuscoguttatus*) during cold storage

Penglei Yao[1]; Jing Xie[1, 2, 3, 4, 5, 6] *

[1] College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

[2] Key Laboratory of Aquatic Products High Quality Utilization, Storage and Transportation (Co-construction by Ministry and Province), Ministry of Agriculture and Rural Affairs

[3] National Experimental Teaching Demonstration Center for Food Science and Engineering Shanghai Ocean University, Shanghai 201306, China

[4] Shanghai Engineering Research Center of Aquatic Product Processing and Preservation, Shanghai 201306, China

[5] Shanghai Professional Technology Service Platform on Cold Chain Equipment Performance and Energy Saving Evaluation, Shanghai 201306, China

[6] Marine Biomedical Science and Technology Innovation Platform of Lin-gang Special Area, Shanghai, China

Abstract: [Objective]: This study evaluated the effects of five slaughter methods on energy metabolism, oxidative stress, apoptosis, and quality of brown-marbled grouper during cold storage. [Methods]: Fish were subjected to gill cutting (T1), percussion (T2), CO_2 anesthesia followed by percussion (T3), CO_2 anesthesia (T4), or gradual cooling (T5), and muscle was stored at 4 °C for 0–72 h. Serum cortisol (COR), lactate dehydrogenase (LDH), and glucose (GLU) were measured at 0 h. Muscle ATP and related compounds, lactate, glycogen, pH, reactive oxygen species (ROS), apoptosis, caspase-3 activity, texture, and myofibril fragmentation index (MFI) were assessed during storage. Catalase (CAT) and superoxide dismutase (SOD) activities were determined only at 0 h, and untargeted metabolomics was used to compare T1 with T5. [Results]: T1 showed higher COR, LDH, and GLU, faster ATP and glycogen depletion, generally higher lactate, ROS, apoptosis, caspase-3 activity, and MFI, lower pH, and poorer texture. In contrast, T5 exhibited lower slaughter stress, slower energy depletion, and better texture retention. Higher CAT activity in T1 at 0 h may

reflect an acute compensatory response to oxidative stress, whereas higher SOD activity in T5 was consistent with its lower ROS levels. Metabolomics revealed distinct postmortem metabolic trajectories, with energy and redox metabolism showing sustained differences between treatments. [Conclusion]: Overall, slaughter by gradual cooling better maintained postmortem muscle metabolic homeostasis and delayed quality deterioration during cold storage.

Keywords: Slaughter methods; Brown-marbled grouper; Energy metabolism; Oxidative stress; Apoptosis

资助项目：国家重点研发计划项目“养殖鱼类加工与质量安全控制关键技术与装备”课题 2“养殖鱼类生态保鲜保活与物流品质监控关键技术研究”（2023YFD2401402）。

通讯作者：谢晶，女，博士，教授，水产品保鲜，15692165513，jxie@shou.edu.cn

Enhancement of Gelation and Protein Interactions in Low-Salt Shrimp Gels via Static Magnetic Field Coordinated with Microcrystalline Cellulose

Chunyu Li[1,2], Siyang Liu[1,2], HuamaoWei[1,2*]

1. College of Food Science and Engineering, Ningbo University, Ningbo 315211, China
2. Zhejiang Key Laboratory of Intelligent Food Logistic and Processing, Zhejiang-Malaysia Joint Research Laboratory for Agricultural Product Processing and Nutrition, Ningbo University, Ningbo 315211, China

Abstract

With the purpose of developing low-salt shrimp gel products, the present study explored the influence of the low-temperature static magnetic field (LT-SMF) pre-gelation process combined with the additions of microcrystalline cellulose (MCC) on the gel quality enhancement and its mechanism. LT-SMF process was used to treat the shrimp gels, and different proportions of MCC were added to evaluate the gels via textural properties, drip loss and water distribution, protein properties, and microstructure with molecular docking method. The results suggested that an MCC addition of 0.6% significantly enhanced the hardness, chewiness, and springiness of the shrimp gels, reduced drip loss, and improved water holding capacity. SDS-PAGE analyses and FTIR analysis indicated that the combined LT-SMF and MCC treatment synergistically promoted the formation of β-sheet structures in proteins and facilitated the cross-linking of the myosin heavy chain (MHC), thereby leading the stability of the gel network enhanced. The microstructural results indicated that the collaborative-treated gel network became more uniform and denser. Molecular docking simulations further revealed the stable binding mechanism between biosaccharides in MCC and MHC in shrimp. This study provides a new insight into the development of low-salt shrimp gel products and offers significant theoretical and practical value.

Key words: Low-temperature static magnetic field; shrimp gel; microcrystalline cellulose; protein properties; water distribution.

Funding

This work was financially supported by the National Natural Science Foundation of China (32102024), China.

通讯作者介绍：

魏华茂

男，博士，特聘副研究员

研究方向：1.水产品精深加工与高值化利用；2.水产品贮藏与保鲜。

联系方式：+86-0574-87604388；weihuamao@nbu.edu.cn

Enhancing the flavor profiles of sheep bone soup by supplementing Solen grandis meat

Zheng Yuqi[1,2], Liu Liang[1,2], Liang Hongxia[1], Zheng Jie[2], Song Zhiyuan[1*]

1. College of Food Science and Engineering, Dalian Ocean University, Dalian 116023, Liaoning; 2. Liaoning Ocean and Fisheries Science Research Institute, Dalian 116023, Liaoning

Abstract : [Objective] Sheep bone soup (SBS) is well received but is hindered by a lack of flavor richness and mutton odor, limiting its sensory quality and market acceptance.This study used *Solen grandis* meat as a flavor-improving raw material andinvestigated the effects of different addition levels on the non-volatile organic compounds (NVOCs) and volatile organic compounds (VOCs) of SBS; [Methods] *S. grandis* meat was added to SBS at 50, 75, 100, and 125 g (SBS-SG1-SBS-SG4). SBS without *S. grandis* served as the control (SBS-F), and *S. grandis* soup (SGS) was included as a reference. Physicochemical indices and taste-active compounds were determined, taste profiles were evaluated using an electronic tongue (E-tongue), and VOCs were characterized via gas chromatography-ion mobility spectrometry (GC-IMS), followed by correlation analysis between NVOCs and VOCs; [Results]The results indicated that adding *S. grandis* significantly reduced the pH and elevated the contents of soluble solids, total amino acids, and taste-active compounds in SBS ($P < 0.05$). E-tongue analysis verified that the composite soups possessed remarkably higher umami intensity and richness than SBS, without affecting the original taste attributes of sourness, sweetness, saltiness, and bitterness. Altogether, GC-IMS detected 68 VOCs, among which aldehydes were the dominant aroma components. SBS-SG3 had the highest relative total aldehydes content, with abundant sulfur-containing volatile substances that effectively masked the mutton off-odor of SBS. Correlation analysis demonstrated that flavor synergy between umami amino acids and nucleotides was reinforced under low-to-medium supplementation levels (50-75 g), while the abundant correlations between NVOCs and VOCs, achieving optimal flavor balance, were observed in the SBS-SG3; [Conclusion] SBS-SG4 had the highest equivalent umami concentration, whereas SBS-SG3 showed a more coordinated profile of taste-active and volatile flavor compounds. These results suggest that the addition of 100 g of *S. grandis* meat may provide a suitable balance between

umami intensity and aroma characteristics. These findings clarify the material basis of *S. grandis*-induced flavor improvement and provide theoretical data for intensive shellfish processing and the innovative exploitation of composite ready-to-cook seafood soups.

Key words: *Solen grandis*; sheep bone soup; non-volatile flavor compounds; volatile flavor compounds; umami synergism

基金项目: 辽宁省自然科学基金（2026-MS-342）

通讯作者: 宋志远，女，博士，讲师，研究方向为水产品加工，电话：13842897231，E-mail: songzhiyuan@dlou.edu.cn

Environmental salinity shapes nutritional quality and taste components of mud crab *Scylla paramamosain* from two natural habitats in eastern Guangdong of China

Yongyi Chen [1, 2, 3, #], Zhiwei Li [1, 2, 3, #], Douglas R. Tocher [1], Óscar Monroig [4], Harold Corke [5], Mhd Ikhwanuddin [2, 3, 6], Hongyu Ma [1, 2, 3, *], Ye Yuan [1, 2, 3, *]

[1] Guangdong Provincial Key Laboratory of Marine Biotechnology, Shantou University, Shantou 515063, China

[2] International Joint Research Center for the Development and Utilization of Important Mariculture Varieties Surrounding the South China Sea Region, Shantou University, Shantou 515063, China

[3] STU-UMT Joint Shellfish Research Laboratory, Shantou University, Shantou 515063, China

[4] Instituto de Acuicultura de Torre de la Sal (IATS), CSIC, Castellón, Spain

[5] Biotechnology and Food Engineering Program, Guangdong Technion-Israel Institute of Technology, Shantou 515063, Guangdong, China

[6] Higher Institute Centre of Excellence (HICoE), Institute of Tropical Aquaculture and Fisheries, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

Abstract: Environmental salinity alters the nutritional quality and taste of mud crab *Scylla paramamosain*, affecting consumer purchasing behavior. We designed a comparative study on two salinity habitats (Niu Tian Yang, NTY, ≈2‰; Zhelin Bay, ZLB, ≈22‰) in eastern Guangdong, examining the proximate composition, collagen, amino acids, fatty acids, free amino acids, and nucleotides in the hepatopancreas, body and appendicular muscles of mud crab. Results revealed that NTY crabs had significantly higher content of lipid in the hepatopancreas compared to ZLB crabs. NTY crabs accumulated significantly higher contents of collagen and n-3 long-chain polyunsaturated fatty acids in body and appendicular muscles, while ZLB crabs had significantly higher levels of most amino acids in muscles. Muscle tissues were mainly composed of sweet free amino acids, while the hepatopancreas contained more bitter one. The ZLB crabs had significantly higher equivalent umami concentration in all three edible parts. These findings demonstrate that high-salinity environments enhance umami flavor, whereas low-salinity conditions favor collagen deposition and n-3 LC-PUFA enrichment. Overall, this study provides a scientific basis for optimizing

aquaculture salinity management to balance consumer preferences for nutrition and taste.

Keywords: *Scylla paramamosain*; salinity; amino acids; n-3 long-chain polyunsaturated fatty acids

基金：国家自然科学基金（42306125）；广东省科技计划项目（2026A0202020022, STKJ2024044）

通讯作者：

马洪雨，男，博士，1979 年出生，山东招远人，教授，主要从事海洋经济动物养殖与育种学研究，15917902158，mahy@stu.edu.cn

袁野，男，博士，1991 年出生，安徽六安人，副教授，主要从事海水蟹脂质营养生理及代谢调控机制研究，13502931635，yeyuan@stu.edu.cn

Flavor formation and metabolic transformation during mixed microbial fermentation of rapidly fermented low-salt fish sauce from mandarin fish viscera

Jiali Lu, Xinhui Huang, Juanjuan Xian, Guoping Wu, Chan Zhong

College of Food Science and Engineering, Jiangxi Agricultural University, Nanchang 330045, Jiangxi, China

Abstract: Low-salt fish sauce produced via traditional fermentation suffers from the uncontrolled proliferation of spoilage microorganisms, excessive biogenic amine accumulation, and inferior flavor quality, which severely limits its industrial-scale production and application. In this study, a mixed microbial fermentation system consisting of *Tetragenococcus halophilus, Debaryomyces hansenii,* and *Bacillus subtilis* was constructed to rapidly prepare low-salt fish sauce (10%, w/v salt) from mandarin fish viscera within 30 days. The results demonstrated that the mixed microbial fermentation markedly improved the safety and quality of the fish sauce product. Specifically, the final amino acid nitrogen content reached 1.033 g/100 mL, the umami amino acid content increased by 12.19%, while the volatile basic nitrogen content decreased by 35.48%. Meanwhile, the total biogenic amine content was reduced to 340.50 mg/kg, which was substantially lower than the 498.22 mg/kg detected in the control group. A total of 33 aroma-active compounds with odor activity values (OAV > 1) were identified via GC-MS-based flavoromics analysis. The synergistic accumulation of aldehydes, heterocyclic compounds, alcohols and esters jointly contributed to the characteristic aroma of rapidly fermented mandarin fish viscera fish sauce. Untargeted metabolomics analysis based on UPLC-QTOF-MS detected 1825 metabolites, of which 388 differential metabolites (VIP > 1.5, $P < 0.05$) were mainly classified as lipids, organic acids, and oxygenated organic compounds. Correlation analysis further indicated that the mixed microbial consortium promoted flavor maturation via synergistic proteolysis, amino acid and lipid metabolism. The multi-omics analysis elucidated the synergistic metabolic and flavor-forming mechanism of mixed microbial co-fermentation, providing a theoretical basis for the high-value utilization of aquatic processing by-products and industrial quality optimization of rapidly fermented low-salt fish sauce.

Key words: Rapid fermentation; Low-salt fish sauce; Mixed starters; Flavor formation; Metabolomics

基金项目：江西省农业农村厅名特优水产品产业技术体系专项基金（JXARS-15）；国家自然科学基金项目（32460618，32260610）

FPVGR-Pn3G 协同复合物抑制 DPP-IV 的作用机制及其消化吸收特性

陈忠琴[1,2*]，苏小洁[1]，吴碧怡[1]，曹文红[1,2]，高加龙[1]，朱国萍[1]，谭明堂[1]

1（广东海洋大学 食品科技学院，国家贝类加工技术研发分中心（湛江），广东省水产品加工与安全重点实验室，广东省海洋生物制品工程实验室，广东省海洋食品工程技术研究中心，广东省水产预制食品加工与品质控制工程技术研究中心，广东 湛江，524088）

2（广东海洋大学深圳研究院，广东 深圳，518120））

摘要：【目的】探究牡蛎源五肽FPVGR（FR）与花青素芍药素-3-O-葡萄糖苷（Pn3G）协同抑制二肽基肽酶IV（DPP-IV）的作用机制及其复合物的消化吸收特性，为开发天然来源的2型糖尿病防治功能性食品组分提供理论依据。【方法】通过优化浓度比、pH、时间和温度制备FR-Pn3G复合物；采用紫外可见光谱、荧光光谱、傅里叶变换红外光谱（FTIR）、分子对接及分子动力学模拟表征二者互作机制；利用CompuSyn软件计算联合指数（CI）评价二者协同效应，结合荧光猝灭、酶抑制动力学及分子动力学模拟技术解析DPP-IV抑制机制；通过体外模拟胃肠消化和Caco-2细胞单层模型评估复合物的消化稳定性与肠吸收特性。【结果】FR与Pn3G通过氢键、疏水力及π-π堆积形成稳定复合物，呈现辅色效应。CI值均低于0.9，证实二者具有协同抑制DPP-IV的作用，且复合物表现为混合型抑制模式（竞争+非竞争）。经胃肠消化后，复合物DPP-IV抑制活性保留率达96.42%，为单独Pn3G的1.81倍；复合物在Caco-2细胞中的吸收率为21.96%，分别为Pn3G和FR的3.46倍和1.50倍（$P<0.05$）。【结论】FR-Pn3G复合物通过多种非共价力稳定结合，实现对DPP-IV的协同抑制，并显著提升消化稳定性和肠吸收效率，在口服功能性降糖食品领域具有良好的开发与应用前景。

关键词：牡蛎五肽；芍药素-3-O-葡萄糖苷；DPP-IV；协同抑制；消化稳定性

基金项目：国家自然科学基金项目（32201971）；广东省基础与应用基础研究基金（2024A1515011763）；湛江市科技计划项目（2021E05017）；现代农业产业技术体系专项资金资助（CARS-49）.

第一作者：陈忠琴，女，博士，副教授，研究方向：海洋食品营养与功能。电话：15122120857. E-mail：chenzhongqin@gdou.edu.cn）

Fractional Extraction and Lipid Profile Characterization of *Procambarus clarkii* Oil via Non-targeted Lipidomics

JianZHANG[12]， YangLI[12] , MingYuYIN[12*]， XiChangWANG[12*]

[1] College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

[2] Shanghai Engineering Research Center of Aquatic-Product Processing and Preservation, Shanghai 201306, China

Abstract: This study employed ultrasound-assisted hexane extraction (UAHER) to fractionally extract lipids from the enzymatic hydrolysis residue of *Procambarus clarkii* heads, and analyzed lipid composition dynamics using non-targeted lipidomics. Response surface methodology optimized the conditions to a solid-liquid ratio of 1:5.3, ultrasonic time of 21 min, and power of 320 W, achieving a high actual oil recovery of 94.12%. Furthermore, the total lipid yield (2.21%) was higher than that of the Folch method (2.10%). The physicochemical properties of the extracted oil met the secondary crude fish oil standards. Fatty acid profiling demonstrated that, compared to singular enzymatic hydrolysis (HEH), hexane extraction of the residue (HER), and chloroform-methanol extraction (CMER), UAHER significantly enhanced polyunsaturated fatty acids (PUFA) while effectively retaining EPA and DHA (1.86%). Furthermore, lipidomic analysis revealed that the secondary hexane extraction was the core factor remodeling the lipid profile. Ultrasonic cavitation did not uniformly increase all lipids; rather, it specifically facilitated the release of complex structural lipids, significantly upregulating subclasses such as diacylglycerols (DG), diacylglyceryl trimethylhomoserines (DGCC), ether-linked phosphatidylinositols (EtherPI), and sphingomyelins (SM). Notably, complex molecules like DGCC(33:5) and glycosylated sterol ST(29:1;O;Hex;FA(22:0)) were maximally enriched. In conclusion, UAHER achieves highly efficient lipid recovery and specifically enriches high-value functional lipids, providing a reliable theoretical and practical foundation for the valorization of aquatic processing by-products.

Keywords: Fractional extraction; Ultrasound; Enzymatic hydrolysis; Lipidomics; Polyunsaturated

fatty acids.

Funding: This research was financially supported by grants from the National Key Research and Development Program of China (2023YFD2401503)

Corresponding author: Xichang Wang, male, Ph.D.,Professor. Research interests: Aquatic Product Processing and Storage Engineering、Food Nutrition and Flavor Analysis, and Quality Evaluation and Control. E-mail: xcwang@shou.edu.cn.

MingYuYIN, male, Lecturer, Research interests: Marine bioactive lipids and lipidomics; lipids and nutritional quality of aquatic products.Stabilization and delivery of nutritional functional factors.Research and development of nutritional health foods based on the concept of marine and terrestrial resource integration. E-mail: myyin@shou.edu.cn

From internal degradation to quality deterioration: Lipid peroxidation-induced protein changes in sea bass (Lateolabrax japonicus) during storage revealed by multi-omics

Xinyang Li[1], Xiaoguo Ying[1], Bin Zhang[1*], Shanggui Deng[1], Gengsheng Xiao[1], Yujuan Xu[2], Soottawat Benjakul[3], Xiuzhu Yu[4], Lukai Ma[2*]

1. Zhejiang Provincial Key Laboratory of Health Risk Factors for Seafood, Collaborative Innovation Center of Seafood Deep Processing, College of Food and Pharmacy, Zhejiang Ocean University, Zhoushan 316022, China

2. College of Light Industry and Food, Zhongkai University of Agriculture and Engineering/Key Laboratory of Green Processing and Intelligent Manufacturing of Lingnan Specialty Food, Ministry of Agriculture and Rural Affairs/Guangdong Provincial Key Laboratory of Lingnan Specialty Food Science and Technology, Guangzhou 510225, China

3. Faculty of Agro-Industry, International Center of Excellence in Seafood Science and Innovation, Prince of Songkla University, Songkhla, Thailand

4. Research Center of Grain and Oil Functionalized Processing in Universities of Shaanxi Province, College of Food Science and Engineering, Northwest A&F University, 22 Xinong Road, Yangling 712100, Shaanxi, China

Abstract： This study revealed that during frozen storage of sea bass, reactive carbonyl species from oxidized visceral lipids migrated into the muscle, inducing “lipid-protein co-oxidation.” In viscera-containing (CV) samples, myofibrillar protein carbonyl content increased by 108.26%, Ca^{2+}-ATPase activity decreased by 50.9%, and total sulfhydryl content declined by 13.44%. Visceral lipid oxidation also altered free amino acid profiles, elevating bitter-tasting histidine and lysine while reducing sweet proline and glycine, which was consistent with electronic tongue results showing enhanced umami but reduced sweetness. Volatile analysis indicated enriched hydrocarbons and aldehydes in CV group. Proteomics identified 140 differentially expressed proteins, mainly associated with immune and structural functions, with KEGG enrichment highlighting PPAR signaling and immune pathways. Notably, immune proteins exhibited pronounced degradation. This, combined with the breakdown of structural proteins, accelerated muscle quality deterioration.

Keywords: Lipid oxidation, Reactive carbonyl, Volatile metabolomics, Proteomics, Immune proteins

通讯作者：

姓名：张宾

性别：男

学位：博士

职称：教授

研究方向：1. 水产品加工物质基础；2. 水产品保鲜与品质安全；3. 水产动物养殖与营养调控（水产品加工及贮藏）

电话：15158157652

资助项目：广东省重点领域研发计划（2023B0202080003）；国家自然科学基金（32302135、32472272）；浙江省“先锋”“领头雁”研发计划（2023C02006）；广东省现代农业产业共性关键技术创新团队（加工与保鲜共性关键技术，2024CXTD16）；舟山市重大工业研究项目（2024C0101、2025C03006）

Fucoidan oligosaccharides from *Kjellmaniella crassifolia* ameliorate ulcerative colitis by regulating the TLR4 and NF-κB signaling pathway and modulating gut microbiota

Zhiying Xu [1#], Zheyu Jia [1#], Liu Li [1], Feiyan Zeng [1], Jiyan Sun [1], Yichao Ma [1,2,3], Wenzheng Shi [4], Shu Liu [1,2,3], Yunhai He [1,2,3], Qiukuan Wang [1,2,3] and Dandan Ren [1,2,3]*

[1] College of Food Science and Engineering, Dalian Ocean University, Dalian, PR China

[2] National R & D Branch Center for Seaweed Processing, Dalian, PR China

[3] Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian , China

[4] College of Food Sciences & Technology, Shanghai Ocean University, Shanghai, China

* Correspondence: rendandan@hotmail.com

[#] These authors contributed equally to this work.

Abstract

Ulcerative colitis (UC) is a form of Inflammatory Bowel Disease (IBD), which is marked by severe abdominal pain, weight loss, perianal bleeding, and diarrhea. This study successfully isolated and purified four low-molecular-weight fucoidan oligosaccharides through acid hydrolysis and Bio Gel P10 gel filtration. The molecular weights were $2.9 \times 10^4 – 1.36 \times 10^5$ Da, 182 – 1012Da, 161 – 939Da and 161 –939Da, respectively. A mouse model of colitis was induced using Dextran Sulfate Sodium (DSS). The results indicated that fucoidan and fucoidan oligosaccharides could ameliorate murine ulcerative colitis, with the oligosaccharides (200mg/kg/d) demonstrating superior therapeutic effects. This superiority was likely attributed to the lower molecular weight and higher content of total sugars and fucose. The primary mechanisms involved the modulation of gene and protein expression levels associated with the Toll-like receptor 4, Myeloid differentiation primary response 88, Nuclear Factor kappa-light-chain-enhancer of activated B cells, p65, and Inhibitor of kappa light polypeptide gene enhancer in B-cells, alpha (TLR4, MYD88, NF-κB p65, and IκB-α) signaling pathways，which reduce the production of inflammatory cytokines such as Tumor Necrosis Factor-alpha, Interleukin-1 beta and Interleukin-6 (TNF-α, IL-1β, and IL-6). Additionally, these oligosaccharides alleviated oxidative stress, enhanced the levels of intestinal barrier proteins (Claudin family member 4 and Zonula occludens protein 1), regulated the abundance and diversity of the gut microbiota, and increased the levels of short-chain fatty acids (SCFAs) in the intestine. It is worth emphasizing that this study can only demonstrate that fucoidan oligosaccharides have a mitigating effect on intestinal

inflammation in mice. Further research is needed in the future to investigate the structure-activity relationship of fucoidan oligosaccharides and their impact on human intestinal microbiota, in order to further elucidate their anti-inflammatory mechanisms.

Keywords: Fucoidan; Fucoidan oligosaccharides; Ulcerative colitis; Anti-inflammatory mechanism; Gut microbiota

Glycosylated fish collagen peptides with different degrees of modification: effects on gelation properties and volatile flavor of tilapia surimi

Shiyu Qiu [1, 2], Jianwei Cen [1], Huan Xiang [1], Shuxian Hao [1], Ya Wei [1], Chunsheng Li [1], Xiao Hu [1], Jun Li [4], Yongqiang Zhao [1, 3,] Hui Huang [1,*]

1.Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, China

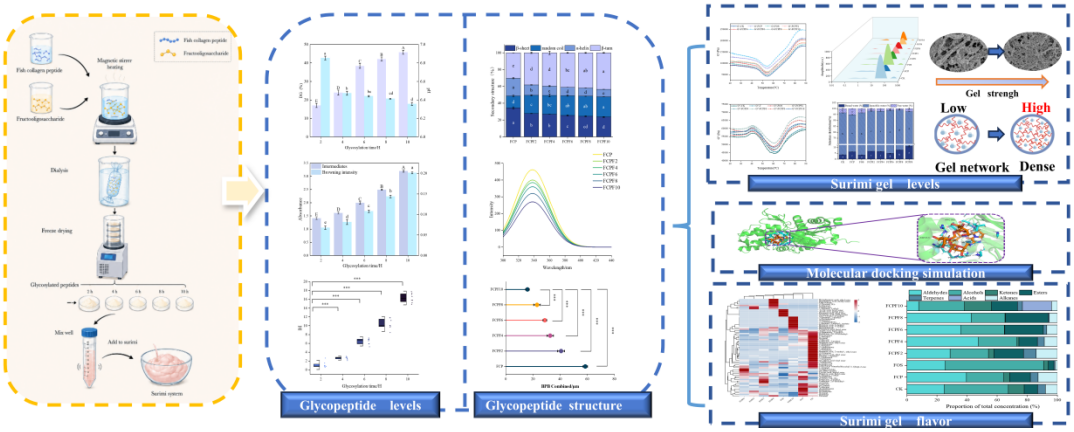
2.College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

3.Key Laboratory of Efficient Utilization and Processing of Marine Fishery Resources of Hainan Province, Sanya Tropical Fisheries Research Institute, Sanya, China

4.Guangdong Provincial Key Laboratory of Lingnan Specialty Food Science and Technology, Key Laboratory of Green Processing and Intelligent Manufacturing of Lingnan Specialty Food, Ministry of Agriculture and Rural, College of Light Industry and Food, Zhongkai University of Agriculture and Engineering, Guangzhou 510225, China

Abstract :This study investigates how glycosylation time of fish collagen peptides affects the quality and flavor of tilapia surimi. Increased glycosylation altered peptide secondary structure (β-turn and random coil), while fluorescence intensity and surface hydrophobicity decreased progressively ($p<0.05$). Incorporating glycosylated peptides into surimi strengthened protein–protein and protein–water interactions, improving gel strength, texture, WHC, and rheological properties, and producing a more homogeneous gel network. The 6 H glycosylated peptides showed the most pronounced improvements, including higher WHC, greater gel strength, and more stable water distribution. These peptides also enhanced flavor: decreased unsaturated alcohols reduced fishy odor and lipid oxidation off-flavors, while enrichment of low-molecular-weight esters imparted a fresher, fruity aroma. Excessive glycosylation, however, impaired gel performance and flavor. Molecular docking confirmed hydrogen bonding as a key driving force in complex formation. Overall, moderate glycosylation markedly improved surimi gel functionality, offering an effective strategy for utilizing fish collagen peptides.

Key words : Glycosylated peptides, Tilapia surimi, Gel properties, Molecular docking, Volatile flavor compounds



Green and efficient extraction of fish oil: Quality optimization based on a deep eutectic solvent method

Xiaoguo Ying[a,1], Chenyang Zhao[a,1], Bin Zhang[a,*], Chuandong Fang[a], Shanggui Deng[a], Lukai Ma[b,*]

a Zhejiang Provincial Key Laboratory of Health Risk Factors for Seafood, Collaborative Innovation Center of Seafood Deep Processing, College of Food and Pharmacy, Zhejiang Ocean University, Zhoushan 316022, China

b College of Light Industry and Food, Zhongkai University of Agriculture and Engineering/Key Laboratory of Green Processing and Intelligent Manufacturing of Lingnan Specialty Food, Ministry of Agriculture and Rural Affairs/Guangdong Provincial Key Laboratory of Lingnan Specialty Food Science and Technology, Guangzhou 510225, China

1 These authors contributed equally to this work and are considered as co-first authors.

* Corresponding authors.

Abstract：The efficient extraction of high-quality fish oil with desirable sensory characteristics remains challenging owing to the limitations of conventional techniques such as Soxhlet extraction and enzymatic hydrolysis. In this study, we developed an ultrasound-assisted deep eutectic solvent method (DESM) for extracting bluefin tuna oil and compared its quality and flavor with oils extracted using traditional Soxhlet extraction (SEM) and enzymatic hydrolysis (EH) methods. Through process optimization, the optimal extraction conditions were determined as:ultrasonication temperature of 60 ℃, duration of 60 min, power of 200 W, and a solid-to-liquid ratio of 1∶10 (*W/W*). Analyses using an electronic nose, electronic tongue, and volatile compound profiling indicated that the flavor profile of DESM-extracted fish oil was more diverse than that of SEM-extracted oil. Additionally, DESM-extracted oil contained compounds such as caryophyllene and 2-methyl-1-undecanol, which imparted a light greasy taste and a distinctive aroma. In contrast, undesirable odors, including greasy hexanal, strongly greasy 2-hexenal, and bitter almond-like benzaldehyde, were significantly reduced. However, these results reflect instrumental flavor differences rather than direct sensory preference. These findings suggest that DESM has potential for further development as a green fish oil extraction strategy, although additional validation of solvent residue control,

storage stability, and sensory acceptability is still required.

Keywords: Deep eutectic solvents; Fish oil extraction; Process optimization; Volatile components

通讯作者：

张宾，男，博士，教授职称：副教授，主要从事水产品加工物质基础方面的研究，Email：zhangbin@zjou.edu.cn

马路凯，男，博士，副教授，主要从事油脂营养与安全相关方面的研究，Email: malukai@zhku.edu.cn

资助项目：本研究由国家自然科学基金项目(32472272 , 32302135)、广东省重点领域研发计划项目(2023B0202080003)、广东省现代农业产业共性关键技术创新研究团队建设项目(常见的加工和保存关键技术) (2026CXTD16)和舟山市级重大产业科技攻关项目(2023C03006)的资助。

Halogenated Natural Products in Various Tropical Reef Fish Species

Qiong Wu[1,2]，Catherine Munschy[3]，Nathalie Bodin[4]，Walter Vetter[2*]

1. State Key Lab of Marine Food Processing & Safety Control, National Engineering Research Center of Seafood, School of Food Science and Technology, Dalian Polytechnic University, Dalian, 116034, China; 2. University of Hohenheim, Institute of Food Chemistry (170b), Garbenstraße 28, Stuttgart, D-70599, Germany;3.Ifremer, CCEM Contamination Chimique des Ecosystèmes Marins, Nantes, F-44000, France;4. SFA (Seychelles Fishing Authority), Fishing Port, Victoria, Mahé, Seychelles.

Abstract: More than 8,000 halogenated natural products (HNPs) have been documented, and approximately 10 classes are structurally similar to POPs and are persistent and bioaccumulative; in some marine biota, HNPs can occur at levels up to two orders of magnitude higher than POPs, leading AMAP to identify them as emerging contaminants in 2016. This study investigated HNPs in 17 tropical reef fish species from nearshore Seychelles, a potential HNP hotspot, using ICES-PCBs for comparison. Fish collected between 2014 and 2018 were analyzed for muscle lipids by accelerated solvent extraction with dichloromethane, followed by purification using gel permeation chromatography, silica and alumina columns, and two-dimensional HPLC. HNPs (mainly 2′-MeO-BDE 68, 6-MeO-BDE 47, 2,4,6-TBP, 2,4,6-TBA, Q1, and MHC-1) and ICES-PCBs (PCBs 153, 138, 180, 118, 101, 28, and 52) were quantified by GC/ECNI-MS. ΣHNP concentrations ranged from 9.5 to 1000 ng/g lipid mass (lm), whereas ICES-PCBs were only 0.2–4.7 ng/g lm, similar to previous reports for Seychelles swordfish and tuna. The much higher and widely variable ΣHNP levels indicate the occurrence of HNP hotspots and an inconsistent presence and distribution of HNP producers. Polybrominated HNPs, especially 2′-MeO-BDE 68, 6-MeO-BDE 47, and 2,4,6-TBP, dominated the HNP profile; Q1 contributed <10% to ΣHNPs, and MHC-1 (<LOQ–16 ng/g lm) was within the ICES-PCB range. Overall, HNPs, mainly MeO-BDEs, were much higher than major POP classes in tropical reef fish from nearshore Seychelles and may represent a new threat to marine food safety in FAO fishing area 51.5.

Key words: Halogenated natural products (HNPs)、Tropical reef fish、MeO-BDEs、Marine food safety

Funding: Natural Science Foundation of China (32402251), Liaoning Provincial Science and Technology Plan Joint Program (2025-MSLH-047).

第一作者介绍：吴琼、男、博士、讲师、食品中新污染物的感知预警与评价、15998678404、qiong.wu@dlpu.edu.cn.

Improving the Quality of Surimi Powder Produced by an Innovative Low-temperature Spray-drying Process Using Thermal Protectants: A Comparative Evaluation of Protein Structure and Gel Properties

Xueting CAO[1], Long ZHANG[1*]

1.College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

Abstract: To improve protein structural stability during low-temperature spray drying and enhance the gel properties of rehydrated surimi gels, this study systematically evaluated the effects of maltodextrin, sucrose, pregelatinized cassava starch, lecithin, and ATP on the physicochemical properties of surimi powder and the quality of rehydrated gels. Compared with the control, ATP and sucrose increased solubility by approximately 41.99% and 36.15%, respectively. They also increased the absolute zeta potential by approximately 43.95% and 29.07%, respectively, while reducing surface hydrophobicity by approximately 70.76% and 52.42%, respectively ($P < 0.05$). After rehydration and heating, the storage modulus (G') at 90°C increased by approximately 28% and 25% in the ATP and sucrose groups, respectively. Water-holding capacity (WHC) increased by approximately 28.27% and 21.79%, respectively. The proportion of immobilized water increased by approximately 8.82% and 7.62%, and gel strength increased by approximately 24.80% and 18.63%, respectively ($P < 0.05$). These changes contributed to the formation of a denser gel network, indicating enhanced intermolecular interactions and interfacial properties of surimi myofibrillar proteins. XRD, XPS, FTIR, SDS-PAGE, intrinsic fluorescence, and sulfhydryl/disulfide bond analyses showed that the protectants modulated protein conformation, molecular packing, and surface chemical composition. Combined with microstructural observations, these results indicated that ATP was the most effective protectant in alleviating protein denaturation and aggregation. Molecular docking further confirmed the stronger binding affinity of ATP for myosin and actin. Therefore, ATP showed greater application potential in this system and could serve as a novel

protectant for improving the quality of low-temperature spray-dried surimi powder.

Keywords: Surimi powder; Low-temperature spray drying; ATP; Protein structure; Gel properties

Funding: This study was supported by the National Key Research and Development Program of China (2022YFD2100901) and a general project of R&D and industrialization demonstration of marine fish protein processing technology (No. D-8006-21-0126).

Corresponding author: Long ZHANG, male, Ph.D., Associate Professor. Research interests: quality evaluation and regulation of aquatic products; processing and comprehensive utilization of aquatic products. Tel: +86-13127805520; E-mail: l-zhang@shou.edu.cn.

Influence of Fermented Feed on the Volatile Flavor Profile of *Procambarus clarkii* (Crawfish) through Alterations in Nutritional Components and Fatty Acid Metabolism

Meijiao Gui [a], Wanxin Xie [a], Mengli Han [a], Wenzheng Shi [a], Rong Zhu [b], Shaicheng Zhu [b*], Xugan Wu [b,c*]

a. College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

b. Centre for Research on Environmental Ecology and Fish Nutrition of the Ministry of Agriculture and Rural Affairs, Shanghai Ocean University, Shanghai 201306, China

c. National Demonstration Centre for Experimental Fisheries Science Education, Shanghai Ocean University, Shanghai 201306, China;

Abstract: This study investigated quality changes in crayfish (*Procambarus clarkii*) meat and hepatopancreas when fed fermented cooked corn (FCM), fermented mixed ingredients (FMI), or compound feed (CF), focusing on nutritional composition and flavor to evaluate the best farming methods. Results showed that the FCM diet yielded (21.5%) the highest edible yield ($P<0.05$). The CF diet had no advantage in meat crude protein or hepatopancreas coloration. All groups had muscle tissue EAA/TAA and EAA/NEAA ratios above the standard, indicating sufficient essential amino acid availability. Fatty acid composition revealed that meat quality significantly surpassed that of the hepatopancreas. Fermented feeds reduced hepatopancreas bitterness, enhanced meat umami, and enriched volatile flavors. Thus, FCM is optimal for improving product quality and reducing feed costs.

Keywords: Freshwater Crayfish (*Procambarus clarkii*), Nutritional composition, Flavor Characteristics, Fermented feed

资助项目：

亚洲区域合作基金澜沧江-湄公河流域农业合作项目（编号：18240066）；

安徽宝洁生物科技有限公司研发项目（编号：D-8006-25-0129）。

通讯作者：

Shaicheng Zhu, Dr.

Centre for Research on Environmental Ecology and Fish Nutrition of the Ministry of Agriculture and Rural Affairs, Shanghai Ocean University

No.999 Hucheng Huan Road, Shanghai, P.R. China 201306

E-mail: sczhu@shou.edu.cn

Xugan Wu, Prof.

Centre for Research on Environmental Ecology and Fish Nutrition of the Ministry of Agriculture and Rural Affairs, Shanghai Ocean University

No.999 Hucheng Huan Road, Shanghai, P.R. China 201306

E-mail: xgwu@shou.edu.cn

Interaction Mechanism of Protein Changes and Microbial Metabolism in Chinese hook snout carp (*Opsariichthys bidens*) during Refrigerated Transport Simulating Natural Conditions

Jinzeng Wang[1], Lin Xu, Xiaoguo Ying[1*], Shanggui Deng[1], Jin Yu[2], Xudong Weng[3], Martina Sartoni[4], Alessandra Guidi[4], Jixiang Zhang[1 4*]

1. Key Laboratory of Health Risk Factors for Seafood of Zhejiang Province, College of Food Science and Pharmacy, Zhejiang Ocean University, Zhoushan 316022, China.

2. Longyou Aquaculture Development Center, Agricultural and Rural Bureau of Longyou County, Quzhou 324400, China

3. Zhejiang Yulaoda Agricultural Technology Co., Ltd., Quzhou 324400, China

4. Department of Veterinary Sciences, University of Pisa, Pisa 56124, Italy

Abstract: Chinese hook snout carp (*Opsariichthys bidens*) deteriorates readily during postharvest transport, yet the interplay between muscle protein degradation, volatile flavor formation, and microbial metabolism under realistic transportation conditions remains poorly understood. This is the first study to systematically investigate the interaction mechanism of protein changes and microbial metabolism in Chinese hook snout carp during refrigerated transport simulating natural conditions at 4 °C, 16 °C, and 32 °C. Elevated temperatures accelerate myofibrillar protein denaturation. Compared with fresh samples, α-helix content decreases by approximately 8.5% under 32 °C for 24 h, while random coil content increases by 12.3%, accompanied by reduced water-holding capacity (moisture content declining from 81.64% to 74.92%). Flavor profiles are dominated by aldehydes at 4 °C, whereas sulfur compounds, indole, and pyridines gradually accumulate with rising temperature, and severe flavor deterioration occurs within only 12 h at 32 °C. Low-temperatures enriched psychrotrophic *Acinetobacter* and *Pseudomonas*, whereas elevated temperatures promoted diverse mesophilic spoilage bacteria with enhanced amino acid, lipid, and carbohydrate metabolism. Transport temperature serves as the primary driver of quality loss, with storage duration exerting cumulative amplification effects. Our findings provide mechanistic insights into temperature-dependent quality deterioration that can inform cold-chain optimization strategies.

Keywords: Cold chain transportation, simulating natural conditions, volatile flavor compounds, high-throughput sequencing, microbial community succession

通讯作者：

姓名：应晓国

性别：男

学位：博士

职称：副教授

研究方向：冷链物流

电话：15158157652

资助项目：本研究由金枪鱼全产业链智能切割与精深加工关键技术研究项目（2025C03006）以及水产品加工副产物多维化加工与高值化利用关键技术及新产品开发项目（2024C0101）联合资助。

κ-卡拉胶-大豆分离蛋白乳液膜的性质调控及其在冷冻虾滑中的应用

赵 源，任中阳，石林凡，张玉苍，翁武银*

集美大学海洋食品与生物工程学院，福建省厦门市，361021

摘要：本研究利用 κ-卡拉胶（KC）乳液替代 KC 和大豆油改良大豆分离蛋白（SPI）膜的机械性能和水蒸气阻隔能力，探究了 SPI 和 KC 比例对 SPI-KC 复合膜基质相容性和理化性质的影响，旨在开发可用于冷冻虾滑保鲜的可食用包装膜。结果显示，当 SPI:KC 比例为 98:2 时，成膜液中的 KC 分布均匀且油滴粒径最小。干燥后，复合膜表现出分布均匀的 KC 和油滴，以及光滑致密的膜结构。降低 KC 含量会促进油滴的上浮和聚集，而增加 KC 含量会导致 KC 聚集、油滴粒径增大，并在膜截面产生褶皱结构。随着 KC 含量的增加，膜的抗拉伸强度逐渐提高，而玻璃化转变温度和断裂伸长率在 SPI:KC 比例为 98:2 时最高。同时，SPI:KC 比例为 98:2 的膜显示出最低的水蒸气透过率（1.56×10^{-10} g·m^{-1}·s^{-1}·Pa^{-1}）。将复合膜应用于冷冻虾滑包装抑制了冷冻诱导的冰晶形成，降低了虾滑的煮制膨胀率，从而改善了虾滑产品的硬度。因此，通过调节 SPI:KC 比例可制备出具有良好机械性能和水蒸气阻隔能力的复合膜，能够作为可食性包装改善虾滑在冷冻和蒸煮后的品质。

关键词：大豆分离蛋白；κ-卡拉胶；可食用包装膜；基质相容性；虾滑

通讯作者*：翁武银，男，博士，教授，研究方向：水产品加工，E-mail：wwymail@jmu.edu.cn

资助项目：国家自然科学基金（32272266）

κ-卡拉胶在不同基质中对小鼠肠道黏膜屏障及肠道菌群调控的研究

郭娟娟*，尚旭珂，陈培琳

泉州师范学院海洋与食品学院，泉州，362000

摘要 [目标]卡拉胶（CGN）是一种硫酸化多糖，因其优异的理化特性成为食品加工领域广泛应用的食品添加剂，但其安全性一直饱受争议。已有研究表明酪蛋白食品基质对 κ-CGN 中硫酸基团的暴露量及构象具有显著影响，但这种差异对生理学功能的影响及其机制还未得到良好的阐述。[方法]本研究旨在以 κ-卡拉胶为研究对象，分别将其溶解在水溶液及酪蛋白溶液中，用不同浓度的 κ-CGN 及 κ-卡拉胶/酪蛋白（κ-carrageenan-casein，κ-CC）溶液处理小鼠，基于体内动物模型探究 κ-CGN 水溶液及 κ-CC 溶液对小鼠生理功能及肠道黏膜屏障的影响。[结果]研究显示，κ-CGN 与 κ-CC 均能通过破坏微生物群稳态而引发不同程度的肠道屏障损伤。值得注意的是，含有较低硫酸基团含量的 κ-CC 可通过增加 *Oscillibacter* 菌群丰度、降低 *Weissella* 菌群丰度，从而修复由等效剂量的 κ-CGN 水溶液所诱导的肠道屏障损伤。这些缓解作用亦体现在：肿瘤坏死因与 C 反应蛋白水平降低、白细胞介素 10 水平升高、黏液及杯状细胞分泌增加，以及上皮细胞紧密连接蛋白 ZO-1 与黏蛋白 2（MUC2）的表达水平改善。[结论]本研究证实，与水溶液中的 κ-CGN 相比，溶解于酪蛋白中的 κ-CGN 对肠道屏障损伤具有积极的调节作用，这一发现可为 CGN 的加工与应用提供积极指导。

关键词：κ-卡拉胶；酪蛋白；肠道屏障损伤；肠道菌群

*** 通讯作者**

郭娟娟，女，博士研究生，教授，研究方向：海洋藻类加工与应用，电话: 18046037840; Email: gjjfst15@163.com

资助: 国家自然科学基金 [No. 32001625，No. 2023J01161233], 福建省自然科学基金[No. 32402119].

Study on the Regulation of Intestinal Mucosal Barrier and Intestinal Microbiota in mice by kappa-Carrageenan in different Matrices

Juanjuan Guo[1,*], Xuke Shang[1], Peilin Chen[1]

1. College of Oceanology and Food Sciences, Quanzhou Normal University, Quanzhou 362000, China

Abstract:[Objective]Carrageenan (CGN), a sulfated polysaccharide, is widely used as a food additive due to its excellent properties. However, its safety remains controversial. Previous studies have reported that there are significant differences in the physicochemical conformation and sulfate group exposure of κ-carrageenan (κ-CGN) dissolved in aqueous solutions and casein matrices, but the impact of this difference on physiological functions and its mechanism have not been well explored. [Methods]Therefore, in this paper, κ-CGN was used as the research object. It was dissolved in aqueous and casein solutions respectively. The mice were treated with different concentrations of κ-CGN and κ-carrageenan/casein (κ-carrageenan-casein, κ-CC) solutions. Based on the in vivo animal model, the effects of κ-CGN and κ-CC on the physiological functions and intestinal mucosal barrier of κ-CGN were explored.[Results]Research has shown that both κ-CGN and κ-CC can induce different extents of intestinal barrier damage through disrupting microbiota homeostasis. Importantly, κ-CGN in casein with lower sulfate groups content was found to repair the intestinal barrier injury induced by an equivalent dose of κ-CGN aqueous through increasing the abundance of *Oscillibacter* and decreasing *Weissella*. These alleviating effects were reflected in lower levels of tumor necrosis factor (TNF)-α and C-reaction protein (CRP), higher levels of interleukin (IL)-10, raised secretion of mucus and goblet cells, and improved expression of epithelial cell compact proteins zonula occluden (ZO)-1 and mucin protein 2 (MUC2). [Conclusion] This study states that κ-CGN in casein has a positive regulatory effect on the intestinal barrier damage compared to in aqueous solution, which can provide guidance for processing and utilization of CGN.

Key words: carrageenan; casein; intestinal barrier damage; gut microbiota;

*** Corresponding Author**

Juanjuan Guo, Female, PhD, Research: Marine Algae Processing and Applications. Tel: 18046037840; Email: gjjfst15@163.com

Funding: This work was supported by the National Natural Science Foundation of China [No. 32001625], National Natural Science Foundation of China [No. 32402119], Natural Science Foundation of Fujian Province [No. 2023J01161233].

Low-molecular-weight fucoidan alleviates DSS-induced colitis in mice through modulation of the NF-κB and MAPK pathways-related mRNA and protein expression

Yingying Zhao[1], Yan Liu[1], Shumin Cai[1], Nali Zhang[1], Shuangshuang Wu[1], Yuxin Shi[1], Yichao Ma[1,2,3], Shu Liu[1,2,3], Yunhai He[1,2,3], Qiukuan Wang[1,2,3] , Dandan Ren[1,2,3,*]

1. College of Food Science and Engineering, Dalian Ocean University, Dalian, 116023, China；
2. National R&D Branch Center for Seaweed Processing, Dalian, 116023, China；
3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian, 116023, China.

Abstract: Low-molecular-weight fucoidan (LWMF) possesses favorable absorbability and potent anti-inflammatory activity. This study explored its therapeutic effects and mechanisms in DSS-induced colitis mice. LWMF was prepared from *Kjellmaniella crassifolia* fucoidan via hydrochloric acid degradation, purified by Bio-gel column chromatography, and biochemically characterized. Colitis mice received LWMF at 50 or 100 mg/kg·d by gavage. Inflammatory cytokines, oxidative stress markers, and intestinal mRNA and protein expression were assessed. Results showed that hydrochloric acid effectively degraded the polysaccharide，accompanied by a sigificant decrease in molecular weight. LWMF alleviated body weight loss, reduced the disease activity index (DAI), increased colon length, and enriched gut microbiota. Both doses downregulated pro-inflammatory cytokines (IL-6, IL-1β, TNF-α, NLRP3) and MDA content, upregulated anti-inflammatory cytokine (IL-10) and antioxidant enzymes (CAT, SOD, GSH-Px), and improved mRNA and protein expression via the NF-κB and MAPK pathways. LWMF alleviates colitis through antioxidative, anti-inflammatory effects and targeted modulation of the NF-κB/MAPK pathway, with the high dose showing superior efficacy, supporting its potential as a natural therapeutic candidate against colitis.

Key words: Low-molecular-weight fucoidan; Degradation; Colitis

Acknowledgements: *This work was supported by the Basic Research Funds for Liaoning Provincial Undergraduate University [grant number LJ222410158016 and*

2024JBTDZ003]; LiaoNing Revitalization Talents Program [grant number XLYC2413020]; and the China Agriculture Research System [grant number CARS-50].

Corresponding author: Dandan Ren, female, Ph.D., Professor. Research interests: utilization of algal resources. Tel: +86-0411-84763559; E-mail: rdd@dlou.edu.cn

Maternal n-3 PUFA availability modifies gestational cadmium toxicity across the maternal–placental–fetal axis

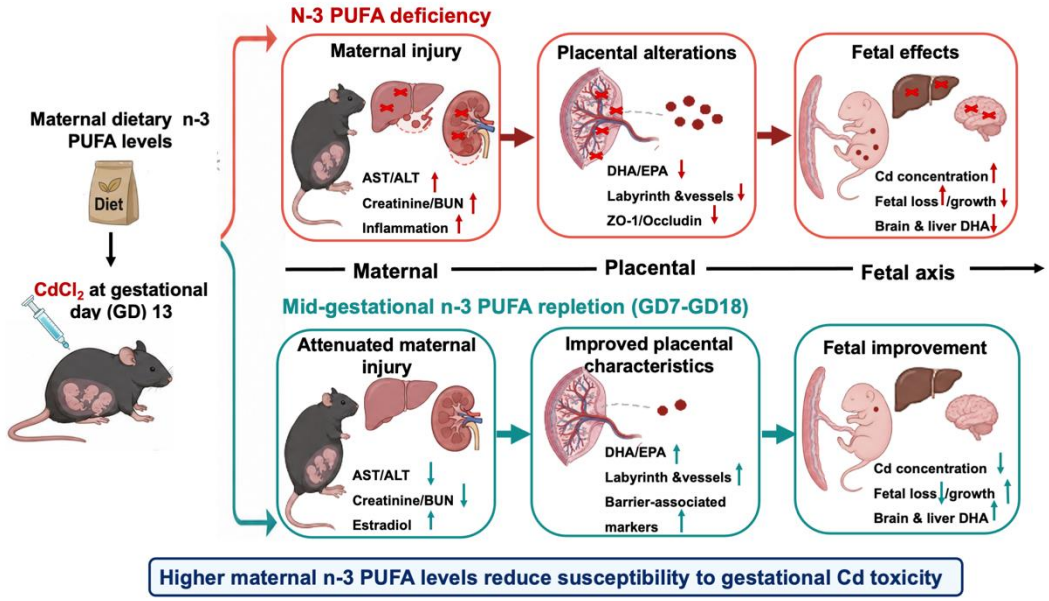
Ruo-tong Kan[1], Shan-Yun Yu[1], Xian-Shu Wang[1], Yi-Fei Ning[1], Lei Ma[1], Yu-Ming Wang[1, 2], Cheng-Cheng Wang[1,*], and Tian-Tian Zhang[1,*]

1. College of Food Science and Engineering, Ocean University of China, Qingdao, 266404, Shandong;

2. Sanya Institute of Oceanography, Ocean University of China, Sanya, 572000, P.R. Hainan;

Abstract:

Maternal nutrition may modify vulnerability to environmental toxicants, but whether maternal n-3 polyunsaturated fatty acid (PUFA) levels influence cadmium (Cd)-induced developmental toxicity remains unclear. Here, maternal, placental, and fetal responses to acute gestational Cd exposure were investigated using mouse models combining graded maternal n-3 PUFA diets with mid-gestational n-3 PUFA repletion. Maternal n-3 PUFA deficiency aggravated Cd-induced hepatic and renal injury, fetal loss, and fetal growth restriction. These adverse outcomes were accompanied by impaired placental development and barrier-related characteristics, increased Cd concentrations in fetal tissues, and disrupted fatty acid profiles in the placenta, fetal liver, and fetal brain. Molecular analyses further revealed alterations in inflammatory, metabolic, and developmental pathways across maternal, placental, and fetal tissues. Importantly, mid-gestational n-3 PUFA supplementation from GD7 to GD18 partially reversed these alterations by attenuating maternal injury, reducing fetal loss and fetal Cd burden, improving placental structure and fetal growth, and increasing DHA proportions in placental and fetal tissues. Together, these findings identify maternal n-3 PUFA levels as a modifiable nutritional determinant of susceptibility to gestational Cd toxicity and highlight mid-gestational n-3 PUFA repletion as a potential nutritional strategy for protecting the maternal–placental–fetal axis against environmental toxicant-induced injury.



Key words: Cadmium; N-3 polyunsaturated fatty acids; Pregnancy; Placenta; Fetal development;

通讯作者：

1、张恬恬，女，博士研究生，教授，E-mail: zhangtiantian@ouc.edu.cn

研究方向：（1）海洋食品全生命周期主动健康营养理论（2）特定健康需求的功效成分制备与功能评价（3）基于海陆结合理念的主动健康精准营养产品创制

2、王成成，男，博士研究生，副教授，E-mail: wangchengcheng@ouc.edu.cn

研究方向：（1）基于表观遗传的海洋食品时序营养学机制；（2）基于血脑屏障的活性脂质营养健康机制；（3）基于多成分-多靶点的精准营养食品创制理论与技术

资助项目：

2024YFD2401600，国家重点研项目，《水产特色营养食品绿色高效制造的理论与技术研究》

Metabolite composition and taste quality of *Eriocheir sinensis* under different steaming methods

Renyue ZHANG[1,2], Derui CHEN[1,2], Fengyi QIAO[1,2], Guanli LI[1,2], Guangyao ZHANG[1,2], Xichang WANG[1,2], Long ZHANG[1,2*]

1. College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China; 2. Shanghai Engineering Research Center of Aquatic-Product Processing and Preservation, Shanghai 201306, China

Abstract :[Objective] To investigate the effects of cold-water steaming with increasing temperature (CI) and boiling-water steaming at constant temperature (BC) on the taste quality and metabolite composition of *Eriocheir sinensis*, and to elucidate the metabolic and enzymatic mechanisms underlying the tissue-specific formation of umami during steaming; [Methods] The taste characteristics of muscle and ovary tissues subjected to CI and BC steaming were evaluated using sensory evaluation and electronic tongue analysis. Widely targeted metabolomics combined with KEGG pathway analysis was used to characterize metabolic differences, followed by targeted quantification of free amino acids (FAAs) and flavor nucleotides. Taste activity values (TAVs) and equivalent umami concentration (EUC) values were calculated to evaluate the contributions of taste-active compounds. In addition, AMP degradation was investigated under different temperatures and pH conditions to clarify the roles of adenosine monophosphate deaminase (AMPD) and 5′-nucleotidase in nucleotide transformation; [Results] Sensory evaluation and electronic tongue analysis indicated that CI group enhanced ovaries umami, whereas BC group increased muscle umami ($p < 0.05$). Widely targeted metabolomics showed impacts on amino acid and energy metabolism. CI group significantly increased total amount of free amino acids and nucleotides. Enzyme activity experiments confirmed that cold water with increasing temperature augmented adenosine monophosphate deaminase activity (maximal: 30℃, pH 6.0) and 5′-inosine monophosphate levels ($p < 0.05$). Equivalent umami concentration value analysis showed that CI group amplified ovaries umami (increased by 4.19 g MSG/100 g) by increasing nucleotides content, while BC group mainly intensified muscle umami (0.34 g MSG/100 g) through increasing glutamic

acid levels; [Conclusion]. The two steaming methods enhanced umami through tissue-specific metabolic mechanisms. BC steaming mainly enhanced muscle umami through the accumulation of glutamic acid, whereas CI steaming promoted ovarian umami primarily by facilitating AMPD-mediated nucleotide conversion and IMP accumulation. Considering its greater enhancement of taste-active compounds and overall taste quality, CI steaming is recommended as a preferred steaming method for *E. sinensis*.

Keywords: *Eriocheir sinensis*; Steaming methods; Umami; Widely targeted metabolomics; Energy metabolism; Adenosine monophosphate deaminase (AMPD); 5'-Nucleotidase (5'-ND)

Moderate reactive oxygen species enhance antimicrobial activity and quality preservation of oyster meat by ozone micro-nano bubble water

Shichen Zhu[a*], Rongrong Mu[a], Shulai Liu[a], Yuting Ding[a,b], Yanbo Wang[c], Xuxia Zhou[a*]

[a] Key Laboratory of Green, Low-carbon and Efficient Development of Marine Fishery Resources, National R&D Branch Center for Pelagic Aquatic Products Processing (Hangzhou), College of Food Science and Technology, Zhejiang University of Technology, Hangzhou 310014, Zhejiang, China

[b] Food Science Research Institute of Zhangzhou, Zhangzhou 363000, Fujian, China

[c] Beijing Technology & Business University, Beijing 100048, China

*Corresponding author

Abstract: The inherent instability and strong oxidation of ozone limit its application in preserving delicate seafood. In this study, ozone micro-nano bubble (O_3-MNB) water was employed to enhance ozone stability and regulate reactive oxygen species (ROS) formation. The results suggested that the ozone micro-nano water had great ozone stability, evidenced by the reduced size (52.04%~74.55%), increased absolute zeta potential (5.54%~13.31%) and prolonged half-lives (11.2%~108.2%). Notably, the O_3-M-W I group achieved sustained antimicrobial activity by moderate ROS formation with the limited oxidative damages. However, the rapid decay of excessive ROS in O_3-M-W III undermined the antimicrobial performance and increased oxidative risks. The O_3-M-W I group decreased relative abundance of *Shewanella putrefaciens* by triggering the leakage of intracellular contents and disruption of membrane integrity. This work aimed to provide some inspirations for development of a high-efficiency quality maintenance strategy for seafood by controllable ROS formation.

Keywords: Ozone micro-nano bubbles, Reactive oxygen species (ROS), Antimicrobial mechanisms, Oxidation, Oyster meat

本研究得到国家重点研发计划（2024YFD2401901）、浙江省自然科学基金会（LZ25C200003）、浙江省省属高校基本科研业务费专项资金（RF-A2024005）、北京工商大学食品风味与健康交叉创新研究开放课题

（FFHCI-2026034）的资金支持。

周绪霞，女，博士，教授，博士生导师，浙江工业大学健行特聘教授。美国佛罗里达大学食品与农业科学研究所博士后。现任健康食品与智能制造研究中心主任、全省深蓝渔业资源绿色低碳高效利用重点实验室副主任。入选农业农村部神农青年英才、浙江省 151 人才工程第二层次、浙江省高校领军人才培养计划。获浙江省农业科技先进工作者称号。邮箱：xzhou@zjut.edu.cn

朱士臣，男，九三学社社员，工学博士，副教授，硕士生导师，浙江工业大学食品科学与工程系副主任。研究方向为食品功能性胶体结构设计、食品冷冻保护技术开发。主持国家自然基金、国家重点研发项目子课题、浙江省自然基金（重点、探索）、省属高校基本科研业务费项目、中国博士后科学基金面上资助等科研项目。 邮箱：zhusc@zjut.edu.cn

Modification of shrimp tropomyosin properties for improved functional performance: TGase modification and polyphenol-beta-glucan modification

Shiqi Liu[1], Ru Meng[1], Kexin Jiang[1], Yinuo Bai[1], Zhenxing Li[2], Lingyi Liu[3], Jin Wang[4], Lianliang Liu[1]*

1. School of Food Science and Engineering, Ningbo University , Ningbo, 315832, Zhejiang; 2. College of Food Science and Engineering, Ocean University of China, Qingdao, 266000,Shandong; 3. Department of Food Science and Technology, University of Nebraska, Lincoln, NE 68583, USA; 4. Southeast university, Schcool of public health, Nanjing, 210009, Jiangsu

Abstract :This study elucidated the structural and functional modulations of shrimp tropomyosin (TM) by transglutaminase (TGase), β-glucan and polyphenols (syringic acid/luteolin) via multi-spectroscopy and molecular docking. All modifications induced significant conformational changes in TM ($P < 0.01$) and enhanced its emulsifying/antioxidant properties with distinct disparities. TGase-TM had the maximum solubility and surface hydrophobicity ($P < 0.01$) and elevated emulsification activity. β-glucan-TM showed the lowest free amino content, highest β-sheet/β-turn ($P < 0.01$) and optimal emulsion stability. Polyphenol-TM exhibited the strongest fluorescence quenching ($P < 0.01$), with luteolin-TM possessing the highest antioxidant capacity. This work provides a theoretical basis for the directional modification and industrial application of TM as a food functional ingredient.

Key words: tropomyosin; chemical modifications; β-glucan; dietary polyphenols; functional properties

资助项目: National Natural Science Foundation of China (32472329), Youth Science and Technology Innovation funding of Ningbo (2024QL030).

通讯作者: Lianliang Liu（刘连亮），男，博士，教授， 主要研究方向为食品生物技术与食品安全，18858213789 ，lianliang626@hotmail.com

Molecular mapping of off-odor in post harvest golden pompano (*Trachinotus ovatus*): From microbial succession to TAAR5/OR2W1 receptor recognition

Leyi Shi[3,4], Yanyan Wu[3,4], Huan Xiang[3], Di Wang[3], Peng Liang[1*], Yueqi Wang[2,3,4*]

[1]College of Oceanology and Food Science, QuanZhou Normal University, Quanzhou, 362000, China

[2]Guangxi College and University Key Laboratory Development and High-value Utilization of Buibu Gulf Seafood Resources, College of Food Engineering, Beibu Gulf University, Qinzhou, Guangxi 535000, China

[3]Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs, National R&D Center for Aquatic Product Processing, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, China

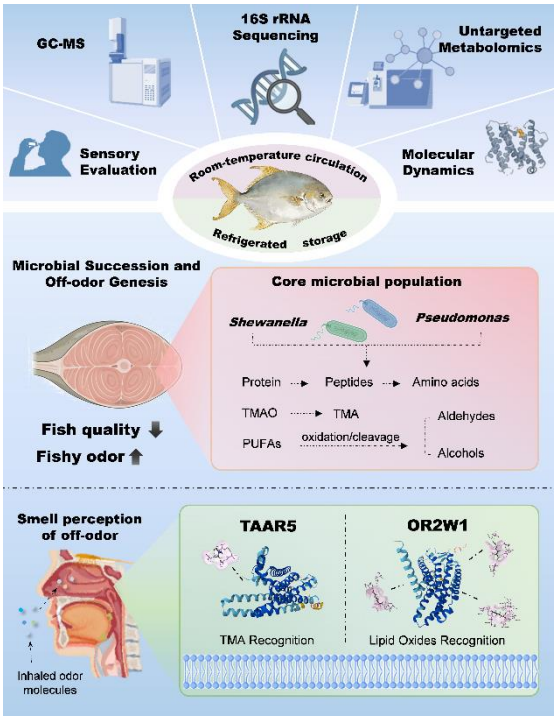
[4]College of Food Science and Engineering, Ocean University of China, Qingdao 266000, China

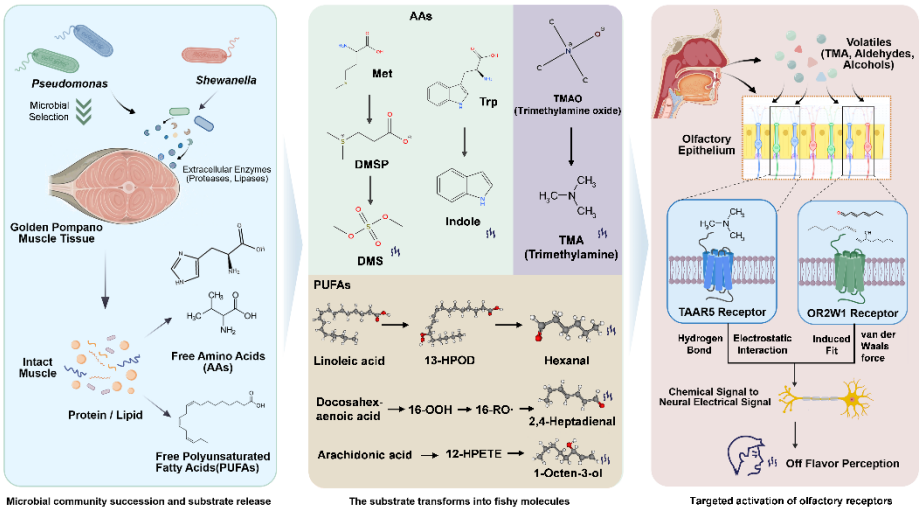
Abstract: This study integrated multi-omics and molecular dynamics (MD) simulations to elucidate the mechanisms of microbial spoilage and targeted off-odor formation in post-harvest golden pompano(*Trachinotus ovatus*). Microbiome and metabolome analyses revealed that *Pseudomonas* and *Shewanella* act as the dominant specific spoilage organisms, driving severe amino acid degradation and polyunsaturated fatty acid oxidation. This metabolic succession leads to a substantial accumulation of characteristic odor-causing volatiles, including trimethylamine (TMA), hexanal, 2,4-heptadienal, and 1-octen-3-ol, with TBARS levels surging to 42.47 nmol/g after 48 h of storage. At the perception level, MD simulations unveiled that TMA stably binds the TAAR5 receptor via electrostatic and hydrogen-bond networks. Concurrently, OR2W1 exhibits differentiated binding for lipid oxidation products: hydrophobic interactions with hexanal, structural matching with 2,4-heptadienal, and induced conformational rearrangements by 1-octen-3-ol. Bridging microbial succession to olfactory receptor dynamics, this cross-scale study provides a theoretical basis for developing precise off-odor suppression strategies in aquatic products.

Key words: Golden pompano; Volatile compounds; Core spoilage bacteria; Metabolomics; Olfactory receptors

资助项目： This work was supported by the National Natural Science Foundation of China (32672869); the Key Technologies Research and Development Program of Guangdong Province (2025B1111140001); the earmarked fund for CARS (CARS-46)； the Special Support Program for Young Top Talents in Guangdong Province (NYQN2024004); and the Special Scientific Research Funds for Central Non-profit Institutes of the Chinese Academy of Fishery Sciences (2020TD69).

通讯作者：王悦齐，男，博士，研究员，海洋食品生物加工与高值化利用/食品风味量化表征与靶向调控，15622145303，wangyueqi@scsfri.ac.cn





Nanoparticles prepared from different plant protein isolates using alkali-heat synergistic pH-shifting method to stabilize Antarctic krill oil-loaded high internal phase emulsions

Yiru Zhou[1], Guangyi Kan[2]

College of Food Science & Technology, Shanghai Ocean University, Shanghai 201306, China

Abstract

Using an alkali-heat (pH 12.0, 80 °C) synergistic pH-shifting technique, nanoparticles were prepared from five plant protein isolates: soybean, faba bean, mung bean, pea, and potato. The method can unfold and partially hydrolyzes proteins and drives self-assembly into nanoparticles. The treatment decreased the content of β-sheet (e.g., SPI: from 46.22% to 32.85%, average reduction of ∼12%) and raised the content of α-helix and β-turn structures, resulting in the unfolding of the protein and a significant rise in surface hydrophobicity. The majority of proteins formed relatively small nanoparticles (e.g., POINP: 9.0 ± 2.5 nm), but pea protein produced relatively large aggregates (18.9 ± 7.0 nm and 70.4 ± 7.1 nm). Soybean and faba bean protein nanoparticles produced the most stable AKO-loaded high internal phase emulsions (HIPEs) with bimodal droplet-size distribution, high absolute zeta potential (>30 mV), and low interfacial tension (<15 mN/m). These HIPEs were characterized by strong shear-thinning, solid-like gel characteristics, and stable solid-like gel behavior during 25–90 °C thermal sweeps, while severe heating at 121 °C caused droplet growth, indicating moderate thermal stability. The emulsions also inhibited lipid oxidation, with SPINP- and MPINP-stabilized HIPEs exhibiting the lowest PVmax (40.63–46.25 meq/kg oil) and MDAmax (53.80–58.77 nmol/mL oil), while PPINP-HIPEs showed the weakest oxidative protection (PVmax = 54.81, MDAmax = 72.27). Moreover, in vitro digestion indicated that the emulsions increased the release of free fatty acids (50.98–67.12%) and astaxanthin bioaccessibility (34.35–42.20%) relative to mixed-oil (16.19% and 11.08%, respectively). This work first compares five plant proteins, revealing an interfacial-architecture-associated trade-off between oxidative stability and bioaccessibility to guide nanoparticle selection for lipid delivery.

[Objective] To prepare nanoparticles from five plant protein isolates—soybean, faba bean, mung bean, pea, and potato—using an alkali-heat (pH 12.0, 80 °C) synergistic pH-shifting technique, and to compare their structures,

interfacial behavior, and performance in stabilizing high internal phase emulsions (HIPEs), thereby revealing the trade-off between oxidative stability and bioaccessibility for guiding nanoparticle selection in lipid delivery.

[Methods] The alkali-heat synergistic pH-shifting treatment unfolded and partially hydrolyzed the proteins and drove their self-assembly into nanoparticles. The resulting nanoparticles were characterized for β-sheet, α-helix, and β-turn contents, surface hydrophobicity, and particle size. AKO-loaded HIPEs stabilized by these nanoparticles were then prepared. The emulsions were evaluated for droplet-size distribution, zeta potential, interfacial tension, rheological properties, thermal stability during 25–90 °C thermal sweeps and after severe heating at 121 °C, lipid oxidation (PVmax and MDAmax), and in vitro digestion behavior, including free fatty acid release and astaxanthin bioaccessibility relative to mixed oil.

[Results] The treatment decreased β-sheet content (e.g., SPI: from 46.22% to 32.85%, average reduction of ~12%) and increased α-helix and β-turn contents, resulting in protein unfolding and a significant rise in surface hydrophobicity. Most proteins formed relatively small nanoparticles (e.g., POINP: 9.0 ± 2.5 nm), but pea protein produced relatively large aggregates (18.9 ± 7.0 nm and 70.4 ± 7.1 nm). Soybean and faba bean protein nanoparticles produced the most stable AKO-loaded HIPEs, with bimodal droplet-size distribution, high absolute zeta potential (>30 mV), and low interfacial tension (<15 mN/m). These HIPEs showed strong shear-thinning, solid-like gel characteristics, and stable solid-like gel behavior during 25–90 °C thermal sweeps, while severe heating at 121 °C caused droplet growth, indicating moderate thermal stability. The emulsions also inhibited lipid oxidation, with SPINP- and MPINP-stabilized HIPEs exhibiting the lowest PVmax (40.63–46.25 meq/kg oil) and MDAmax (53.80–58.77 nmol/mL oil), whereas PPINP HIPEs showed the weakest oxidative protection (PVmax = 54.81, MDAmax = 72.27). Moreover, in vitro digestion indicated that the emulsions increased free fatty acid release (50.98–67.12%) and astaxanthin bioaccessibility (34.35–42.20%) relative to mixed oil (16.19% and 11.08%, respectively).

[Conclusion] This work first compares five plant proteins, revealing an interfacial-architecture-associated trade-off between oxidative stability and bioaccessibility to guide nanoparticle selection for lipid delivery.

Key words: Plant protein isolate; Alkaline-heat treatment; Nanoparticle; Antarctic krill oil; High internal phase emulsion

本研究得到了国家重点研发计划（2023YFD2401503）、上海水产品高值化加工与利用创新团队（上海海洋大学）、上海市教育委员会－食品科学与技术高原学科资助项目（上海海洋大学）的资助。通讯作者王锡昌：男，博士，教授，研究方向：食品营养风味分析、水产品加工及贮藏工程；15692165510；xcwang@shou.edu.cn。

Nutritional and Flavor Profile Differences Among Three Venerid Clam Species: A Multi-Dimensional Quality Approach

Weilin Zheng[1], Binbin Li[2], Lin Wang[3], Nan Pan[4,5], Dengyuan Liao[5], Bei Chen[4,5], Kun Qiao[4,5], Yongchang Su[5], Yihui Chen[1], Zhiyu Liu[4*], Shuji Liu[5*]

（1.College of Food Science, Fujian Agriculture and Forestry University, Fuzhou 350002, China; 2. College of Chemical Engineering, Huaqiao University, Xiamen 361021, China; 3. Jinshan College of Fujian Agriculture and Forestry University, Fuzhou 350002; 4. National Research and Development Center for Marine Fish Processing (Xiamen) / Key Laboratory of Cultivation and High-value Utilization of Marine Organisms in Fujian Province, Xiamen 361013, China; 5.Fisheries Research Institute of Fujian, Xiamen 361013, China

Abstract：To systematically elucidate the differential nutritional and flavor profiles of manila clam (*Ruditapes philippinarum*), hard clam (*Meretrix meretrix*) and undulate venus clam (*Paphia undulata*), basic nutritional components, inorganic ions, amino acids, fatty acids and non-volatile taste-active compounds were determined in this study. Combined with bionic sensory technologies including electronic tongue and electronic nose, as well as headspace solid-phase microextraction coupled with gas chromatography-mass spectrometry (HS-SPME-GC-MS), comparative evaluations were performed from multiple dimensions involving nutrition, taste and aroma. The results revealed that no significant differences were observed in moisture content among the three clams, with crude protein contents ranging from 10.82% to 12.18%. The crude lipid content of *P. undulata* reached 1.55%, and its polyunsaturated fatty acid level was significantly higher than those of *R. philippinarum* and *M. meretrix* (P<0.05). The taurine content in *R. philippinarum* was 2.39 times and 1.61 times that of *M. meretrix* and *P. undulata*, respectively. A total of 16 amino acids were detected in all three clams. The proportion of essential amino acids in total amino acids varied from 34.87% to 39.72%, and the ratios of essential amino acids to non-essential amino acids exceeded 60% for all samples. Sulfur-containing amino acids were identified as the primary limiting amino acids for all species. The taste activity values (TAVs) of inorganic ions (Na^+, K^+, PO_4^{3-}, Cl^-) and free amino acids including glutamic acid, glycine, arginine and alanine were all greater than 1. *R. philippinarum* possessed the highest proportion of umami amino acids in total free amino acids, reaching 60.93%. Analysis of taste-active nucleotides indicated that adenosine monophosphate (AMP) was the dominant taste-active nucleotide in M. meretrix, with a concentration of (65.36 ± 1.81) mg/100 g, whereas inosine monophosphate (IMP) dominated in *R. philippinarum* and *P. undulata*. *R. philippinarum* exhibited the highest equivalent umami concentration (EUC) of 88.96 mg MSG/100 g. Electronic tongue measurements verified similar overall taste profiles among the three clams. Principal component analysis based on electronic nose data demonstrated that the aroma characteristics of *R. philippinarum* were clearly distinguished from those of *M. meretrix* and *P. undulata*. In total, 67 volatile compounds were identified via volatile flavor analysis, among which alcohols constituted the predominant category for all samples. Odor activity value (OAV) analysis confirmed that 1-octen-3-ol acted as the common characteristic fishy odor compound in the three clams. Trans-2,4-decadienal presented an OAV of 623.23, serving as the marker aroma component discriminating R. philippinarum from the other two clam species. In conclusion, this study clarified interspecific differences in nutritional composition and flavor properties of the three Veneridae shellfish from multi-dimensional

perspectives of nutrition, taste and aroma. The findings can provide theoretical support for differentiated intensive processing and dietary nutrition development of shellfish resources.
Keywords： *Ruditapes philippinarum*; *Meretrix meretrix*; *Paphia undulata*; nutritional components; taste characteristics; volatile flavor compounds

Fundings： Fujian Province Special Fund Project for Promoting High-quality Development of Marine and Fishery Industry (FJHYF-L-2025-30; FJHY-YYKJ-2024-1-3; FJHYF-L-2023-13)
Correspondence: Liu Zhiyu, 13906008638@163.com; Liu Shuji, cute506636@163.com

O-B 改性淀粉乳液作为新型添加剂提升巨型鱿鱼鱼糜凝胶的 3D 打印适配性与品质

尤露瀚，程依帆，贾茹*

宁波大学食品科学与工程学院，浙江 宁波 315211

摘要：

为解决巨型鱿鱼鱼糜内源蛋白酶导致的凝胶与3D打印性能差的问题，本研究探究OSA-球磨复合改性淀粉（O-B）乳液对鱼糜 3D 打印制品品质的改善作用。首先制备不同浓度 O-B 淀粉乳液，对其粒径、Zeta 电位、微观形貌及储存、离心稳定性进行表征；随后将 5%O-B 淀粉制备的优化乳液以 0%-20%添加量掺入鱼糜打印墨水，测定其流变特性、打印适配性、凝胶理化性质、蛋白二级结构、水分分布与微观结构，依据 IDDSI 标准评价其作为吞咽障碍食品适用性。结果表明 5%O-B 淀粉制备的乳液稳定性最优；当添加量为 10%时，鱼糜墨水具备适宜剪切变稀特性，打印准确率达 98.47%、稳定性达 94.45%。同时，O-B 乳液的加入促近了蛋白疏水相互作用及二硫键的形成，提升了 β-折叠的含量，形成致密凝胶网络，显著提高了持水性、降低蒸煮损失；打印成品满足 IDDSI 6 级食品标准。综上，O-B Pickering 乳液可改善鱿鱼鱼糜蛋白交联与凝胶网络，提升 3D 打印品质，为吞咽障碍专用鱼糜制品的开发提供了理论依据。

关键词：改性淀粉乳液；3D 打印；巨型鱿鱼鱼糜；蛋白性质；吞咽障碍食品

资助项目：浙江省自然科学基金(LTGN24C200002)；宁波市自然科学基金(2024J163)；浙江省属高校基本科研业务费(SJLY2025009)

通讯作者：贾茹，女，博士，教授，研究方向：水产品加工；电话：19858325572；

E-mail：jiaru@nbu.edu.cn

Omics insights into the mechanisms of flavor changes in Eriocheir sinensis under different restraint methods during live transportation

Fengyi Qiao[a,b], Yi Wu[a,b], Renyue Zhang[a,b], Wenqing Zhai [a,b], Siqi Zhou [a,b], Derui Chen [a,b], Xichang Wang[a,b], Long Zhang[a,b,*]

a College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

b Shanghai Engineering Research Center of Aquatic-Product Processing and Preservation, Shanghai 201306, China

Abstract: [Objective]: *Eriocheir sinensis* frequently experiences stress from inappropriate restraint during live transportation, impairing animal welfare and edible quality. [Methods]: This study employed flavoromics and metabolomics to investigate the mechanisms linking physiological metabolism with edible quality changes in deteriorated tissues of *E. sinensis* under different restraint methods. [Results]: The hepatopancreas was identified as the key tissue of deterioration. The degree of deterioration ranked as follows: net-bag binding (NB) group > plastic-box binding (PB) group > cotton-rope binding (RB) group. Oxidative stress reduced the antioxidant capacity of hepatopancreas, accelerated polyunsaturated fatty acids oxidation, and increased energy consumption. Relevant energy metabolites, as flavor compounds or precursors, largely determine the flavor quality of the hepatopancreas. Compared with Con, 7 key bitter differential oxylipins (KBOPs) were upregulated in the NB, whereas only 1 KBOP was upregulated in the RB and PB. Differential energy metabolites and oxylipins primarily involved glutathione metabolism, ferroptosis, alcoholic liver disease, arachidonic acid metabolism, and linoleic acid metabolism. Molecular docking suggested that KBOPs contribute to bitterness and may increase cardiovascular risk. [Conclusion]: This study clarifies the metabolism-quality link, supporting the development of aquatic live-keeping technologies.

Key words: *Eriocheir sinensis*; Flavor quality; Energy metabolism; Oxylipins; Bitter; Transportation

stress.

资助项目：科技部重点研发计划 (No. 2023YFD2401505)
通讯作者：张龙，男，博士，副教授，主要研究方向：水产品品质评价与调控、水产品加工与综合利用，电话： 13127805520，E-mail: l-zhang@shou.edu.cn。

Phosphorylation dynamics of myofibrillar and sarcoplasmic proteins associated with quality changes in large yellow croaker (*Larimichthys crocea*) during early cold storage

Chuhan Bian[1], Jing Xie[1,2,3,4,5,6*]

1 College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

2 Key Laboratory of Aquatic Products High Quality Utilization, Storage and Transportation (Co-construction by Ministry and Province), Ministry of Agriculture and Rural Affairs

3 National Experimental Teaching Demonstration Center for Food Science and Engineering Shanghai Ocean University, Shanghai 201306, China

4 Shanghai Engineering Research Center of Aquatic Product Processing and Preservation, Shanghai 201306, China

5 Shanghai Professional Technology Service Platform on Cold Chain Equipment Performance and Energy Saving Evaluation, Shanghai 201306, China

6 Marine Biomedical Science and Technology Innovation Platform of Lin-gang Special Area, Shanghai 201306, China

Abstract: [Objective] To investigate the changes in myofibrillar protein (MP) and sarcoplasmic protein (SP) phosphorylation in large yellow croaker (*Larimichthys crocea*) during refrigerated storage and their associations with energy metabolism, quality, and protein structure. [Methods] Large yellow croaker was stored at 4 °C for 5 days. Protein phosphorylation, ATP, glycogen, lactic acid, pH, color, texture, myofibrillar fragmentation index (MFI), carbonyl content, and Ca^{2+}-ATPase activity were determined. Correlation analysis was performed to evaluate the associations between phosphorylation and quality-related parameters. [Results] MP phosphorylation peaked on day 1 and subsequently declined, whereas SP phosphorylation showed relatively stable fluctuations. ATP briefly increased before declining, while glycogen was gradually depleted and lactic acid fluctuated. pH and lightness decreased, whereas texture parameters increased during rigor mortis and subsequently declined. MFI and carbonyl content increased, while Ca^{2+}-ATPase activity decreased.

MP phosphorylation was closely associated with texture and protein oxidation, whereas SP phosphorylation was strongly correlated with glycolytic metabolites and color. [Conclusion] MP and SP phosphorylation showed distinct dynamics during refrigeration and were associated with changes in energy metabolism, muscle quality, and protein structure, providing a basis for understanding phosphorylation-related quality changes in refrigerated large yellow croaker.

Key words: Protein posttranslational modifications; Protein phosphorylation; Meat quality; Myofibrillar protein; Sarcoplasmic protein.

资助项目：国家重点研发计划项目“养殖鱼类加工与质量安全控制关键技术与装备”课题 2“养殖鱼类生态保鲜保活与物流品质监控关键技术研究”（2023YFD2401402）

通讯作者：谢晶，女，博士，教授，水产品保鲜，15692165513，jxie@shou.edu.cn

Postmortem Quality Changes in Grass Carp during Chilled Storage: Dynamic Association with the Lysosomal-Mitochondrial Apoptotic Pathway

Wang Lishi, Yu, Dawei, Jiang, Qixing, Xia Wenshui

(State Key Laboratory of Food Science and Resources, School of Food Science and Technology, Jiangnan University, Wuxi, Jiangsu, 214122, China)

Abstract: [Objective]： During postmortem chilled storage of grass carp, the intracellular metabolic environment and organelle functions undergo continuous changes, accompanied by protein degradation and muscle softening. However, the dynamic relationship between lysosomal and mitochondrial responses remains unclear. **[Methods]：** In this study, changes in the physiological environment, lysosomal membrane stability, mitochondrial function, apoptosis-related signaling, and muscle quality were systematically investigated during chilled storage. **[Results]：** The results showed that lysosomal membrane stability decreased significantly during the early stage of storage, while muscle pH reached its lowest level at 4 h. After 6 h, lysosomal reactive oxygen species (ROS) increased significantly, accompanied by the release of cathepsins B, D, and L into the sarcoplasm. During 0–24 h of storage, mitochondrial ROS continuously accumulated, mitochondrial permeability transition pore (MPTP) opening increased, and mitochondrial membrane potential decreased. Meanwhile, mitochondrial cytochrome c (Cyt-c) content decreased, whereas cytosolic Cyt-c increased, accompanied by increased caspase-3 activity. With prolonged storage, the myofibril fragmentation index and drip loss increased, while water-holding capacity and shear force decreased. **[Conclusion]：** These results indicate that lysosomal and mitochondrial functional changes exhibit pronounced time-dependent patterns and show dynamic associations during key stages of chilled storage, suggesting that they may jointly contribute to postmortem muscle protein degradation and flesh softening in grass carp.

Key words： Grass carp; Cold storage; Lysosome; Mitochondria; Meat quality

*资助项目：国家自然科学基金，32572646

通讯作者：姜启兴，男，博士，教授，食品加工与保藏及综合利用，0510-85327363，qixingj@163.com；余达威，男，博士，副教授，食品智能包装与保鲜，yudw@jiangnan.edu.cn。

Preparation and Characterization of Shikonin-Incorporated Gelatin Films with Antibacterial and Antioxidant Activities and Their Application in Beef Preservation

Ruiying Ran, Haipeng Wu, Shiwei Bao,Mei Yang, Guoping Wu, Chan Zhong

College of Food Science and Engineering, Jiangxi Agricultural University, Nanchang 330045, Jiangxi, China

Abstract: Beef is highly susceptible to spoilage during cold storage due to microbial proliferation and lipid oxidation, which severely limits its shelf life. In this study, shikonin-incorporated gelatin composite films were fabricated, characterized, and their potential as active coatings for chilled beef preservation was evaluated. Shikonin incorporation significantly enhanced the antibacterial activity of the gelatin films against three *Listeria* strains (*Listeria monocytogenes* ATCC 19115, *Listeria ivanovii* ATCC 1919, and *Listeria seeligeri* ATCC 35967). The bacterial count reductions were 0.87, 1.50, and 1.38 $\log_{10}$ CFU/mL at 4°C, and 0.88, 1.35, and 1.22 $\log_{10}$ CFU/mL at 25°C, respectively. Meanwhile, shikonin greatly improved the antioxidant capacity of the films. The DPPH scavenging activity increased from 12.68% and 13.23% to 73.34% and 74.33% at 4°C and 25°C, respectively, while the ABTS scavenging rate increased from 9.27% and 9.89% to 88.03% and 88.18% at 4°C and 25°C, respectively. In the beef cold storage preservation experiment, the untreated beef exhibited noticeable quality deterioration on day 5. By comparison, beef samples coated with the composite films maintained favorable freshness on day 7, with the pH value, total volatile basic nitrogen content, and total viable count recorded as 5.84, 122.5 mg/kg, and 3.38 $\log_{10}$ CFU/g, respectively, all of which met the requirements of Chinese national food safety standards. In addition, the sustained release of active shikonin from the composite coating effectively reduced the thiobarbituric acid value and inhibited lipid oxidation in beef. These findings demonstrate that the synergistic antibacterial and antioxidant activities of shikonin endow the gelatin composite coatings with excellent preservation performance, which can effectively prolong the shelf life of chilled beef to at least 7 days, providing a feasible and promising strategy for maintaining the freshness and food safety of chilled beef during cold storage.

Key words: Shikonin; Gelatin composite film; Antibacterial and antioxidant activity; Beef preservation; *Listeria monocytogenes*

基金项目：国家自然科学基金项目（32460618，32260610）；江西省农业农村厅名特优水产品产业技术体系专项基金（JXARS-15）

Preparation, Characterization, and pH-Responsive Intestinal Release Properties of Gel Beads Encapsulating Sea Cucumber Mouthpart Peptides

Yige Wu [1,2], Lijun Hu [1,2], Yue Li [1,2], Tiantian Hao [2,3], Zhidong Song [2,3], Gongming Wang [2,3], Chunna Jiao [2,3,*] and Jian Zhang [2,3,*]

1. College of Food Sciences and Technology, Shanghai Ocean University, Shanghai 200120, China;

2. Shandong Marine Resource and Environment Research Institute, Yantai 264006, China;

3. Yantai Key Laboratory of Quality and Safety Control and Deep Processing of Marine Food, Yantai 264006, China

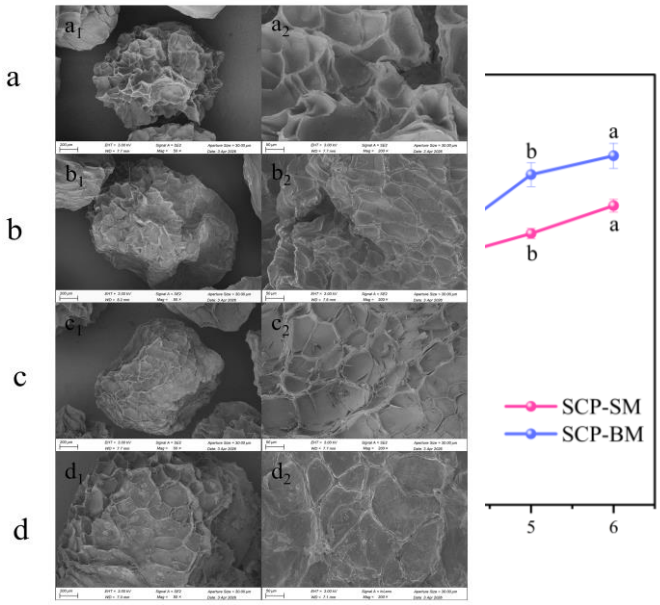
Abstract :Sea cucumber mouthpart peptides (SCPs) are marine bioactive peptides with considerable application potential. However, their oral delivery remains challenging because of their poor stability and low intestinal bioavailability. To develop a delivery system for SCPs with gastric protection and pH-responsive intestinal sustained-release properties, double-layer gel beads (SCP-BMs) were fabricated through ionic gelation, with SCPs as the core material and sodium alginate (SA) and chitosan (CS) as the wall materials. The preparation conditions of the gel beads were optimized using single-factor experiments and response surface methodology (RSM). The optimized gel beads were then characterized for their morphology, thermal stability, in vitro gastrointestinal release behavior, and antioxidant activity. The results showed that the optimal preparation conditions were 1.67% (w/v) sodium alginate, 0.96% (w/v) chitosan, and 2.16% (w/v) CaCl2. Under the optimized conditions, the encapsulation efficiency (EE) reached 94.33%, significantly higher than that of the single-layer gel beads (SCP-SMs, 58.61%). Structural characterization showed that SCP-BMs exhibited a more compact structure than SCP-SMs, along with improved thermal stability. In vitro release and antioxidant assays demonstrated that SCP-BMs exhibited better gastric protection, pH-responsive intestinal release, and higher 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2′-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS) radical

scavenging activity compared with SCP-SMs. This study demonstrated that the SA/CS double-layer wall material system effectively improved the encapsulation efficiency, structural stability, and intestinal release behavior of SCP gel beads. These findings provide a feasible strategy for the development of SCP delivery systems and offer a theoretical basis for the high-value utilization of sea cucumber byproducts.

Key words : sea cucumber mouthpart peptides; gel beads; structural characterization; sustained-release performance; antioxidant activity

Funding : This research was funded by the Shandong Provincial Modern Agricultural Industry Technology System Sea Cucumber Industry Technology System Construction Project (SDAIT-22-08) and the National Key Research and Development Program of China (No. 2024YFD2402104).

Correspondence: Zhang Jian, male, Ph.D., researcher. His main research direction is marine bioactive substances. Tel: 18153518121; E-mail: zjsd408@163.com



Preservative efficacy of slightly acidicelectrolyzed water on refrigerated large yellow croaker: Insights into quality deterioration, flavor migration, and shelf-life extension

Shuji Liu[1], Binbin Li[1,2+], Weilin Zheng[1,3], Shuo Shan[4], Xiaoting Chen[1], Nan Pan[1], Xiangyang Lin[1], Yongchang Su[1], Tingru Chen[1], Chao Zhao[4], Yihui Chen[3*], Zhiyu Liu[1*]

1. Fisheries Research Institute of Fujian Province, National Research and Development Center for Marine Fish Processing (Xiamen) / Key Laboratory of Cultivation and High-value Utilization of Marine Organisms in Fujian Province, Xiamen 361013, China; 2. College of Chemical Engineering, Huaqiao University, Xiamen 361021, China; 3. College of Food Science, Fujian Agriculture and Forestry University, Fuzhou 350002, China; 4. College of Marine Sciences,Fujian Agriculture and Forestry University, Fuzhou 350002, China.

Abstract: This study aimed to elucidate the preservation efficacy and underlying mechanisms of slightly acidic electrolyzed water (SAEW) on refrigerated large yellow croaker (Larimichthys crocea). With distilled water as the control (CK), compared the effects of SAEW on sensory quality, microbial counts, physicochemical, freshness indicators, textural, moisture distribution, and flavor profile changes of large yellow croaker during refrigerated storage. The results demonstrated that SAEW reduced the initial total viable count by 1.09 lg (CFU/g), significantly suppressed its upward trend, and delayed the time point of exceeding the safety limit by 3 days. On the 12th day of storage, the total volatile basic nitrogen content in the CK group exceeded the limit of 30 mg/100 g (reaching 32.43 mg/100 g), while that in the SAEW group remained within the acceptable range (28.29 mg/100 g). Meanwhile, the accumulation of thiobarbituric acid reactive substances and abnormal pH elevation were also inhibited. Texture Profile Analysis and Low-Field Nuclear Magnetic Resonance results revealed that SAEW preserved myofibrillar integrity, reduced immobilized-water loss, and better maintained hardness and chewiness. Electronic-sensory and Gas Chromatography-Mass Spectrometry detection indicated that SAEW delayed adenosine triphosphate degradation, retained the umami substance inosine monophosphate, limited the formation of bitter metabolites

such as hypoxanthine, blocked the production of trimethylamine-related spoilage odorants, and stabilized characteristic aldehydes and alcohols (nonanal, n-hexanal, and 1-octen-3-ol), thereby retarding flavor deterioration. Overall, SAEW extended the refrigerated shelf life of large yellow croaker by approximately 3 days, providing theoretical and technical support for its application in cold-chain preservation and processing.

Key words: Large yellow croaker; Slightly acidic electrolyzed water; Preservation; Volatile flavor compounds; Quality changes

Fundings: the Seed Industry Innovation and Industrialization Project of Fujian Province (2021FJSCZY01), Marine and Fishery Integrated Services Program of Fujian Province (FYZF-KTYJ-2026-1-5), and Special Funds Program for Promoting High-Quality Development of Marine and Fishery Industry in Fujian Province (FJHYF-L-2023-29 & FJHYF-L-2023-4).

* Correspondence:13906008638@163.com, harris2197395@163.com

+ These authros contributed equally to this work.

Quality Analysis of Refrigerated Dried Shrimp (*Acetes chinensis*) via Physical Chemistry and Non-Targeted Metabolomics: Advancing Product Development

Author names: Chenxuan Feng [1], Mingxiao Yin [1,2], Xin Gu [1], Shanshan Shui [1,2*], Bin Zhang [1,2*]

2. Zhoushan Key Laboratory of Marine Food Nutrition and Intelligent Processing, College of Food Science and Pharmacy, Zhejiang Ocean University, Zhoushan, China;2. Pisa Marine Graduate School, Zhejiang Ocean University, Zhoushan, China;

Abstract: This study investigated quality changes and metabolic profiles of raw-dried *Acetes chinensis* during refrigerated storage at 4℃ for 60 days, and evaluated the storage stability and nutritional value of air-fried shrimp during ambient storage at 25℃ for 120 days. For raw-dried shrimp, L^* value declined progressively whereas the browning index increased continuously. The peroxide value (PV) exhibited an upward trend throughout storage, while thiobarbituric acid reactive substances (TBARS) displayed a biphasic pattern of initial increase followed by decrease. Total volatile basic nitrogen (TVBN) and total viable count (TVC) accumulated significantly over time. Non-targeted metabolomic analysis identified 1,903 metabolites. Differential metabolites were predominantly concentrated in lipid metabolism, particularly glycerophospholipid and sphingolipid metabolism, as well as nucleotide and amino acid metabolism. For air-fried shrimp, the L^* value decreased and the b^* value increased during ambient storage, whereas moisture content and water activity reached a dynamic equilibrium after an initial minimum. The PV increased continuously, with a sharp rise observed between 90 d and 120 d. The TVC showed a steady positive correlation with storage time. Nutritional profiling indicated that the air-fried product contained high protein (56.99 g/100 g), low fat (4.67 g/100 g), and remarkably elevated calcium (2287 mg/100

g). These findings provided a theoretical foundation for optimizing refrigerated storage protocols for raw-dried shrimp and offered practical guidance for the industrial development of air-fried shrimp products.

Keywords: *Acetes chinensis*; Raw-dried shrimp; Refrigerated storage; Air frying; Non-targeted metabolomics; Lipid oxidation

Corresponding author*: Shanshan Shui, E-mail address: shuiss@zjou.edu.cn, ORCID: 0000-0003-1095-7749; and Bin Zhang, E-mail address: zhangbin@zjou.edu.cn, ORCID: 0000-0003-4696-9098. No.1, Haida South Road, Lincheng Changzhi Island, Zhoushan, Zhejiang province, 316022 P. R. China.

Funding Acknowledgements

This study was funded by the National Key R&D Program of China (Grant No. 2021YFD2100504), the National Natural Science Foundation of China (Grant No. 32301972 & U23A20263), and the Zhejiang Provincial Natural Science Foundation of China (Grant No. LRG25C200001).

Rapid Analytical and Quantitative Evaluation of Formaldehyde in Squid Based on Tri-step IR and Partial Least Squares

Jie Yu[1], Dongchen Gu[1], Mengjun Zou[1], Changhua Xu[1,2]*

[1] College of Food Science & Technology, Shanghai Ocean University, Shanghai 201306, PR China;

[2] Shanghai Engineering Research Center of Aquatic-Product Processing Preservation, Shanghai 201306, PR China

Abstract: A rapid and quantitative method was developed for the determination of formaldehyde in squid using Tri-step infrared spectroscopy combined with partial least squares (PLS) regression. Squid samples treated with different concentrations of formaldehyde were analyzed by Fourier transform infrared spectroscopy (FT-IR), second-derivative infrared spectroscopy (SD-IR), and two-dimensional correlation infrared spectroscopy (2DCOS-IR), while high-performance liquid chromatography (HPLC) was used as the reference method. Formaldehyde treatment induced concentration-dependent spectral variations, particularly in protein- and glycogen-related absorption bands, and spectral curve-fitting further indicated the transformation of β-sheet structures into α-helix and β-turn conformations. A significant linear relationship was observed between formaldehyde concentrations in squid and soaking solutions (R^2 = 0.9838). The PLS prediction model showed good quantitative performance, with R^2 of 0.9787 and RMSEC of 5.51 for the calibration set, and R^2 of 0.9774 and RMSEP of 6.08 for the validation set. The method achieved a detection limit of 15 mg/kg and reduced the analysis time to approximately 5 min per sample. These results demonstrate that Tri-step infrared spectroscopy combined with PLS provides a rapid and effective approach for screening and quantitative determination of formaldehyde in squid.

Key words: Squid; Formaldehyde; Tri-step infrared spectroscopy; Partial least squares; Rapid detection

Funding: National Natural Science Foundation of China (No. 31401571); Natural Science Foundation of Shanghai (No. 14ZR1420000); Key Projects in the National Science & Technology Pillar Program during the Twelfth Five-year Plan Period (Nos. 2015BAD17B01 and 2015BAD17B02); Thermo Fisher Scientific Inc. (China), Food Rapid Detection Methods and

Applications (No. D-8006-15-0009).

Corresponding author: Changhua Xu, male, Ph.D., Professor. Research interests: rapid food testing.

Tel.: 18516275495. E-mail: chxu@shou.edu.cn

Screening and Characterization of a Pufferfish-Skin-Derived Keratin Repair Peptide, LGGF (LG4), for Damaged Human Hair

Jun-Jie Li[1], Yu-Tong Li[1], Bo-Yan Li[1], Chang-Hua Xu[1,2,3,4,*]

1. College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, P. R. China;

2. Shanghai Engineering Research Center of Aquatic-Product Processing and Preservation, Shanghai 201306, China;

3. Laboratory of Quality and Safety Risk Assessment for Aquatic Products on Storage and Preservation (Shanghai), Ministry of Agriculture, Shanghai 201306, China;

4. National R&D Branch Center for Freshwater Aquatic Products Processing Technology (Shanghai), Shanghai 201306, China;

Abstract: [Objective] To screen a keratin repair peptide from pufferfish skin and evaluate its effects on damaged human hair and the possible molecular basis. [Methods] Keratin repair peptides (KRPs) were prepared from pufferfish skin by enzymatic hydrolysis, ultrafiltration, gel filtration, and RP-HPLC. Repair-active fractions were screened by infrared spectroscopic imaging, and LGGF (LG4) was identified by LC-MS/MS. Its effects were evaluated by amino acid analysis, infrared spectroscopic imaging, differential scanning calorimetry, scanning electron microscopy, and molecular docking. [Results] LG4 treatment increased total amino acid content by 9.97 g/100 g, including increases of 1.24 g/100 g in cysteine and 2.35 g/100 g in total hydrophobic amino acids. Protein distribution increased by 18%-20%, and the relative helical content of α-helical keratin increased from 83.57% to 97.01%. Molecular docking predicted a binding affinity of -7.8 kcal/mol, with five hydrophobic interactions and one hydrogen bond between LG4 and hair keratin. The distributions of cystine-related products and lipids shifted toward those of normal hair, and cuticle scale arrangement was improved. [Conclusion] LG4 improved compositional and structural indicators of damaged hair. The findings suggest that its effects may involve interactions with α-

keratin together with changes in cystine-related products, lipid distribution, and cuticle organization, providing a basis for high-value utilization of pufferfish skin in hair-care ingredients.

Key words: Keratin repair peptide; Pufferfish skin; Damaged human hair; Infrared spectroscopic imaging; Molecular docking

Funding: National Natural Science Foundation of China (32371321); National Key R&D Program of China (2020YFD0900905).

Corresponding-author profile: Name: Chang-Hua Xu; Gender: Male; Degree: Ph.D.; Professional title: Professor; Research interests: precise nutritional regulation based on multimolecular spectroscopy and special food research; Tel.: 18516275495; E-mail: chxu@shou.edu.cn.

Seafood: processing, preservation, nutrition, marketing, and policy

Jiawei Sun1, Zongcai Tu2, Wenge Yang3, Haixia Yu4, Lingyue Zhang5, Ronglong Jiang6, Tao Huang7*

1 College of Food Science and Engineering, Ningbo University, Ningbo 315832, China

2 National R&D Center for Freshwater Fish Processing, Jiangxi Normal University, Nanchang 330022, China;

3 Zhejiang-Malaysia Joint Research Laboratory for Agricultural Product Processing and Nutrition, Ningbo University, Ningbo 315832, China

4 Ocean Research Centre of Zhoushan, Zhejiang University, Zhoushan, 31600 China

5 Faculty of Medicine, Nursing and Health Sciences, Monash University, 27 Rainforest Walk, Clayton, VIC, 3168, Australia

Abstract : Seafood is an essential component of the global diet and economy, with diverse species and products contributing to the nutrition and well-being of populations worldwide. This paper provides a comprehensive review of key aspects related to seafood, including processing, preservation, nutrition, marketing, and policy. The processing of seafood involves traditional techniques such as frozen and ultracold, and some new techniques such as high pressure, plasma, pasteurization, which are crucial for maintaining product quality and extending shelf life. Furthermore, the nutritional value of seafood, rich in proteins, omega-3 fatty acids, vitamins, and minerals, is discussed in detail, highlighting the health benefits associated with seafood consumption. The marketing of seafood products involves strategies for promoting and distributing these products to consumers, addressing consumer preferences, trends, and sustainability concerns. Finally, the paper explores the policy aspects related to seafood, including food safety standards, and sustainability initiatives, emphasizing the importance of policy frameworks in ensuring the responsible management of seafood resources.

Key words: seafood ;preservation; nutrition; marketing

Structural and functional responses of myofibrillar proteins from yellow croaker to plasma-activated buffer: evidence from a simulated PAW system

Fangqi Yuan [1,3] , Quanyou Guo [2,*] , Huamao Wei [1,3,*]

1.College of Food Science and Engineering, Ningbo University, Ningbo 315211, China；2. East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Shanghai 200090, China；3.Zhejiang Key Laboratory of Intelligent Food Logistic and Processing, Zhejiang-Malaysia Joint Research Laboratory for Agricultural Product Processing and Nutrition, Ningbo University

Abstract: As a green non-thermal technology, plasma-activated water (PAW) generates reactive oxygen and nitrogen species (RONS) through plasma–liquid interactions and thereby affects the oxidation, conformation, and functionality of aquatic myofibrillar proteins (MPs). To investigate the regulatory effects of PAW on yellow croaker MPs, the original extraction buffer was replaced with plasma-activated buffer of different activation times, and the oxidation, conformation, and functional changes of MPs during chilled storage were evaluated. The results indicate that moderate PAW treatment induces mild oxidation and modulates protein conformation. PAW-30 s showed a lower bromophenol blue binding capacity (31.55 ± 0.95 μg), indicating limited intermolecular interactions and moderate aggregation that partially masked hydrophobic groups and improved structural stability. As the treatment time was extended to 60 s and 120 s, PAW further promoted the oxidation of thiol groups, altered surface hydrophobicity and intrinsic ffuorescence characteristics, and enhanced the conformational rearrangement and intermolecular cross-linking of MP. SDS-PAGE results showed that the effects of PAW were primarily concentrated on the myosin heavy chain (MHC), as shown by MHC band weakening and increased high-molecular-weight aggregates, without obvious low-molecular-weight degradation. Molecular docking analysis further indicated that representative reactive oxygen species in PAW, H_2O_2 and O_3 can bind to speciffc regions on the MHC surface, thereby inducing local microenvironmental disturbances and oxidative modifications. Overall, PAW regulated yellow croaker MPs mainly through mild oxidation-induced conformational rearrangement and intermolecular cross-linking rather than extensive chain cleavage, with moderate

activation being more favorable for maintaining MP structural stability and functional properties.

Key words: Plasma-activated water；Larimichthys crocea；Myoffbrillar protein；Oxidative modification；Secondary structure

Funding：This work was ffnancially supported by the National Key Research and Development Program of China (2023YFD2401400) and Ningbo Todayfood Co., Ltd.

通讯作者：1. 郭全友，男，工学博士，研究员，水产品质量安全与加工室主任、东海水产研究所宁德创新研究院执行院长，水产品加工与贮藏、食品微生物学、水产品品质评价与调控，021-65678984，guoqy@ecsf.ac.cn；

2.魏华茂，男，博士，副研究员，水产品精深加工与高值化利用、水产品贮藏与保鲜，0574-87604388，weihuamao@nbu.edu.cn.

Synergistic Cryoprotection of Carboxymethylated Propylene Glycol Alginate and Carboxymethylated Artemisia Sphaerocephala Krasch gum in Shrimp Gel

Kaina Duan[1,2], Yeqi Luan[1,2], Ru Jia[1,2,*]

1. College of Food Science and Engineering, Ningbo University, Ningbo, Zhejiang 315211, China

2. Zhejiang Key laboratory of Intelligent Food Logistic and Processing, Zhejiang-Malaysia Joint Research Laboratory for Agricultural Product Processing and Nutrition, Ningbo University, Ningbo 315211, China

Abstract: Freeze–thaw cycles can cause severe deterioration in the structural integrity and quality of shrimp gel. This study investigated the synergistic cryoprotective effects of carboxymethylated propylene glycol alginate (CM-PGA) and carboxymethylated artemisia sphaerocephala krasch gum (CM-ASK) under a setting–freezing–cooking system. Different CM-PGA/CM-ASK ratios were incorporated into shrimp gel, and gel properties, water migration, protein secondary structure, chemical interactions, microstructure, and oxidative stability were systematically evaluated during five freeze–thaw cycles. The 1:1 CM-PGA/CM-ASK composite exhibited the strongest protective effect, maintaining higher gel strength, a greater proportion of ordered protein secondary structures, and a denser and more homogeneous gel network. After five freeze–thaw cycles, the increase in drip loss was limited to 10.16%, compared with 15.14% in the untreated control. The superior cryoprotective performance was associated with the structural complementarity between CM-PGA and CM-ASK, which enhanced molecular entanglement, hydrogen bonding, and electrostatic interactions, thereby restricting water migration, stabilizing the protein network, and alleviating freeze–thaw-induced oxidative and structural damage. These findings demonstrate that the 1:1 CM-PGA/CM-ASK composite can effectively improve the freeze–thaw stability of shrimp gel and highlight its potential as a natural polysaccharide-based cryoprotectant for aquatic gel products.

Key words: shrimp gel; freeze–thaw cycles; carboxymethylated propylene glycol alginate; carboxymethylated artemisia sphaerocephala krasch gum ; cryoprotection

Synergistic regulation of heat-induced gelation in golden pompano (*Trachinotus ovatus*) myofibrillar proteins by Na^+/K^+ ratio: Structural evolution and water migration

Tianle Tian[a,c], Yamei Wu[c], Miaomiao Han[c], Yongqiang Zhao[c,d], Huan Xiang[c], Shaoling Yang[c], Yanyan Wu[a,b,c,d*], Yueqi Wang[b,c,d*]

[a]College of Food Science and Technology, Shanghai Ocean University, Shanghai, China

[b]Guangxi College and University Key Laboratory Development and High-value Utilization of Buibu Gulf Seafood Resources, College of Food Engineering, Beibu Gulf University, Qinzhou, Guangxi 535000, China

[c]Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs, National R&D Center for Aquatic Product Processing, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, China

[d]Key Laboratory of Efficient Utilization and Processing of Marine Fishery Resources of Hainan Province, Sanya Tropical Fisheries Research Institute, Sanya 572018, China

Abstract: This study investigated the synergistic effects of Na^+/K^+ ratios on the structural evolution and heat-induced gelation of myofibrillar proteins (MPs) from golden pompano (*Trachinotus ovatus*) under a constant ionic strength of 0.6 mol/L. Results indicated that substituting NaCl with 0.4 mol/L KCl optimally promoted protein solubility, surface hydrophobicity, and total thiol exposure. Furthermore, this specific ionic environment induced a favorable conformational rearrangement, characterized by the transition of α-helices to β-sheets. Consequently, the MPs maintained excellent colloidal dispersion, evidenced by a reduced volume-average particle size and a high absolute ζ-potential. Rheological and microstructural analyses revealed that this optimal ion ratio yielded a gel with a maximized storage modulus (G′) and a highly uniform, densely cross-linked three-dimensional network. Low-field nuclear magnetic resonance (LF-NMR) confirmed that this continuous structural matrix strongly restricted water mobility, shifting the T_2 relaxation time and

increasing the proportion of immobilized water to 13.11%. Conversely, excessive KCl substitution (0.5–0.6 mol/L) triggered severe irreversible aggregation, decreasing protein solubility and resulting in a coarse, loose gel network with poor water-holding capacity. In conclusion, tailoring the Na^+/K^+ binary ionic composition effectively modulates the specific ion effects on protein hydration and intermolecular forces, providing a promising biomolecular strategy for optimizing the textural properties of low-sodium aquatic protein gels.

Key words: Myofibrillar proteins; Heat-induced gel; Low-sodium; Water migration; KCl substitution

The effects of low molecular weight fucoidan on the quality of frozen *Litopenaeus vannamei*

Xuhui Lei[a#], Huirui Wang[a#], Jiyan Sun[a,b,c], Shuangshuang Wu[a,b,c],Yuxin Shi[a,b,c], Zhiying Xu[a,b,c], Yichao Ma[a,b,c], Shu Liu[a,b,c], Yunhai He[a,b,c], Qiukuan Wang[a,b,c],Dandan Ren[a,b,c]*

[a]*College of Food Science and Engineering, Dalian Ocean University, Dalian, PR China;* [b]*National R & D Branch Center for Seaweed Processing, Dalian, PR China;* [c]*Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian, PR China*

*Corresponding author: Prof. Dandan Ren (rendandan@hotmail.com ORCID:0000-0002-9346-0502)

The authors shared the co-first authorship.

Abstract:

Aquatic products are highly valued for their rich nutrient content and unique flavors. However, they are particularly vulnerable to microbial contamination during transportation and storage, which can lead to spoilage. Fucoidan (F) exhibited a broad spectrum of biological activities. Nevertheless, research on its application as an antifreeze agent remains limited. In this study, low molecular weight fucoidan (WIF) was prepared through irradiation degradation using fucoidan as the starting material. The relative molecular weights of WIF obtained via 50 kGy γ-ray irradiation ranged from 4.97×10^3 to 3.25×10^4 Da. The molecular weight and functional groups were determined, and it was found that irradiation degradation method could reduce the molecular weight of fucoidan and change the original chemical composition, Following irradiation, the protein content decreased from 0.94% ± 0.02% to 0.24% ± 0.04%, whereas the reducing sugar content increased from 0.69% ± 0.01% to 6.25% ± 0.36%. Results indicated that soaking treatments with various concentrations of WIF

solution exhibited excellent cryoprotective properties and water-holding capacity (WHC) in frozen Pacific white shrimp (*Litopenaeus vannamei*). Notably, after 180 days of frozen storage, the group treated with 15 g/L WIF maintained a myofibrillar protein Ca^{2+}-ATPase activity of 0.0338 U/mgprot and a total sulfhydryl content of 30.06 μmol/gprot, both of which were significantly higher than those of the other groups ($P < 0.05$). Furthermore, at day 180, the surface hydrophobicity of the 15 g/L WIF group was 61.35μg/mgprot, significantly lower than that of the control groups ($P < 0.05$). These findings demonstrate that WIF effectively inhibits the decline of Ca^{2+}-ATPase activity, the oxidation of sulfhydryl groups, protein carbonylation, the exposure of hydrophobic residues, and the accumulation of malondialdehyde (MDA). In conclusion, compared with fucoidan F with large molecular weight, WIF with lower molecular weight showed better antifreeze and water retention ability under the same concentration condition. The antifreeze and water retention effect of WIF on frozen *Litopenaeus vannamei* was positively correlated with its addition amount.

Keywords: low molecular weight fucoidan; *Litopenaeus vannamei*; frozen storage; freshness preservation

Ultrasonication during acid-heat fibrillation tailors soy protein isolate architecture for high internal phase emulsion gels: Linking fibril structure to astaxanthin stability and bioaccessibility

Guangyao Zhang[a,b], Renyue Zhang[a,b], Guanli Li[a,b], Guangyi Kan[a,b], Yang Li[a,b], Long Zhang[a,b], Mingyu Yin[a,b], Xichang Wang[a,b*]

[a] College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

[b] Shanghai Engineering Research Center of Aquatic-Product Processing and Preservation, Shanghai 201306, China

Abstract

This study investigated the effects of ultrasound-assisted acid-heat (UAH) treatment on the fibrillation behavior and structural evolution of soy protein isolate (SPI), and further examined how fibril architecture influences the structural and functional properties of high internal phase emulsion gels (HIPEGs) and the stability and gastrointestinal bioaccessibility of encapsulated astaxanthin. Compared with conventional acid-heat (CAH) treatment, UAH generated well-developed SPI fibrils with structural characteristics comparable to those obtained after 12 h of CAH treatment within only 1–1.5 h. Moderate ultrasonication promoted protein unfolding, β-sheet-rich fibrillar assembly, and fibril elongation, indicating that ultrasonication regulated protein self-assembly during acid–heat fibrillation, whereas excessive ultrasonication induced aggregation and disrupted fibrillar organization. HIPEGs stabilized by well-developed SPI fibrils exhibited improved emulsifying properties, water-holding capacity, viscoelasticity, and microstructural stability compared with those prepared using granular SPI or less-developed fibrils. Notably, UAH-1 h produced fibrils and HIPEGs with structural and rheological characteristics comparable to those of the CAH-12 h group. When applied to astaxanthin-loaded HIPEGs, fibrillar SPI provided higher astaxanthin loading and better retention during heating, while also preserving higher proportions of 9-cis- and 13-cis-astaxanthin than granular SPI and oil controls. Furthermore, fibril-stabilized HIPEGs promoted

astaxanthin transfer into the intestinal aqueous/micellar fraction and exhibited higher gastrointestinal bioaccessibility, with the effects depending on fibril architecture. These findings demonstrate that controlling SPI fibril architecture through ultrasound-assisted acid–heat treatment provides a structural basis for designing HIPEGs with enhanced colloidal functionality and improved protection and gastrointestinal bioaccessibility of astaxanthin.

Keywords: Soy protein isolate; Protein fibrillation; Ultrasound-assisted acid–heat treatment; High internal phase emulsion gels; Astaxanthin

*This research was financially supported by grants from the National Key Research and Development Program of China (2023YFD2401503) .

*Corresponding author: Xichang Wang

*Gender: Male

*Degree: PhD

*Professional Title: Professor

*Research Direction: Food nutrition and quality evaluation

*E-mail address: xcwang@shou.edu.cn

*Address: No.999, Hucheng Ring Rd, Nanhui New City, Pudong New District, Shanghai, P.R.

Ultrasound-assisted phosphate soaking improves the quality of frozen shrimp: Insights into gel properties and proteomic profiling

Yu Liu[1], Tengyang Guo[1], Jia Cai[1], Zhaoqing Zhang[1], Naiyong Xiao[1], Zefu Wang[1], Shuai Wei[1], Yantao Yin[*1], Shucheng Liu[*1]

College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Guangdong Provincial Engineering Laboratory for Marine Biological Products, Guangdong Provincial Engineering Technology Research Center of Seafood, Zhanjiang 524088, China.

Abstract: Frozen storage often causes quality deterioration of *Litopenaeus vannamei*. Phosphate soaking can improve the quality of frozen shrimp; however traditional soaking has problems with long time and uneven. Ultrasound is a green non thermal processing technology. Nevertheless, the effect of ultrasound assisted phosphate soaking on the quality of shrimp has not been thoroughly studied. In this study, shrimp samples were subjected to conventional phosphate soaking (2 h) or ultrasound-assisted phosphate soaking at 100, 200, or 300 W for 1 h, followed by frozen storage at -18 °C for 30 days. The results showed that, compared to traditional soaking, ultrasound-assisted soaking remarkedly improved the gel quality of shrimp, especially at 300 W. Specifically, ultrasound-assisted soaking significantly reduced cooking loss, increased water-holding capacity, and improved hardness, chewiness, and resilience compared with conventional soaking ($p < 0.05$). Low-field nuclear magnetic resonance revealed a marked increase in immobilized water and a decrease in free water in the 300 W group ($p < 0.05$), while scanning electron microscopy showed a more uniform and denser gel microstructure. Proteomic analysis revealed that ultrasound-assisted soaking upregulated myosin light chain and deubiquitinating enzymes (ubiquitinyl hydrolase 1), downregulated aminopeptidases, and increased the levels of heat shock protein 70 and superoxide dismutase.Ultrasound-assisted phosphate soaking effectively improved the gel quality of frozen *Litopenaeus vannamei* by modulating proteolytic pathways and enhancing protein network

formation. This study provides technical support for the application of ultrasound in the high-quality processing of shrimp.

Key words: White leg shrimp; Surimi gels; Frozen storage; Ultrasound; Phosphate

通讯作者:

殷燕涛(1989—)，男，博士，副教授，研究方向为海洋食品保鲜与加工。E-mail：yantaoyin@gdou.edu.cn；

刘书成(1979—)，男，博士，教授，研究方向为海洋食品保鲜与加工。E-mail：Lsc771017@163.com

资助项目：本研究得到广东省重点研发计划（项目编号：2025B1111140001）、广东海洋大学大学生创新实验项目（项目编号：S202610566023）以及广东省科技厅博士科研启动费资助计划（项目编号：060302042315）的资助。

Unveiling the hidden benefits of integrated multi-trophic aquaculture (IMTA) in estuarine ecosystems: Beyond growth performance to nutritional enhancement

Yongyi Chen [1, 2, 3, #], Minjing Yang [1, 2, 3, #], , Óscar Monroig [4], Douglas R. Tocher [1], Harold Corke [5], Mhd Ikhwanuddin [2, 3, 6,] Hongyu Ma [1, 2, 3, *], Ye Yuan [1, 2, 3, *]

[1] Guangdong Provincial Key Laboratory of Marine Biotechnology, Shantou University, Shantou 515063, China

[2] International Joint Research Center for the Development and Utilization of Important Mariculture Varieties Surrounding the South China Sea Region, Shantou University, Shantou 515063, China

[3] STU-UMT Joint Shellfish Research Laboratory, Shantou University, Shantou 515063, China

[4] Instituto de Acuicultura de Torre de la Sal (IATS), CSIC, Castellón, Spain

[5] Biotechnology and Food Engineering Program, Guangdong Technion-Israel Institute of Technology, Shantou 515063, Guangdong, China

[6] Higher Institute Centre of Excellence (HICoE), Institute of Tropical Aquaculture and Fisheries, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

Abstract: Estuarine ecosystems are characterized by high nutrient availability and diverse ecological niches, creating favorable conditions for integrated multi-trophic aquaculture (IMTA) systems that may simultaneously improve aquaculture environmental quality and product nutritional value. In this study, we established an IMTA system consisting of mud crab (*Scylla paramamosain*), Pacific white shrimp (*Litopenaeus vannamei*), oyster (*Crassostrea ariakensis*), and the macroalga (*Gracilaria tenuistipitata*). We compared it with a conventional polyculture system containing only crab, shrimp, and oyster. We evaluated water-quality dynamics, growth performance, and the nutritional composition of the cultured species. Compared with the control, the IMTA system reduced total nitrogen by 28.40% and total phosphorus by 49.58%. During the later culture period, the weight of shrimp and mud crab were significantly higher in the IMTA group ($P < 0.05$), whereas did not differ significantly between the two systems ($P > 0.05$). MTA also improved amino-acid nutritional quality, with the essential amino acid index (EAAI) increasing from 43.28 to 55.60 in shrimp hepatopancreas, from 40.40 to 58.05 in mud crab

hepatopancreas, and from 51.04 to 60.14 in mud crab muscle. In oysters, the EAAI changed only slightly, from 39.25 to 39.91. Fatty-acid profiles were also altered: DHA increased significantly in most tissues except shrimp muscle, EPA increased in mud crab and oyster, and oyster n-3 PUFA content increased from 25.53 to 31.74 mg/g. In conclusion, these results indicate that IMTA can reduce nutrient accumulation in estuarine aquaculture ponds while improving the amino acid and fatty acid nutritional quality of cultured products, supporting the coordinated optimization of aquaculture environmental quality and aquatic food nutritional value.

Key words: Integrated multi-trophic aquaculture (IMTA); Estuarine ecosystems; Growth performance; Amino acids; Fatty acids; Water quality

基金：国家自然科学基金（42306125）；广东省科技计划项目（2026A0202020022, STKJ2024044）

通讯作者：

马洪雨，男，博士，1979 年出生，山东招远人，教授，主要从事海洋经济动物养殖与育种学研究，15917902158，mahy@stu.edu.cn

袁野，男，博士，1991 年出生，安徽六安人，副教授，主要从事海水蟹脂质营养生理及代谢调控机制研究，13502931635，yeyuan@stu.edu.cn

Valorization of *Eriocheir sinensis* Processing By-Products into ACE Inhibitory Peptides: Mechanisms and Application Potential

Yi Wu[a], Fengyi Qiao[a], Zehui Qiu[a], Yuyao Shi[a,*], Xichang Wang[a,*]

[a] College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China;

*Corresponding author: Xichang Wang, Yuyao Shi

*E-mail address: xcwang@shou.edu.cn; edie_shiyuyao@163.com

Address: No.999, Huchenghuan Rd, Nanhui New City, Pudong New District, Shanghai, P.R. China.

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.

Keywords: *Eriocheir sinensis*; utilization of by-products; ACE inhibitory activity peptides; molecular mechanism

Funding project: Agriculture Research System of Shanghai, China (Grant NO.202504)

Corresponding author: Xichang Wang (Wang Xichang), male, Ph.D., Professor, research direction: Food Nutrition Flavor Analysis and Quality Evaluation Control，E-mail:xcwang@shou.edu.cn

V 型淀粉在罗非鱼鱼糜制品中的应用：凝胶品质改善与关键腥味物质吸附

刘阳 1，黄广娣 1，王丽萌 1, 刘书成 1*

广东海洋大学食品科技学院，广东省湛江市，524000

摘要：罗非鱼是我国养殖产量最大的淡水鱼品种，是我国冷冻鱼糜生产的核心原料，鱼糜制品是我国水产品精深加工的重要支柱品类。凝胶强度不足、腥味突出是制约罗非鱼鱼糜制品品质提升与消费者接受度的关键因素，现有凝胶改良与脱腥技术多为单一功能，难以兼顾质构优化与风味调控，易造成产品口感劣变、风味改变、工艺复杂等问题。淀粉是鱼糜加工中最常用的辅料，V 型淀粉是一种具有单螺旋疏水空腔结构的改性淀粉，兼具凝胶填充与小分子包合吸附功能。本研究以罗非鱼鱼糜为研究对象，探究 V 型淀粉对鱼糜凝胶品质的改善效果，解析其对鱼糜关键腥味物质的吸附行为。本研究可实现凝胶品质改良与腥味脱除的协同作用，为 V 型淀粉在淡水鱼糜制品加工中的工业化应用提供了全面的理论依据与技术支撑。

关键词：V 型淀粉；鱼糜制品；质构特性；挥发性气味

2-苯乙醇对木糖葡萄球菌的特异性代谢调控：与发酵鱼中乳杆菌的对比分析

高沛[1,*]，包世达[1]，姜启兴[1]，杨淑涵[1]，张晓靖[1]，刘绍泉[2,3]，于沛沛[1]，杨方[1]，夏文水[1,4]

[1]江南大学食品学院，食品科学与资源挖掘全国重点实验室，江苏省食品安全与质量控制协同创新中心 江苏无锡 214122

[2]新加坡国立大学食品科学与技术系 新加坡 117546

[3]新加坡国立大学(苏州)研究院 江苏苏州 215123

[4]尚好科技有限公司 山东青岛 266700

摘要: 2-苯乙醇（2-PE）是一种群体感应信号分子，可调控发酵食品中微生物的代谢。尽管其对乳酸菌（LAB）的作用近期已得到表征，但其在木糖葡萄球菌中的调控作用仍属未知。本研究在模拟酸鱼系统中考察了 2-PE 对木糖葡萄球菌 135 的浓度依赖性效应，并重点将其代谢响应模式与既往报道的戊糖乳植物杆菌进行比较。与乳酸菌中 2-PE 主要通过还原性三羧酸循环调节氨基酸代谢不同，其对木糖葡萄球菌主要表现出氧化应激响应，其特征为抗坏血酸消耗、甲硫氨酸亚砜积累及谷胱甘肽代谢上调。此外，2-PE 触发了乳酸菌驱动发酵中所缺失的芳香化合物（如苯乙醇乙酸酯、2-苯乙醛）的生物合成。这些差异化的调控机制凸显出，2-PE 的代谢影响具有物种依赖性，取决于受体菌株固有的胁迫耐受性与酶系组成。本研究结果将 2-PE 不仅界定为一种群体感应信号分子，更将其视为一种物种选择性代谢调节剂，从而为靶向调控酸鱼制品风味的提供了新途径。

关键词： 2-苯乙醇；群体感应；木糖葡萄球菌；代谢反应；酸鱼发酵

资助项目：国家自然科学基金(31801575)、江苏现代农业（大宗鱼类）产业技术体系(JATS [2023] 464)、国家大宗淡水鱼产业技术体系(CARS-45)

通讯作者：高沛，男，博士，副研究员，研究方向：食品科学、食品发酵、水产品加工，电话：18206188719，E-mail：g_pei1988@163.com

2-Phenylethanol triggers species-selective metabolic reprogramming in Staphylococcus xylosus: A comparative paradigm to lactobacilli in fermented fish

Pei Gao [1,*], Shida Bao [1], Qixing Jiang [1], Shuhan Yang [1], Xiaojing Zhang [1], Shaoquan Liu [2,3], Peipei Yu [1], Fang Yang [1], Wenshui Xia [1,4]

1. School of Food Science and Technology, State Key Laboratory of Food Science and Resources, Collaborative Innovation Center of Food Safety and Quality Control in Jiangsu Province, Jiangnan University, Wuxi, 214122, Jiangsu; 2.Department of Food Science and Technology, National University of Singapore, Singapore 117546, Singapore; 3. National University of Singapore (Suzhou) Research Institute, Suzhou, 215123, Jiangsu; 4. SoHao Fd-Tech Co., QingDao, 266700, ShanDong

Abstract: 2-Phenylethanol (2-PE) is a quorum-sensing molecule that regulates microbial metabolism in fermented foods. While its effects on lactic acid bacteria (LAB) have been recently characterized, its regulatory role in *Staphylococcus xylosus* remains unknown. This study investigated the concentration-dependent effects of 2-PE on *S. xylosus* 135 in a simulated sour fish system and, importantly, compared its metabolic response patterns with those previously reported for *Lactiplantibacillus pentosus*. Unlike LAB, where 2-PE primarily modulated amino acid metabolism via the reductive TCA cycle, *S. xylosus* exhibited a dominant oxidative stress response characterized by ascorbic acid depletion, methionine sulfoxide accumulation, and upregulated glutathione metabolism. Furthermore, 2-PE triggered the biosynthesis of aromatic compounds (e.g., 2-phenethyl acetate, 2-phenylacetaldehyde) that are absent in LAB-driven fermentation. These distinct regulatory mechanisms underscore that the metabolic impact of 2-PE is species-dependent, governed by the intrinsic stress tolerance and enzymatic repertoire of the recipient strain. Our findings position 2-PE not merely as a quorum-sensing molecule but as a species-selective metabolic modulator, offering new avenues for targeted flavor modulation in fermented fish products.

Key words: 2-Phenylethanol; Quorum sensing; *Staphylococcus xylosus*; Metabolic response; Sour fish fermentation

3 种热加工工艺对鲭鱼冷藏期间品质的影响

陈施园，林慧敏*，张宾

浙江海洋大学食品与药学学院，浙江 舟山 316022

摘要：鲭鱼是富含多不饱和脂肪酸和血红素的低值经济鱼类，加工贮藏中易发生脂质氧化，导致鱼肉色泽、质构及风味发生劣变。针对其冷藏易劣变、预制品质不稳定等问题，该研究比较烤制、低温慢煮与油炸 3 种热加工工艺对鲭鱼出品率、质构、感官及冷藏期间的品质变化。结果表明，低温慢煮显著提高鲭鱼出品率；油炸鲭鱼硬度高于其他两种工艺。3 种热加工工艺鲭鱼的感官评分存在一定差异，均呈现相应的工艺优势，可满足不同的感官偏好与消费需求。在冷藏过程中，三者的亮度值（L^*值）与水分含量呈上升趋势；烤制与低温慢煮鲭鱼 pH 值均为先降低后升高趋势，低温慢煮鲭鱼的硬度与 pH 值趋势相同，烤制鲭鱼的硬度与 pH 值趋势相反，油炸鲭鱼的硬度与 pH 值在冷藏期间均下降。

关键词：鲭鱼；低值；热加工工艺；冷藏；品质变化；预制产品

The Effects of Three Heat Processing Methods on the Quality of Mackerel (Scomber scombrus) During Refrigeration

CHEN Shiyuan, LIN Huimin*, ZHANG Bin

School of Food Science and Pharmacy, Zhejiang Ocean University, Zhoushan 316022, China

Abstract: Mackerel is a low-cost and economically valuable fish that is rich in polyunsaturated fatty acids and heme. During processing and storage, it is prone to lipid oxidation, resulting in deterioration of the color, texture, and flavor of the fish meat. To address the issues of rapid deterioration during refrigeration and unstable pre-pre pared

quality of mackerel, this study compared the effects of three thermal processing methods—roasting, low-temperature slow cooking, and frying—on the yield, texture, sensory properties, and quality changes of mackerel during refrigeration. The results showed that low-temperature slow cooking significantly increased the yield of mackerel; the hardness of fried mackerel was higher than that of the other two methods. There were certain differences in the sensory scores of mackerel produced by the three thermal processing methods, and each method demonstrated its corresponding advantages, which could meet different sensory preferences and consumption demands. During refrigeration, the L^* values (brightness values) and moisture contents of the three methods showed an upward trend; the pH values of roasted and low-temperature slow-cooked mackerel showed a trend of first decreasing and then increasing. The hardness of low-temperature slow-cooked mackerel followed the same trend as its pH values, while the hardness of roasted mackerel showed an opposite trend to its pH values. The hardness and pH values of fried mackerel both decreased during refrigeration.

Key words: mackerel; low value; heat processing technology; refrigeration; quality change; pre-prepared product

资助项目：国家重点研发计划项目（2021YFD2100504）

第一作者简介：陈施园（2002—），女（汉），硕士研究生，研究方向：水产品精深加工。E-mail: 13553617290@163.com

*通信作者：林慧敏（1979—），女（汉），教授，博士，研究方向：水产品精深加工。E-mail: linhuixiaomin@126.com

阿魏酸交联花青素-鱼明胶基智能水凝胶与指示膜的制备及虾新鲜度监测应用

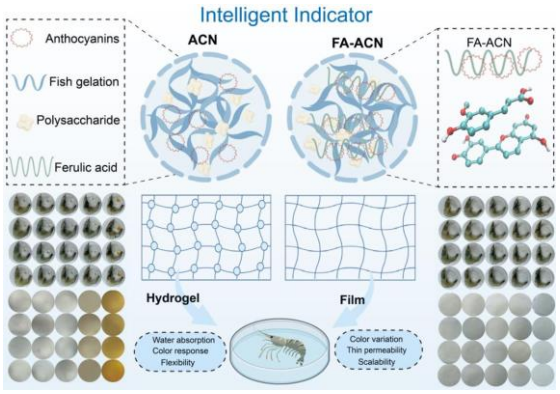
应晴芳[1]，刘云丽[2]，黄涛[1*]

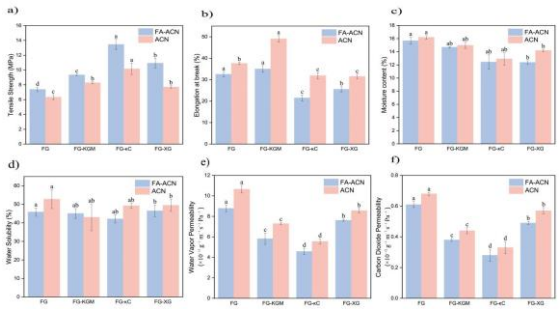
宁波大学食品科学与工程学院，浙江 宁波，315832

摘要：开发基于鱼明胶的天然花青素智能包装材料，用于水产品新鲜度可视化监测。以鱼明胶为基质、阿魏酸为交联剂、花青素为 pH 响应指示剂，制备智能水凝胶与薄膜，表征材料微观结构、理化及显色性能，并将其应用于鹰爪虾贮藏新鲜度检测。结果：阿魏酸交联可改善膜力学性能与阻隔性能；该材料对 pH 变化具有灵敏颜色响应，虾腐败过程中可发生肉眼可辨的颜色转变，与虾挥发性盐基氮等腐败指标变化具有良好对应关系。结论：阿魏酸交联花青素-鱼明胶体系可作为简易可视化指示包装，为水产食品智能保鲜包装开发提供参考。

关键词：鱼明胶；花青素；阿魏酸；智能指示膜；虾新鲜度

附图：





基金项目：基金项目：浙江省“尖兵领雁 + X” 研发攻关计划（2024C04050）；宁波市青年科技创新领军人才项目（2023QL038）；宁波市青年博士创新研究项目（2023J380）；浙江省教育厅一般科研项目（Y202353405）

[1*]通信作者：黄涛（1987-），男，博士，特聘研究员，研究方向：水产品资源高值化综合利用，E-mail: cdhuangtao@163.com。

靶向耐冷性摩根菌 LuxS/AI-2 群体感应系统的抑制剂筛选及其抑腐作用研究

王迪 1

中国水产科学研究院南海水产研究所，广东广州，510300

摘要：目的：筛选靶向耐冷性摩根菌 LuxS/AI-2 群体感应系统的抑制剂，并评价其抑制菌株致腐作用及延缓黄鳍金枪鱼片腐败的效果。**方法：**分子对接筛选 70 种食源化合物，结合分子动力学、AI-2 活性、基因表达、细胞表型和冷藏鱼片试验验证。**结果：**迷迭香酸（RA）与 LuxS 稳定结合，MIC 为 2 mg/mL。1/4 MIC RA 不影响细菌生长、形态和膜电位，但使 24 h AI-2 活性降低 41.68%、*luxS* 表达降低 26%，并下调 *hdc*、*speC* 和 *cysM*。RA 处理降低了接种鱼片中的生物胺和挥发性盐基氮含量，并在冷藏鱼片中降低了菌落总数、挥发性盐基氮和脂质氧化水平。**结论：**RA 在亚抑菌浓度下通过干扰 LuxS/AI-2 群体感应抑制耐冷性摩根菌的致腐作用，在较高浓度下还具有直接抑菌作用，表现出作为天然水产品保鲜剂的应用潜力。

关键词：耐冷性摩根菌；群体感应；虚拟筛选；迷迭香酸

资助项目：国家自然科学基金青年科学基金项目（32201937）；

王迪，女，博士，副研究员，水产品品质调控，18847010298，

wangdi1991624@hotmail.com

Evaluation of a virtually screened quorum sensing inhibitor for Morganella psychrotolerans as a preservative in yellowfin tuna fillets

Di Wang[1]

1. Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs, National R&D Center for Aquatic Product Processing, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, Guangdong

Abstract: **Objective:** To identify a natural quorum-sensing inhibitor targeting LuxS in *Morganella psychrotolerans* and assess preservation of yellowfin tuna. **Methods:** Seventy food-derived compounds were screened by molecular docking. The selected compound was validated by molecular dynamics, growth and AI-2 assays, microscopy, membrane-potential measurement, RT-qPCR, and refrigerated tuna models. **Results:** Rosmarinic acid (RA) bound LuxS stably and had an MIC of 2 mg/mL. At one-quarter MIC (0.5 mg/mL), RA did not alter growth, morphology, or membrane potential, but reduced 24-h AI-2 activity by 41.68% and *luxS* expression by 26%; *hdc*, *speC*, and *cysM* decreased by 19%, 11%, and 15%, respectively. RA reduced biogenic amines, total volatile basic nitrogen, total viable counts, and thiobarbituric acid reactive substances in tuna. **Conclusion:** At subinhibitory concentrations, RA limits *M. psychrotolerans*-mediated spoilage through LuxS/AI-2 interference; higher concentrations add antimicrobial activity. These findings support its potential as a natural seafood preservative.

Key words: *Morganella psychrotolerans*; Quorum sensing; Virtual screening; Rosmarinic acid

白兰花活性物质在水产品保鲜中的应用

战林洁[1,2] 胡亚芹[1,2*]

1.海南热带海洋学院食品科学与工程学院 海南三亚 572022

2.中国海洋大学三亚海洋研究院 海南三亚 572025

摘要：目的：水产品因富含不饱和脂肪酸和蛋白质，在贮运过程中极易发生微生物腐败、脂质氧化及风味劣变，是制约产业提质增效和绿色发展的关键瓶颈。本研究围绕天然植物源保鲜剂开发的前沿需求，系统综述白兰花（*Michelia×alba*）活性物质在水产品保鲜中的应用潜力与挑战。方法：系统梳理国内外关于白兰花活性物质的化学组成、抑菌抗氧化机制及其在水产品保鲜中的应用研究进展，比较分析白兰花提取物在水产加工副产物利用、冷链保鲜及活性包装体系中的集成应用形式，并重点探讨提取物组成、添加剂量、基质交互作用及加工条件对其保鲜效能的影响。结果：白兰花主要活性成分包括萜类、多酚和生物碱等，其作用机制涉及破坏病原微生物细胞膜完整性、干扰能量代谢，以及通过清除自由基和螯合金属离子抑制脂质过氧化链式反应；白兰花活性物质兼具抑菌与抗氧化双重功能，在替代化学合成保鲜剂方面显示出良好前景，但其成分标准化不足、风味交互作用不明确、剂量-效应关系缺乏系统验证等问题仍需深入研究。结论：未来应围绕“减损增效、绿色低碳”的产业导向，重点开展活性成分协同增效、稳态化包埋递送及智能化响应释放等关键技术研究，推动白兰花源保鲜剂在水产品冷链全链条中的精准应用，为我国水产品加工绿色转型提供科技支撑。

关键词：白兰花；水产品保鲜；抑菌活性；抗氧化活性；绿色加工；冷链品质调控

基金项目：海南热带海洋学院高层次人才项目（RHDRC202117）；海南热带海洋学院青年人才项目（RHDRC202307）

通讯作者：胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，联系方式为 15868109010，邮箱为 1004346262@qq.com

Application potential and Challenges of bioactive substances from Michelia×alba in Green Preservation of Aquatic Products

Linjie Zhan[1,2] Yaqin Hu[1,2*]

1.College of Food Science and Engineering, Hainan Tropical Ocean University, Sanya, Hainan, 572022

2.Sanya Oceanographic Institution, Ocean University of China, Sanya, Hainan, 572025

Abstract: [Objective] Aquatic products are highly susceptible to microbial spoilage, lipid oxidation, and flavor deterioration during storage and transportation due to their rich content of unsaturated fatty acids and proteins, which poses a critical bottleneck constraining quality improvement and green development of the industry. Aligned with the frontier demand for natural plant-derived preservatives, this review systematically summarizes the application potential and challenges of bioactive substances from *Michelia×alba* in aquatic product preservation. [Methods] The chemical composition, antibacterial and antioxidant mechanisms, and application progress of *Michelia×alba* bioactive substances in aquatic product preservation were systematically reviewed. The integrated application forms of *Michelia×alba* extracts in byproduct utilization, cold-chain preservation, and active packaging systems were comparatively analyzed, with particular emphasis on the influences of extract composition, dosage, matrix interactions, and processing conditions on preservation efficacy in real food systems. [Results] The major active components of *Michelia×alba* include terpenes, polyphenols, and alkaloids, which exert their effects by disrupting cell membrane integrity, interfering with energy metabolism in pathogenic microorganisms, and inhibiting lipid peroxidation chain reactions through free radical scavenging and metal chelation. These active substances possess dual antibacterial and antioxidant functions, showing promising potential as alternatives to synthetic preservatives. However, challenges including insufficient compositional standardization, unclear flavor interactions, and lack of systematic dose-response validation remain to be addressed. [Conclusion] Future efforts should focus on key technologies such as synergistic enhancement of active components, stabilized encapsulation delivery, and intelligent responsive release, following the industry orientation of "loss reduction, efficiency enhancement, and low-carbon transition," to facilitate precise application of *Michelia×alba*-derived preservatives throughout the entire cold chain and provide scientific support for the green transformation of China's aquatic product processing industry.

Key words: *Michelia×alba*; aquatic product preservation; antibacterial activity; antioxidant activity; green processing; cold-chain quality control

鲍鱼内脏多糖制备及降血糖活性研究

韦小妙[1]，刘鑫悦[2]，孙乐常*

集美大学海洋食品与生物工程学院，福建省厦门市，361021

摘要: 为探究鲍鱼内脏多糖的降血糖活性及构效关系，以鲍鱼内脏为原料，酶解制备粗多糖，通过醇沉、Sevage 法脱蛋白、DEAE-52 离子交换柱和 Sephadex G-50 凝胶柱等手段纯化获得均一多糖组分 AVP-b1，并对其化学组成、分子量、单糖组成、抗氧化及降血糖活性进行研究。结果表明，AVP-b1 重均分子量为 25663 Da，总糖含量为 82.55±0.07%，蛋白残留量仅 0.68±0.01%，硫酸基含量为 11.96±0.03%，糖醛酸含量为 16.90±0.03%，属于富含硫酸基和糖醛酸的酸性硫酸化多糖。其单糖组成以半乳糖为主，其次为葡萄糖醛酸。AVP-b1 具有一定 DPPH 自由基清除能力（IC_{50}=3.42 mg/mL），并表现出良好的 α-葡萄糖苷酶抑制活性（IC_{50}=1.45 mg/mL）。此外，该多糖在 pH 3.0-8.0 范围内活性稳定，经体外胃肠消化后仍保持较高抑制能力。化学修饰结果显示，α-葡萄糖苷酶抑制活性依次为 AVP-b1>还原糖醛酸 AVP-b1>脱硫 AVP-b1>还原糖醛酸脱硫 AVP-b1，表明硫酸基和糖醛酸是其发挥降血糖活性的关键结构。本研究为鲍鱼内脏副产物高值化利用及天然降血糖功能食品开发提供理论依据。

关键词：鲍鱼内脏；多糖；α-葡萄糖苷酶；化学修饰；构效关系

作者简介：韦小妙（2002-），女，硕士研究生，研究方向：食品资源开发与利用，E-mail：2847731075@qq.com。

*通信作者：孙乐常（1985-），男，博士，教授，研究方向：水产加工与贮藏，E-mail：sunlechang@163.com。

Preparation and Hypoglycemic Activity of Polysaccharides from Abalone Viscera

WEI Xiaomiao[1], LIU Xingyue[2], SUN Lechang*

College of Ocean Food and Biological Engineering, Jimei University, Xiamen 361021, Fujian, China

Abstract: To investigate the hypoglycemic activity and structure-activity relationship of

polysaccharides from abalone viscera, crude polysaccharides were prepared by enzymatic hydrolysis of abalone viscera and subsequently purified by ethanol precipitation, deproteinization using the Sevag method, DEAE-52 ion-exchange chromatography, and Sephadex G-50 gel-filtration chromatography, yielding a homogeneous polysaccharide fraction designated AVP-b1. Its chemical composition, molecular weight, monosaccharide composition, antioxidant activity, and hypoglycemic activity were investigated. The results showed that AVP-b1 had a weight-average molecular weight of 25,663 Da, a total sugar content of 82.55±0.07%, a residual protein content of only 0.68±0.01%, a sulfate group content of 11.96±0.03%, and a uronic acid content of 16.90 ±0.03%, indicating that it is an acidic sulfated polysaccharide rich in sulfate groups and uronic acids. Galactose was the predominant monosaccharide, followed by glucuronic acid. AVP-b1 exhibited DPPH radical-scavenging activity (IC_{50}=3.42 mg/mL) and appreciable α-glucosidase inhibitory activity (IC_{50}=1.45 mg/mL). Furthermore, its inhibitory activity remained stable over a pH range of 3.0-8.0, and it maintained high inhibitory activity following in vitro gastrointestinal digestion. Chemical modification experiments showed that α-glucosidase inhibitory activity decreased in the following order: AVP-b1 > uronic acid-reduced AVP-b1 > desulfated AVP-b1 > uronic acid-reduced and desulfated AVP-b1. These findings indicate that sulfate groups and uronic acids are key structural features underlying its hypoglycemic activity. This study provides a theoretical basis for the high-value utilization of abalone viscera by-products and the development of natural functional foods with hypoglycemic properties.

Key words: Abalone viscera; Polysaccharide; α-glucosidase; Chemical modification; Structure-activity relationshipTransglutaminase

鲍鱼内脏黄嘌呤氧化酶抑制肽酶解制备工艺优化及其酶解产物活性研究

莫惠媚[1]，张懿[2]，孙乐常*

集美大学海洋食品与生物工程学院，福建省厦门市，361021

摘要：为提高鲍鱼加工副产物的高值化利用水平，以鲍鱼内脏为原料，以黄嘌呤氧化酶（xanthine oxidase，XOD）抑制率为主要评价指标，采用酶解技术制备鲍鱼内脏酶解产物，对其酶解工艺进行优化并对其酶解产物的生物活性进行研究。首先筛选碱性蛋白酶、胰蛋白酶、中性蛋白酶、风味蛋白酶和木瓜蛋白酶，结果表明，中性蛋白酶酶解产物的 XOD 抑制率最高，为 31.95%。在此基础上，以酶添加量、料液比、酶解时间、酶解温度和 pH 为影响因素开展单因素试验，并采用 Box-Behnken 响应面法进一步优化酶解条件。 最终确定较优酶解工艺为：中性蛋白酶添加量 6%、料液比 1:10、酶解时间 4 h、酶解温度 50 ℃、pH 8.0。在该条件下进行验证试验，鲍鱼内脏酶解产物的 XOD 抑制率达到 42.85±0.25%，与模型预测结果较为一致。 活性评价结果表明，该酶解产物对 XOD 具有较好的浓度依赖性抑制作用，其 IC_{50}为 2.25 mg/mL；同时具有一定的 DPPH 自由基清除能力和 α-葡萄糖苷酶抑制活性，IC_{50}分别为 3.99 mg/mL 和 10.69 mg/mL。 综上，采用中性蛋白酶酶解鲍鱼内脏可获得具有较好 XOD 抑制活性的酶解产物，同时表现出一定的抗氧化和 α-葡萄糖苷酶抑制活性，本研究的结果可为鲍鱼加工副产物的高值化利用及海洋源功能性食品的开发提供理论参考。

关键词：鲍鱼内脏；酶解；黄嘌呤氧化酶；降尿酸活性

作者简介：莫惠媚（2002-），女，硕士研究生，研究方向：食品资源开发与利用，E-mail：2068379317@qq.com。

*通信作者：孙乐常（1985-），男，博士，教授，研究方向：水产品加工与贮藏，E-mail：sunlechang@163.com。

Optimization of Enzymatic Preparation of Xanthine Oxidase-Inhibitory Peptides from Abalone Viscera and Bioactivity of the Hydrolysates

MO Huimei[1], ZHANG Yi[2], SUN Lechang*

College of Ocean Food and Biological Engineering, Jimei University, Xiamen 361021, Fujian, China

Abstract: To promote the high-value utilization of abalone processing by-products, abalone viscera were used as the raw material, and xanthine oxidase (XOD) inhibition rate was employed as the primary evaluation index. Abalone viscera hydrolysates were prepared by enzymatic hydrolysis, and the hydrolysis process was optimized, followed by evaluation of the biological activities of the resulting hydrolysates. Five proteases, namely alkaline protease, trypsin, neutral protease, flavourzyme, and papain, were initially screened. The results showed that the hydrolysate prepared with neutral protease exhibited the highest XOD inhibition rate of 31.95%. Subsequently, single-factor experiments were conducted to investigate the effects of enzyme dosage, solid-to-liquid ratio, hydrolysis time, hydrolysis temperature, and pH, and the hydrolysis conditions were further optimized using Box–Behnken response surface methodology. The optimal hydrolysis conditions were determined as follows: neutral protease dosage of 6%, solid-to-liquid ratio of 1:10, hydrolysis time of 4 h, hydrolysis temperature of 50 °C, and pH 8.0. Under these conditions, verification experiments showed that the XOD inhibition rate of the abalone viscera hydrolysate reached 42.85 ± 0.25%, which was in good agreement with the value predicted by the model. Bioactivity evaluation further demonstrated that the hydrolysate exhibited concentration-dependent inhibitory activity against XOD, with an IC_{50} value of 2.25 mg/mL. In addition, the hydrolysate showed DPPH radical-scavenging activity and α-glucosidase inhibitory activity, with IC_{50} values of 3.99 mg/mL and 10.69 mg/mL, respectively. In conclusion, enzymatic hydrolysis of abalone viscera using neutral protease can produce hydrolysates with favorable XOD inhibitory activity, together with certain antioxidant and α-glucosidase inhibitory activities. These findings provide a theoretical reference for the high-value utilization of abalone processing by-products and the development of marine-derived functional foods.

Keywords: abalone viscera; enzymatic hydrolysis; xanthine oxidase; uric acid-lowering activity

鲍鱼内脏活性成分开发及高值化利用

林伦洲、方婷、刘斌雄、李长城、田美玲*

福建农林大学食品科学学院，福州，福建，350002

摘要：鲍鱼内脏富含多糖、多肽和脂质，具有功能成分开发与高值化利用潜力。本研究团队采用靶向酶解、高压脉冲电场辅助酶解和多级逆流提取，分别制备胶原蛋白肽、多糖和油脂，并结合体外 ACE 抑制试验及 DSS 结肠炎、糖尿病和高脂饮食小鼠模型评价其功能活性。结果表明，靶向酶解所得胶原蛋白肽分子量低于 3 kDa 的组分占 92.7%，体外 ACE 抑制率达 82.12%，并可缓解 DSS 诱导的小鼠结肠炎，减轻氧化应激、改善肠道菌群失衡；高压脉冲电场辅助酶解所得多糖纯度达 60.39%，其可降低糖尿病小鼠空腹血糖、高脂饮食小鼠血脂和肝脂沉积；多级逆流油脂提取率达 81.18%，所得油脂可改善高脂饮食小鼠脂质代谢及氧化应激。研究为鲍鱼内脏活性成分开发与高值化利用提供依据。

关键词：鲍鱼内脏；胶原蛋白肽；多糖；油脂；高值化利用

资助项目：福建省科技厅重大专项专题项目（2021NZ033018），福建省科技厅高校产学合作项目（2021N5011），福建省海洋经济发展专项资金项目（FJHJF-L-2021-2）

通讯作者介绍：田美玲、女、博士研究生、讲师、食品加工与营养、18950311867，tml0214@fafu.edu.cn

鲍鱼内脏降血糖活性肽制备及其作用机理研究

郑欣榆[1]，刘鑫悦[2]，孙乐常*

集美大学海洋食品与生物工程学院，福建省厦门市，361021

摘要: 为探究鲍鱼内脏活性肽的降血糖活性及作用机制，以鲍鱼内脏酶解液为原料，经醇沉、超滤、凝胶过滤色谱和反相高效液相色谱逐步分离纯化降血糖活性肽，结合 LC-MS/MS 鉴定、分子对接、体外酶抑制、抑制动力学及分子动力学模拟对其作用机理开展研究。结果表明，鲍鱼内脏粗多肽具有典型酰胺结构，二级结构以 β-折叠为主，分子量小于 500 Da 的组分占 96.39%。超滤后，小于 3 kDa 组分对 α-葡萄糖苷酶和 DPP-IV 的抑制活性较强，IC_{50} 分别为 5.61 mg/mL 和 2.33 mg/mL。进一步筛选获得 GPPGPPG 和 VGPGLG 两条活性肽。体外验证表明，GPPGPPG 对 α-葡萄糖苷酶和 DPP-IV 的 IC_{50} 分别为 3.79 mg/mL 和 0.14 mg/mL；VGPGLG 的 IC_{50} 分别为 1.84 mg/mL 和 0.06 mg/mL，双重酶抑制活性更优。两条肽可通过氢键、范德华力及疏水相互作用与靶酶活性位点稳定结合；对 α-葡萄糖苷酶均表现为混合型抑制，对 DPP-IV 均表现为竞争性抑制。分子动力学模拟显示，VGPGLG 与两种靶酶形成的复合物稳定性更高。本研究为鲍鱼内脏活性肽的高值化利用及天然降血糖功能食品开发提供理论参考。

关键词：鲍鱼内脏；多肽；分离纯化；α-葡萄糖苷酶；DPP-IV

作者简介：郑欣榆（2003-），女，硕士研究生，研究方向：食品资源开发与利用，E-mail：2847731075@qq.com。

*通信作者：孙乐常（1985-），男，博士，教授，研究方向：水产加工与贮藏，E-mail：sunlechang@163.com。

Study on Preparation and Mechanism of Hypoglycemic Active Peptide from Abalone Viscera

ZHENG Xinyu[1], LIU Xingyue[2], SUN Lechang*

College of Ocean Food and Biological Engineering, Jimei University, Xiamen 361021, Fujian, China

Abstract: To investigate the hypoglycemic activity and underlying mechanisms of bioactive peptides derived from abalone viscera, hypoglycemic peptides were sequentially separated and purified from abalone visceral enzymatic hydrolysate by ethanol precipitation, ultrafiltration, gel filtration chromatography, and reversed-phase high-performance liquid chromatography. LC-MS/MS identification, molecular docking, in vitro enzyme inhibition assays, inhibition kinetics, and molecular dynamics simulations were applied to elucidate their mechanisms of action. The results showed that the crude peptide fraction exhibited characteristic amide bands and a predominantly β-sheet secondary structure. Peptides with molecular weights below 500 Da accounted for 96.39% of the fraction. After ultrafiltration, the fraction with molecular weights below 3 kDa showed strong inhibitory activities against α-glucosidase and dipeptidyl peptidase-IV (DPP-IV), with IC_{50} values of 5.61 and 2.33 mg/mL, respectively. Two bioactive peptides, GPPGPPG and VGPGLG, were further identified. In vitro assays showed that the IC_{50} values of GPPGPPG against α-glucosidase and DPP-IV were 3.79 and 0.14 mg/mL, respectively, whereas those of VGPGLG were 1.84 and 0.06 mg/mL, respectively, indicating superior dual-enzyme inhibitory activity of VGPGLG. Both peptides could stably bind to the active sites of the target enzymes through hydrogen bonding, van der Waals forces, and hydrophobic interactions. They exhibited mixed-type inhibition against α-glucosidase and competitive inhibition against DPP-IV. Molecular dynamics simulations further demonstrated that VGPGLG formed more stable complexes with both target enzymes. This study provides a theoretical reference for the high-value utilization of abalone viscera and the development of natural hypoglycemic functional foods.

Key words: Abalone viscera; Peptides; Separation and purification;α-glucosidase; DPP-IV

包装材料、贮藏温度及品质改良剂对牡蛎预调理制品贮藏品质的影响

莫思远 13，曹文红 123，林海生 123，高加龙 123，谭明堂 123，陈忠琴 123，朱国平 123，郑惠娜 123*

（1 广东海洋大学食品科技学院，广东湛江，524088；

2 广东海洋大学深圳研究院，广东深圳，58120；

3 国家贝类加工技术研发分中心(湛江)，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研究中心，广东湛江，524088.）

摘要:【目的】探究包装材料、贮藏温度及品质改良剂对牡蛎预调理制品贮存品质的影响，为开发高品质水产预调制产品提供理论基础数据。【方法】以预加工牡蛎为研究对象，采用 PE/PET 与 PE/PA 包装，在-18、0、4℃贮藏并实施品质改良剂处理；测定 TVB-N、TBARS、呈味核苷酸、甜菜碱、游离氨基酸及 EUC，结合电子鼻、GC-MS、SEM 评价。【结果】 贮存温度是品质劣变主导因子，温度越低保鲜效果越好；4℃下 PE/PA 高阻氧包装因低氧促进兼性厌氧腐败菌增殖，TVB-N 达 9.14 mg/100mL，显著高于 PE/PET 包装（2.83 mg/100mL）。品质改良剂经抗氧化、抑菌、抗冻保护及物理屏障四重机制抑制品质劣变，-18、0、4℃贮存 7d 处理组 TVB-N 为 4.43、4.60、6.85 mg/100mL，TBARS 为 0.0120、0.0201、0.0186 mg MDA/kg，均低于对照组最高值；且有效延缓 AMP、IMP 降解，EUC 较对照组提高约 15%；电子鼻与 GC-MS 分析显示处理组风味轮廓更接近新鲜对照，1-辛烯-3-醇、1-戊烯-3-醇含量显著降低，扫描电镜观察证实肌纤维结构完整。【结论】包装材料 PE/PET 与品质改良处理协同可有效改善预调理牡蛎制品的品质，且在冷冻条件下（-18℃）品质保持效果最好。

关键词：牡蛎预调理制品；品质改良；包装；品质；风味

作者：莫思远（2427479384@qq.com），女，硕士研究生，研究水产品贮藏与加工

通讯作者：郑惠娜（zhenghn@gdou.edu.cn），女，博士生导师，教授，研究方向为海洋生物资源综合利用

基金项目：国家重点研发专项（2024YFD2401805）；广东省现代农业产业技术体系贝藻创新（2024CXTD23）；现代农业产业技术体系（CARS-49）

Effects of Packaging Materials, Storage Temperature, and Quality Improvers on the Storage Quality of Pre-prepared Oyster Products

MO Siyuan[1,3] ，CAO Wenhong[1,2,3]，LIN Haisheng[1,2,3]，GAO Jialong[1,2,3]，TAN Mingtang[1,2,3]，CHEN Zhongqin[1,2,3]，ZHU Gouping[1,2,3]，ZHENG Huina[1,2,3,*]

(1.College of Food Science and Technology, Guangdong Ocean University, Zhanjiang 524088, China;

2.Shenzhen Institute of Guangdong Ocean University, Shenzhen 518108, China;

3.National Research and Development Branch Center for Shellfish Processing (Zhanjiang), Guangdong Provincial Key Laboratory of Aquatic Products Processing and Safety, Guangdong Provincial Engineering Technology Research Center of Seafood, Zhanjiang 524088, China.)

Abstract 【Objective】This study investigated the effects of packaging materials, storage temperature, and quality improvers on the storage quality of pre-prepared oyster products. The results support the production of high-quality pre-prepared aquatic foods.【Methods】Pre-processed oysters served as the experimental subject. The samples were packaged in PE/PET and PE/PA materials, stored at –18 °C, 0 °C, and 4 °C, and treated with quality improvers. Total volatile basic nitrogen (TVBN), thiobarbituric acid reactive substances (TBARS), flavor nucleotides, betaine, free amino acids, and equivalent umami concentration (EUC) were determined. In addition, the samples were evaluated by electronic nose, gas chromatography–mass spectrometry (GC–MS), and scanning electron microscopy (SEM).【Results】Temperature was the main factor affecting quality, and lower temperatures yielded better preservation. At 4 °C, PE/PA (high oxygen barrier) packaging promoted the growth of spoilage bacteria, giving a TVBN of 9.14 vs. 2.83 mg/100 mL for PE/PET. Quality improvers reduced TVBN and TBARS at all temperatures through four mechanisms. They retarded AMP/IMP degradation, raised EUC by ~15%, preserved flavor (closer to fresh by e-nose/GC–MS, with lower 1-octen-3-ol and 1-penten-3-ol), and maintained myofibrillar integrity by SEM.【Conclusion】PE/PET packaging combined with quality improver treatment effectively improved the quality of pre-prepared oyster products, and the best quality retention was observed under frozen conditions (–18 °C).

Keywords oyster；quality improvement；packaging；storage quality；flavor

丙烯醛对金鲳鱼肌原纤维蛋白氧化修饰、构象变化、交联聚集及 TGase 诱导凝胶特性的影响

高程炎 [1]，刘中原* [2]

食品科学与工程学院，海南大学，海口，570228

摘要：本研究以金鲳鱼肌原纤维蛋白（MP）为对象，考察了丙烯醛对其氧化修饰、结构变化及聚集行为的影响。结果表明，丙烯醛在 0.01–10 mM 范围内呈剂量依赖性提高羰基含量并降低巯基含量，同时内源荧光强度显著下降，与席夫碱含量相关的荧光强度显著增强（增加 7.1 倍）。在 0.01–1 mM 范围内，丙烯醛未显著引起 MP 疏水性暴露、溶解度下降及聚集（P>0.05）。当浓度达到 5 mM 时，丙烯醛导致蛋白结构严重破坏（α-螺旋含量降低、β-转角含量增加、肌球蛋白重链聚合），溶解度急剧下降至 7.03–11.85%。此外，丙烯醛对 MP 的 TGase 诱导凝胶特性也产生了显著影响。浓度为 1 mM 时，形成的凝胶较弱，但滴水损失最低（61.45%）；浓度为 5 mM 时，获得最强且最均匀的凝胶，其储能模量和表观黏度最高，但因明显脱水收缩，滴水损失也最高（82.44%）；当浓度达到 10 mM 时，凝胶呈现明显黄变且微观结构不均匀。上述结果表明，丙烯醛可通过引起氧化修饰、改变蛋白结构并加剧交联聚集，从而显著影响鱼肌原纤维蛋白；同时，丙烯醛也会影响 MP 诱导凝胶的流变特性和凝胶特性。本研究为水产品脂质氧化产物所诱导的蛋白变化及其对品质的影响提供了新的视角与认识，并为控制水产品中脂质氧化来源醛类的积累提供了机制基础。

关键词：丙烯醛；肌原纤维蛋白；蛋白质羰基化；转谷酰胺酶；冻融凝胶化

本研究得到国家自然科学基金 (32402196; 32660660) 资助。

通讯作者：刘中原，男，博士研究生，副教授，热带水产品加工与综合利用，15714114602，liuzy@hainanu.edu.cn

Effect of acrolein on the oxidative modification, conformational alteration, cross-linking aggregation of golden pompano myofibrillar proteins and TGase-induced gelation properties

Chengyan Gao[1], Zhongyuan Liu*[2]

1. School of Food Science and Engineering, Hainan University, Haikuo, 315832, Zhejiang; 2.XX

Abstract : In this study, effects of acrolein on golden pompano myofibrillar protein (MP) were investigated with the

oxidative modification, structural changes and aggregation behavior being specifically concerned. Results indicated that acrolein dose-dependently (0.01–10 mM) enhanced carbonyls content and decreased sulfhydryl group content, which was reflected by the sharply reduced intrinsic fluorescence intensity and the significantly increased fluorescence intensity relating to Schiff base concentration. Within 0.01–1 mM, acrolein did not significantly result in MP hydrophobic exposure, solubility decrease and aggregation ($P > 0.05$). When the concentration reached 5 mM, acrolein caused severe structural disruption (decreased α-helix, increased β-turn, myosin heavy chain polymerization) and sharp solubility declines to 7.03–11.85%. In addition, acrolein caused remarkable modification for the TGase induced gelations of MP. At concentration of 1 mM, a weak gel formed with the lowest drip loss (61.45%). While at 5 mM, the strongest and most uniform gel was obtained with the highest storage modulus and apparent viscosity, albeit with the highest drip loss (82.44%) due to marked syneresis. When the concentration reach 10 mM, the gel displayed marked yellowing and heterogeneous microstructure. These findings indicated that acrolein can significantly affect the fish MP by causing oxidative modifications, altering their structure and intensifying cross-linking aggregation. Acrolein can also affect the rheological properties and gel characteristics of gels induced by MP. This study provides a perspective and insights for the changes in proteins induced by lipid oxidation products of aquatic products and their impact on quality.

Key words: Acrolein; Myofibrillar protein; Protein carbonylation; Transglutaminase; Freeze-thaw gelation

This work was financially supported by the National Natural Science Foundation of China (32402196; 32660660).

不同加工工艺对裙带菜岩藻黄素色泽、含量及结构的影响

Shumin Cai[1], Yingying Zhao, Nali Zhang[1],Yunhai He[1,2,3], Shu Liu[1,2,3], Han Zhang[1,2,3], Qiukuan Wang[1,2,3] , Yichao Ma[1,2,3,*], Dandan Ren[1,2,3,*]

1. College of Food Science and Engineering, Dalian Ocean University, Dalian, 116023, China；
2. National R&D Branch Center for Seaweed Processing, Dalian, 116023, China；
3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian, 116023, China.

摘要：为探究不同加工工艺对裙带菜岩藻黄素含量、色泽及异构体组成的影响，采集实际加工链各节点采集新鲜、烫漂、盐渍、脱盐、脱水及分段干燥样品，并设置冻干与热风干燥对照，采用 C18-HPLC-DAD、色差分析及 C30-HPLC-DAD 进行评价。结果表明，烫漂后岩藻黄素干基含量较新鲜样品升高 44.47% ，盐渍后则降低 77.89%，三段干燥后保留率仅 7.92%。 盐渍及深度干燥是损失关键环节，冻干较热风干燥更有利于其保留。加工过程中色泽发生明显阶段性变化，但与岩藻黄素总量变化并不同步。C30-HPLC-DAD 可有效分离主要几何异构体，各样品均以 all-trans 为主，新鲜样品峰面积占比约 81.04% ，但顺式异构体比例未随加工强度呈单向变化，表明岩藻黄素总量损失与与主要几何异构体相对组成变化并不完全同步。

关键词：裙带菜 ；岩藻黄素 ；加工工艺；异构体

不同加工形态裙带菜对吐司品质特性的影响

张汇洋[1,2,3]，王致君[1,2,3]，颜婷美[1,2,3]，刘舒[1,2,3]，张晗[1,2,3]，马艺超[1,2,3]，任丹丹[1,2,3]，汪秋宽[1,2,3]，何云海[1,2,3*]

1.大连海洋大学 食品科学与工程学院，辽宁 大连 116023；2.国家海藻加工技术研发分中心，辽宁 大连 116023；3.辽宁省水产品加工及综合利用重点实验室，辽宁 大连 116023

摘要：为丰富面包的营养组成，促进裙带菜在烘焙食品中的高值化利用，本研究以裙带菜吐司为研究对象，通过单因素试验确定裙带菜浆液、谷朊粉、酵母等关键原辅料的最适添加水平，并进一步比较裙带菜浆液、裙带菜干粉及空白吐司在品质特性和贮藏稳定性方面的差异。结果表明，裙带菜浆液、加水量、谷朊粉及酵母添加量对吐司品质均有不同程度的影响，其中裙带菜添加量的影响最为显著，适量添加能够维持较好的综合品质，过量添加则会降低面包膨胀能力并影响内部结构。裙带菜不同加工形态对吐司品质产生了不同影响，其中裙带菜浆液组在感官接受度和整体风味表现方面较为突出，能够保持较好的综合感官品质，表现出较好的产品开发潜力。在此基础上，进一步考察各组吐司的贮藏稳定性发现，随贮藏时间延长，各组硬度均呈增加趋势，而弹性变化相对较小。水分变化与组织结构结果表明，不同加工形态的裙带菜可能改变面团中的水分分配及结构形成，从而影响吐司品质。研究结果可为裙带菜在面制品中的合理应用及加工形态选择提供参考。

关键词：裙带菜；吐司面包；加工形态；品质特性；贮藏特性

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）

通讯作者：何云海，男，教授，藻类加工及资源利用，13840847973，hyh@dlou.edu.cn

Effects of Different Processing Forms of Undaria pinnatifida on the Quality Characteristics of Toast Bread

Huiyang Zhang[1,2,3],Zhijun Wang[1,2,3],Tingmei Yan[1,2,3], Shu Liu[1,2,3], Han Zhang [1,2,3], Yichao Ma[1,2,3], Dandan Ren[1,2,3], Qiukuan Wang[1,2,3], Yunhai He[1,2,3*]

1. College of Food Science and Engineering，;2. National R＆D Branch Center For Seaweed Processing;3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian Ocean University , Dalian 116023, China

Abstract :To enrich the nutritional composition of bread and promote the high-value utilization of Undaria pinnatifida in bakery products, this study focused on Undaria pinnatifida toast. The optimal addition levels of key ingredients, including Undaria pinnatifida slurry, gluten, and yeast, were determined through single-factor experiments. Furthermore, the quality characteristics and storage stability of toast supplemented with Undaria pinnatifida slurry, Undaria pinnatifida dry powder, and blank toast were compared. The results showed that the addition levels of Undaria pinnatifida slurry, water, gluten, and yeast had varying effects on toast quality, with the Undaria pinnatifida addition level exerting the most significant influence. Moderate addition maintained acceptable overall quality, whereas excessive addition reduced bread expansion capacity and adversely affected the internal structure. Different processing forms of Undaria pinnatifida led to distinct effects on toast quality. The slurry group exhibited superior sensory acceptability and overall flavor, maintaining good comprehensive sensory quality and demonstrating promising product development potential. On this basis, the storage stability of each group was further investigated. With prolonged storage time, hardness increased in all groups, while springiness changed relatively little. The results of moisture variation and structural organization indicated that different processing forms of Undaria pinnatifida may alter moisture distribution and structural formation in the dough, thereby affecting toast quality. These findings provide a reference for the rational application of Undaria pinnatifida in flour products and the selection of processing forms.

Key words: Undaria pinnatifida; toast bread; processing form; quality characteristics; storage properties

不同结构鱼肉蛋白肽乳化剂的理性制备及乳化性质分析

杨晶晶，林端权*

集美大学海洋食品与生物工程学院，福建厦门，361021

摘要：目前多肽作为天然食品乳化剂备受关注，但在多肽混合体系中，不同结构分子在油-水界面的竞争吸附与乳化性能尚不明确。因此本研究利用一种结合生物信息学功能预测与计算机模拟酶解的靶向筛选方式，从草鱼肌球蛋白源中筛选 6 种具有不同一、二级结构潜在乳化肽，并通过界面张力、物理稳定性、FTIR 和 CLSM 等评估其乳化性能差异。结果表明：6 种多肽（MVSLLQEK、AEIQTALEEAEGTLEHEESK、AALEQTER、EESKKKLAQRL、LAEKDEEMEQIKRNSQRVIESMQST、EQTERGRKVAEME）表现出不同的两亲性空间分布；其中，MK 具有最高预测乳化潜力分数且其降低界面张力的能力较强；相比于其他 4 种多肽，MK 和 LT 稳定的乳液具有较优的乳化性能、较小乳液粒径(0.22μm)、较高 Zeta 电位(-40mV)及较好的储藏稳定性。此外，FTIR 和 CLSM 表明，不同结构多肽在油水界面发生不同的构象重排，进而调控界面膜强度并影响乳液的物理稳定性。该研究为提高目标乳化肽筛选效率和低值鱼肉蛋白高值化利用提供理论依据。

关键词：多肽乳化剂；生物信息学；物理稳定性；傅里叶红外光谱；

资助项目：福建省自然科学基金计划面上项目，2024J0113

通讯作者：林端权，男，工学博士，副教授，主要研究方向为水产品加工贮藏。联系方式：15606066383，dq.lin@jmu.edu.cn

不同静磁场辅助冷冻阶段对凡纳滨对虾冰晶形态与肌肉品质的影响

刘慧敏[1]，皮正林[1]，郑欧阳[1]，刘书成[1]，孙钦秀[1*]

1. 广东海洋大学 食品科技学院，广东省水产品加工与安全重点实验室，广东 湛江 524088

摘要：本文研究在预冷阶段（4 至 0℃，MF-I）、预冷和相变阶段（4 至-5℃，MF-II）、全程阶段（4 至-18℃，MF-III）、仅相变阶段（0 至-5℃，MF-IV）下施加静磁场辅助冷冻（MF）对凡纳滨对虾（*Litopenaeus vannamei*）冷冻动力学及肌肉品质的影响。与浸没冷冻组（IF）相比，MF-II 总冷冻时间缩短了 39.21%，还降低了解冻损失、烹饪损失和离心损失，持水能力提高了 0.76%（$P<0.05$）。MF-II 未对质构产生不利影响，并抑制了冷冻引起的 L^*值升高（$P<0.05$）。LF-NMR 和 MRI 显示，MF-II 限制了水分迁移和损失。冷冻切片和 SEM 证实，MF-II 和 MF-IV 产生的冰晶平均孔隙更小更均匀。综上，MF-II 和 MF-IV 有效调控了冰晶形成和生长，获得了细小且均匀分布的冰晶。由于相变阶段难以精准调控，MF-II 被认为在工业化应用中更易调控，缩短了磁场作用时间并改善虾肌肉品质，具有节能减排的潜能。

关键词：凡纳滨对虾；磁场辅助冷冻；肌肉品质；冰晶

基金项目：国家自然科学基金委员会青年项目（32302165）

***通讯作者：**孙钦秀（1986—），女，博士，副教授，研究方向为海洋食品保鲜与加工

E-mail: sunqinxiugo@163.com

Effects of Different Static Magnetic Field-Assisted Freezing Stages on Ice Crystal Morphology and Muscle Quality in Penaeus vannamei (Litopenaeus vannamei)

Huimin Liu [1], Ouyang Zheng[1], Shucheng Liu[1], Qinxiu Sun[1*]

[1] College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Zhanjiang, 524088, China.

Abstract:This study investigated the effects of applying a 60 mT static magnetic field (MF) to assist freezing during the pre-cooling stage (4 to 0℃, MF-I), the pre-cooling and phase transition stage (4 to -5℃, MF-II), the throughout freezing process (4 to -18℃, MF-III), and only during phase transition stage (0 to -5℃, MF-IV). Compared with the immersion freezing (IF) group, MF-II reduced the total freezing time by 39.21%, decreased thawing loss, cooking loss, and centrifugation loss, and increased water-holding capacity by 0.76% ($P < 0.05$). MF-II did not adversely affect texture and suppressed the freezing-induced increase in L^* value ($P < 0.05$). LF-NMR and MRI analyses showed that MF-II restricted water migration and loss. Cryosectio and SEM observations confirmed that the ice crystals formed by MF-II and MF-IV had smaller and more uniform average pore sizes. In summary, MF-II and MF-IV effectively regulated ice crystal formation and growth, resulting in fine and uniformly distributed ice crystals. Since the phase transition stage is difficult to precisely control, MF-II is considered easier to regulate in industrial applications; it shortens the magnetic field exposure time and improves shrimp muscle quality, offering potential for energy conservation and emission reduction.

Key words: static magnetic field-assisted freezing; *Litopenaeus vannamei*; muscle quality; ice crystals

Funding Project: National Natural Science Foundation of China, Young Scientists Program (32302165)

***Corresponding Author:** Qinxiu Sun (1986-), Doctor, Associate Professor; Research Focus: Preservation and Processing of Marine Foods

E-mail address: sunqinxiugo@163.com (Qinxiu Sun)

不同热前处理对鱼骨浆加工特性、蛋白质结构及风味特性的影响：从组织破碎到风味形成的关联分析

徐舒琪[1,2]，姜启兴[1,2*]

（江南大学食品学院 江苏无锡 214122）

摘要：本研究旨在探讨热前处理对鱼骨浆加工特性、蛋白结构及风味品质的影响，通过比较未热处理、100℃常压蒸制20-60 min和120℃高压蒸制10-30 min对鱼骨浆加工特性、蛋白结构及风味的影响。结果表明，热处理显著降低鱼骨浆粒径、研磨损耗和表观黏度，D50由236.90 μm降至99.67 μm；同时引起蛋白构象重排和氧化增强，内源荧光最大波长由343 nm红移至355 nm。随着热处理强度增加，游离氨基酸总体下降，挥发性风味明显重构。高压蒸制虽进一步改善鱼骨细化效果，但也增加蒸煮损耗并降低蛋白质保留。综上，热前处理可提高鱼骨可研磨性，但应兼顾加工效率、蛋白保留与风味品质。

关键词：鱼骨；前处理；高压蒸制；蛋白结构；风味特性

Effects of Different Thermal Pretreatments on the Processing Characteristics, Protein Structure, and Flavor Properties of Fish Bone Slurry: Correlations from Tissue Disruption to Flavor Formation

Shuqi Xu[1,2] , Qixing Jiang[1,2*]

(School of Food Science and Technology, Jiangnan University, Wuxi 214122, Jiangsu, China)

Abstract: This study aimed to investigate the effects of thermal pretreatment on the processing characteristics, protein structure, and flavor properties of fish bone slurry. Untreated fish bones, fish bones steamed at 100 °C for 20–60 min under atmospheric pressure, and fish bones pressure-steamed at 120 °C for 10–30 min were compared. The results showed that thermal pretreatment

significantly reduced particle size, grinding loss, and apparent viscosity, with D50 decreasing from 236.90 μm to 99.67 μm. Meanwhile, thermal treatment induced protein conformational rearrangement and enhanced protein oxidation, as evidenced by a red shift in the maximum intrinsic fluorescence wavelength from 343 nm to 355 nm. With increasing treatment intensity, the total content of free amino acids generally decreased, while the volatile flavor profile was markedly altered. Although pressure steaming further improved the size reduction of fish bones, it also resulted in greater cooking loss and lower protein retention. Overall, thermal pretreatment enhanced the grindability of fish bones, but optimization should balance processing efficiency, protein retention, and flavor quality.

Key words: Fish bone; Pretreatment; Pressure steaming; Protein structure; Flavor properties

---

通讯作者/ E-mail（姜启兴（1977—），男，博士，教授，博士研究生导师，主要从事食品加工与保藏方面的研究。

E-mail：qixingj@163.com）

不同糖源糖基化鱼明胶的消化抗氧化特性及体外肠道菌群调节作用

支艳玲，任文博，黄涛*

宁波大学，浙江省宁波市，315211

摘要：评价不同糖源糖基化鱼明胶的凝胶、消化抗氧化及肠道菌群调节作用。鱼明胶（FG）经高压预处理，分别与半乳糖（Gal）、高甲氧基果胶（HMP）或 κ-卡拉胶（κC）反应，测定凝胶强度、模拟消化液抗氧化性，并开展体外粪菌发酵和 16S rRNA 测序。结果：FG-Gal0.5、FG-HMP0.5 凝胶强度分别为 363.85 和 411.54 g。各糖源改善消化液 Fe^{2+}螯合力，其他抗氧化指标呈差异化变化。FG-κC0.5 发酵液乙酸、丙酸、丁酸分别为 1534.26、535.02、284.84 μg/mL，菌群组成随糖源变化。糖基化鱼明胶具有体外发酵与菌群调节潜力，可为功能食品原料开发提供依据。

关键词：鱼明胶；糖基化；抗氧化活性；短链脂肪酸；肠道菌群

资助项目：国家自然科学基金面上项目(32572608)

通讯作者：黄涛(1987-)，男，博士，特聘研究员，研究方向:水产品资源高值化综合利用，E-mail:cdhuangtao@163.com。

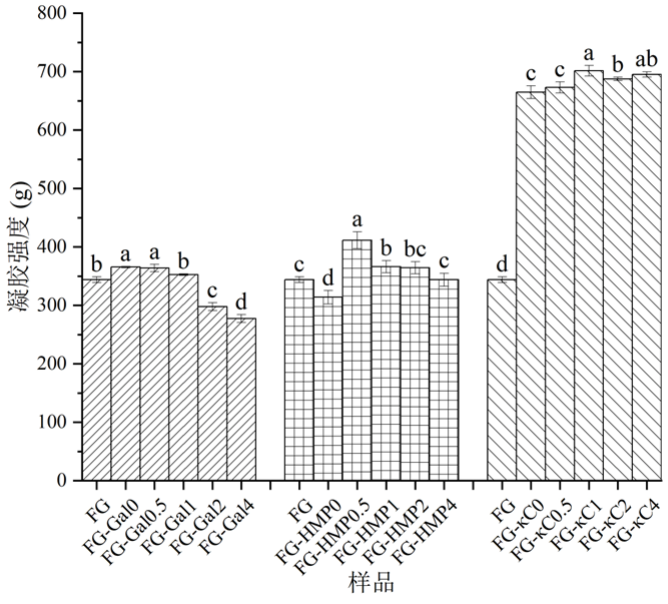


图 1　不同糖源与糖基化反应时间对鱼明胶凝胶强度的影响

代表性实验结果（附表、附图）

表 1　各组体外发酵液中主要短链脂肪酸含量（μg/mL）

组别	乙酸	丙酸	丁酸
Control	871.17	367.69	243.36
FG	1103.92	422.51	229.48
FG-Gal0.5	1526.89	532.69	273.58
FG-HMP0.5	1506.07	504.41	242.39
FG-κC0.5	1534.26	535.02	284.84

注：Control 为空白发酵对照；FG 为未糖基化鱼明胶。

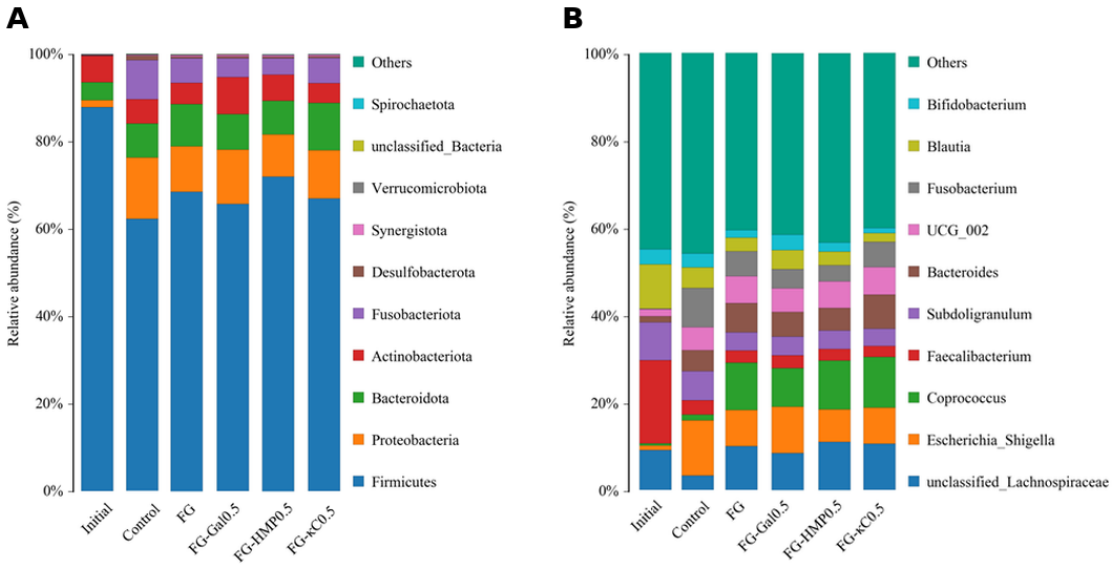


图 2　不同糖源糖基化鱼明胶发酵后菌群在门水平（A）和属水平（B）的组成

不同腌制方式对干制双斑东方鲀鱼片品质的影响

廖萍茹[1]，陈晓婷[2*]，刘淑集[2]，潘　南[2]，苏永昌[2]，陈　贝[2]，

王　慧[1*]，林河通[1]，刘智禹[2]

（1.福建农林大学食品科学学院，福建 福州 350002；

2.福建省水产研究所，福建省海洋生物增养殖与高值化利用重点实验室，福建 厦门 36101）

摘要：【目的】以双斑东方鲀(*Takifugu bimaculatus*)为原料，研究了静态腌制(SC)、真空滚揉腌制(VTC)、超高压腌制(UHP)、超声腌制(UAC)对干制河鲀鱼片品质的影响。【方法】对比不同腌制方式下鱼片的色泽、质构、水分状态、微观结构、滋味特征和挥发性风味物质，分析其品质变化情况。【结果】UAC 组干制鱼片色差变化最小，VTC 组变化最大，二者均能显著提高鱼片强结合水占比，抑制肌纤维过度收缩，硬度较低。微观结构显示，UAC 组肌纤维排列与孔隙分布均匀性较优，VTC 组次之，UHP 组结构致密，SC 组肌纤维收缩剧烈。风味分析显示，UAC 组咸味、鲜味及丰富度突出，氯化物含量最高，总挥发性风味物质及正己醛等特征香气物质丰富，综合感官得分最优，VTC 和 UHP 组次之，SC 组最低。【结论】UAC 可抑制干制河鲀鱼片氧化变色，优化水分分布与肌纤维微观结构，加速盐分渗入并改善产品质构和风味释放，综合品质最优。本研究可为干制河鲀鱼片的开发提供一定的理论依据。

关键词：双斑东方鲀；腌制方式；微观结构；风味物质；感官品质

Effects of different curing methods on the quality of dried fillets of Takifugu bimaculatus

LIAO Pingru[1], CHEN Xiaoting[2*], LIU Shuji[2], PAN Nan[2], SU Yongchang[2], CHEN Bei[2], WANG Hui[1*], LIN Hetong[1], LIU Zhiyu[2]

(1. College of Food Science, Fujian Agriculture and Forestry University, Fuzhou 350002, China；

2. Key Laboratory of Cultivation and High-value Utilization of Marine Organisms in Fujian Province, Fisheries Research Institute of Fujian, Xiamen 361013, China)

Abstract: [Objective] The effects of static curing (SC), vacuum tumbling curing (VTC), ultra-high pressure curing (UHP), and ultrasonic curing (UAC) on the quality of dried *Takifugu bimaculatus*

fillets were investigated using *Takifugu bimaculatus* as the raw material. [Methods] Compare the color, texture, water state, microstructure, taste characteristics and volatile flavor compounds of fish fillets under different curing methods, and analyze their quality changes. [Results] The UAC exhibited the smallest color difference in dried fish fillets, while the VTC showed the largest change. Both groups could significantly increase the proportion of strongly bound water in fish fillets, inhibit excessive contraction of muscle fibers, and result in lower hardness. Microstructure observation revealed that the UAC had better uniformity in muscle fiber arrangement and pore distribution, followed by the VTC. The UHP group possessed a dense structure, and severe muscle fiber contraction was observed in the SC. Flavor analysis indicated that the UAC had prominent saltiness, umami and richness, with the highest chloride content and abundant total volatile flavor substances as well as characteristic aroma compounds such as n-hexanal, achieving the best comprehensive sensory score. The VTC and UHP ranked second, and the SC had the lowest score. [Conclusion] UAC can inhibit oxidative discoloration of dried puffer fish fillets, optimize water distribution and the microstructure of muscle fibers, accelerate salt penetration, improve product texture and flavor release, and achieve the best overall quality. This study can provide a certain theoretical basis for the development of dried puffer fish fillets.

Key words : *Takifugu bimaculatus*; curing methods; microstructure; flavor substances; sensory quality

不同预处理对坛紫菜蛋白提取与功能特性的影响

陈雨萍，林婉玲*

单位 韩山师范学院、广东海洋大学，地区 广东省潮州市湘桥区桥东街道，邮编 521041

摘要：坛紫菜蛋白具有较高的开发利用价值。本研究探究不同预处理对坛紫菜蛋白提取、结构及乳化特性的影响。采用普通粉碎、行星球磨、超高压细胞破碎、高静水压（HPP）及纤维素酶辅助处理，以蛋白提取率、溶解度、总藻胆蛋白含量和蛋白质量浓度进行熵权综合评价，并筛选代表样品分析其溶解性、乳化性能及结构特征。结果表明，不同预处理对蛋白提取效果影响明显，最高提取率为53.49%，最高溶解度为87.53%，最高乳化活性指数为274.19 m^2/g。SDS-PAGE、FTIR、DLS 及 SEM 分析表明，不同处理可引起蛋白二级结构、粒径及微观形貌变化，且乳化活性与单一结构指标无显著相关性。不同预处理对坛紫菜蛋白提取、结构及乳化性能的影响并不同步，其乳化特性可能受蛋白组成、构象及颗粒状态等多因素共同影响。

关键词：坛紫菜；蛋白提取；预处理；乳化特性

资助项目：国家重点研发计划项目，2025YFD2400205

通讯作者：林婉玲，女，博士，教授，水产品加工与海洋功能物质，13826091542，lwlscsf@163.com

长棘海星皂苷提取物的制备及其抗肿瘤活性机制研究

王冬雪，万越，胡亚芹*

海南热带海洋学院，海南省三亚市吉阳区育才路 1 号，572022

摘要：目的：为落实“构建多元化食物供给体系”战略部署，开拓海洋水产新资源，本研究以危害海洋生态的长棘海星为原料，聚焦其皂苷类活性成分的抗肿瘤利用。方法：采用超声辅助乙醇提取结合柱色谱分离制备长棘海星皂苷提取物，通过 MTT、DAPI 染色、划痕愈合及流式细胞术系统评价其对 HepG2 肝癌细胞的增殖抑制、迁移阻滞及凋亡诱导作用；借助高效液相色谱-质谱联用技术鉴定主要成分，通过分子对接预测作用靶点，采用蛋白免疫印迹法深入解析其线粒体凋亡机制。结果：提取物成分以甾体皂苷为主，对 HepG2 细胞表现出显著增殖抑制活性(IC_{50} =40.83μg/mL)，并有效抑制细胞迁移；机制研究表明，皂苷通过上调促凋亡蛋白 Bax、Bad，破坏线粒体膜电位，促使细胞色素 c(cyt-c)释放，释放的 cyt-c 与 Apaf-1 结合并招募激活 caspase-9，进而启动 caspase 级联反应，将细胞周期阻滞于 G1 期并诱导早期凋亡(34.29%)。结论：本研究不仅为长棘海星这一典型海洋有害生物的高值化利用提供了新思路，也为水产食品功能因子在肿瘤干预领域的开发应用奠定理论基础，助力海洋资源全质化综合利用与产业高质量发展。

关键词：长棘海星；皂苷提取物；抗肿瘤活性；线粒体凋亡

基金项目：国家自然科学基金资助项目（32603375）；海南热带海洋学院高层次人才项目（RHDRC202117）；海南热带海洋学院青年人才项目（RHDRC202307；RHDRCZK202624）

胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，15868109010，E-mail: yqhu@zju.edu.cn

Preparation of saponin extract from Acanthaster planci and its antitumor activity mechanism

Wang Dongxue, Wan Yue, Hu Yaqin*

College of Food Science and Engineering, Hainan Tropical Ocean University, Sanya 572022, China

Abstract: [Objective] In order to implement the strategic deployment of "building a diversified food supply system" and develop new marine aquatic resources, this study utilized the ecologically harmful *Acanthaster planci* (crown-of-thorns starfish) as raw material, focusing on the antitumor application of its saponin bioactive components. [Methods] The saponin extract was prepared by ultrasonic-assisted ethanol extraction combined with column chromatography. The inhibitory effects

on proliferation, migration blockade, and apoptosis induction in HepG2 hepatocellular carcinoma cells were systematically evaluated using MTT assay, DAPI staining, wound healing assay, and flow cytometry. The major components were identified by high-performance liquid chromatography-mass spectrometry (HPLC-MS), potential targets were predicted through molecular docking, and the mitochondrial apoptosis mechanism was further elucidated by Western blotting. [Results] The extract mainly consisted of steroidal saponins, which exhibited significant antiproliferative activity against HepG2 cells (IC_{50}=0.83μg/mL) and effectively inhibited cell migration. Mechanistic studies revealed that the saponins upregulated the pro-apoptotic proteins Bax and Bad, disrupted mitochondrial membrane potential, and promoted the release of cytochrome c (cyt-c). The released cyt-c bound to Apaf-1 and recruited/activated caspase-9, subsequently triggering the caspase cascade, which arrested the cell cycle at G1 phase and induced early apoptosis (34.29%). [Conclusion] This study not only provides a new strategy for the high-value utilization of *Acanthaster planci*, a typical marine pest, but also lays a theoretical foundation for the development and application of aquatic food functional factors in tumor intervention, contributing to the comprehensive utilization of marine resources and high-quality industrial development.

Key words: *Acanthaster planci*; Saponin extract; Antitumor activity; Mitochondrial apoptosis

超声辅助 BBR@HMSN 介导的光动力灭活副溶血性弧菌及其在黄鳍金枪鱼保藏中的应用

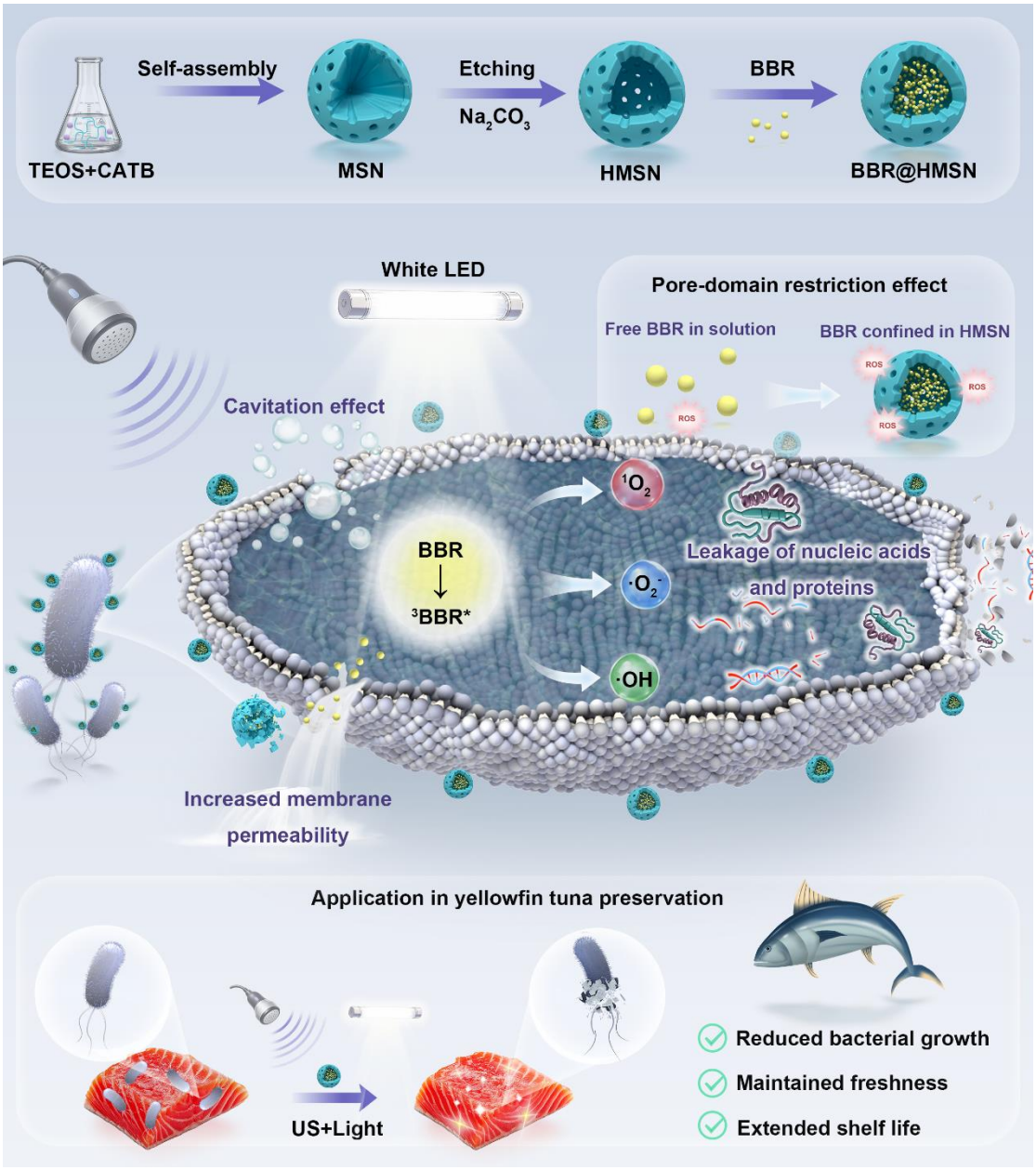
崔纯锋，刘海泉，赵勇*

上海海洋大学食品学院，中国上海，201306

摘要：本研究利用超声辅助 BBR@HMSN 介导的光动力灭活（PDI）实现了对副溶血性弧菌的高效杀灭，并将其应用于黄鳍金枪鱼的保藏。具体而言，将小檗碱（BBR）负载于中空介孔二氧化硅纳米颗粒（HMSN）的中空介孔结构中，通过限制 BBR 的分子内运动，从而激发聚集诱导发光特性，促进活性氧（ROS）的生成。同时，超声空化作用破坏了副溶血性弧菌外膜有序的脂质双分子层排列，形成瞬时孔洞，有利于 ROS 渗透。因此，超声辅助 BBR@HMSN 介导的 PDI 表现出显著增强的革兰氏阴性菌杀灭能力，通过诱导严重的细胞膜损伤，对副溶血性弧菌表现出优异的灭活效率（约 7.24 log CFU mL^{-1}）。分子动力学模拟表明，超声可导致副溶血性弧菌外膜松弛，从而加快 ROS 向内膜及细胞内区域的扩散。此外，该 PDI 能有效杀灭黄鳍金枪鱼片上的副溶血性弧菌，延缓脂质氧化、保持色泽，并将保质期至少延长 2 天。这些发现凸显了超声辅助 PDI 在对抗革兰氏阴性菌以及确保水产品微生物安全方面的潜在应用前景。

关键词：光动力灭活；超声；副溶血性弧菌；膜破坏；黄鳍金枪鱼保藏

图文摘要：



资助项目：上海市农业科技创新项目（T2024108）；上海市科技兴农技术创新项目（2024-02-08-00-12-F00038）。

通讯作者：赵勇，男，博士，教授，研究方向为食品微生物分子生态学、食品质量安全风险评估以及食品质量安全与系统生物学研究。电话 15692165928，邮箱 yzhao@shou.edu.cn

超声辅助磷酸化对鱼明胶消化-发酵特性的影响

曹吕璐 1，范欣欣 1，陈佳静 1，湛胜楠 1，张　鹏 2，黄　涛 1*

（1.宁波大学食品科学与工程学院，浙江宁波 315800；

2.上海福美泰生物科技有限公司,上海浦东新区 200100）

摘要：以鱼明胶（Fish Gelatin, FG）为原料，采用超声辅助磷酸化（Ultrasound-assisted phosphorylation, UAP）改性，探究不同超声功率（50、100、200 W）与温度（50、60、70 ℃）对 FG 消化和发酵特性的影响。通过体外消化和酵解模型研究 FG 的消化特性和发酵特性的影响。结果显示：UAP 可降低 FG 在胃肠道消化阶段的消化速率；与未修饰 FG 相比，100 W、60 ℃处理可增强消化产物的抗氧化活性，在抗氧化性具潜在优势。UAP 显著改变 FG 的发酵特性，尤其在产气量、pH 变化和短链脂肪酸（SCFAs）生成上差异明显；16S rDNA 测序表明，UAP 显著提升了发酵液中微生物多样性和益生菌种类。综上，UAP 能降低 FG 的胃肠道消化特性、提高消化产物抗氧化性并丰富肠道菌群多样性，为改性鱼明胶在功能食品领域的应用提供了技术支撑。

关键词：鱼明胶；超声辅助；磷酸化；消化酵解；短链脂肪酸

Effect of Ultrasound-assisted Phosphorylation on the Digestion and Fermentation Characteristics of Fish Gelatin

CAO Lvlu1，FAN Xinxin1，CHEN Jiajing1，ZHAN shengnan1，ZHANG peng2，HUANG Tao1*

（1.College of Food Science and Engineering, Ningbo University, Ningbo 315800, China

2.Shanghai Fumeitai Biotechnology Co., Ltd., Shanghai 200100, China）

Abstract ： Fish gelatin (FG) was modified by ultrasound-assisted phosphorylation (UAP) to investigate the effects of different ultrasonic powers (50, 100, 200 W) and temperatures (50, 60, 70 °C) on the digestion and fermentation

properties of FG. An in vitro digestion and fermentation model was employed to study the digestive and fermentative characteristics of FG. The results showed that UAP reduced the digestion rate of FG during gastrointestinal digestion. Compared with unmodified FG, UAP treatment at 100 W and 60 °C enhanced the antioxidant activity of the digestion products, offering potential advantages in antioxidant capacity. UAP significantly altered the fermentation properties of FG, particularly in gas production, pH changes, and short-chain fatty acid (SCFAs) generation. 16S rDNA sequencing revealed that UAP significantly increased the microbial diversity and probiotic species in the fermentation broth. In conclusion, UAP can reduce the gastrointestinal digestibility of FG, improve the antioxidant activity of its digestion products, and enrich the diversity of gut microbiota, providing technical support for the application of modified fish gelatin in the functional food field.

Key words: Fish gelatin; Ultrasonic-assisted extraction; Phosphorylation; Digestion and fermentation; Short-chain fatty acids

超声辅助柠檬酸处理的“释放–螯合”效应对坛紫菜重金属去除效率的影响

李振邦 [1]，李雨桐 [1]，许长华 [1, 2*]

1. 上海海洋大学 食品学院，上海 201306； 2. 国家淡水水产品加工技术研发分中心(上海) ，上海 201306 ；3. 秦普生物科技有限公司，中国苏州 215200； 4. 泉州福港佳食品有限公司，中国泉州晋江 362000

摘要：针对坛紫菜重金属残留问题，本研究建立超声辅助柠檬酸（UACA）协同去除技术，并评价其去除效果、作用机制及品质影响。采用单因素试验和 Box–Behnken 响应面优化柠檬酸浓度、超声时间和功率，结合 FT-IR、亚细胞分布和 SEM 分析机制。最优条件为 0.11 mol/L 柠檬酸、27 min、270 W，Cr、As、Cd、Pb 去除率分别为 74.7%、81.2%、92.0%和 51.2%，残留量均低于国家限量标准。UACA 通过“释放–螯合”作用促进重金属解吸与络合；处理后蛋白质、多糖及氨基酸略有损失，但蛋白质营养质量总体稳定。该技术可在兼顾营养品质的同时有效降低坛紫菜多种重金属残留。

关键词：坛紫菜；超声辅助柠檬酸；重金属去除；释放-螯合；工艺优化

项目资助：国家重点研发计划（2024YFD2101200）；绿色健康食品关键技术研发专项（D-8006-26-0194）

通讯作者：许长华，男，博士，教授，食品快检研究，18516275495，chxu@shou.edu.cn

Release–Chelation Effect of Ultrasound Assisted Citric Acid Treatment on Heavy Metal Removal Efficiency in Pyropia haitanensis

Zhenbang Li [1], YutongLi[1], Changhua Xu[1, 2*]

1. College of Food Science & Technology, Shanghai Ocean University, Shanghai 201306, PR China; 2. National R&D Branch Center for Freshwater Aquatic Products Processing Technology (Shanghai), Shanghai 201306, China; 3. Qinpu Biotechnology Pte Ltd., Suzhou 215200, China; 4. Quanzhou Fugangjia Food Co., Ltd., Jinjiang,

Quanzhou 362000, China

Abstract: Heavy metal accumulation in Pyropia haitanensis poses a potential food safety risk. In this study, an ultrasound-assisted citric acid (UACA) treatment was developed to remove Cr, As, Cd, and Pb while evaluating its removal mechanism and effects on nutritional quality. Single-factor experiments and Box–Behnken response surface methodology were used to optimize citric acid concentration, sonication time, and ultrasonic power, while FT-IR, subcellular fractionation, and SEM were employed to investigate the removal mechanism. The optimal treatment conditions were 0.11 mol/L citric acid, 27 min of sonication, and 270 W ultrasonic power. Under these conditions, the removal rates of Cr, As, Cd, and Pb were 74.7%, 81.2%, 92.0%, and 51.2%, respectively, and their residual concentrations were below the corresponding national limits. Structural analyses indicated that UACA promoted heavy metal release and complexation through a "Release–Chelation" effect. Although slight losses of protein, polysaccharides, and amino acids occurred after treatment, the overall protein nutritional quality remained stable. These results demonstrate that UACA can effectively reduce multiple heavy metal residues in P. haitanensis while largely maintaining its nutritional quality.

Keywords: Pyropia haitanensis; ultrasound-assisted citric acid; heavy metal removal; Release - Chelation; process optimization

超声辅助漂洗对鱼糜风味的影响机制

肖乃勇[1]，余红莉[1]，刘书成[1*]

1. 广东海洋大学 食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研发中心，广东省海洋生物制品工程重点实验室，水产品深加工广东普通高校重点实验室，广东 湛江 524088

摘要:【目的】针对淡水鱼糜腥味重、传统漂洗脱腥效率低，探究超声辅助漂洗对淡水鱼糜风味的影响及机制。**【方法】**以传统单次漂洗为对照，采用超声辅助单次漂洗制备斑点叉尾鮰鱼糜，利用固相微萃取-气相色谱和离子迁移谱分析其挥发性成分，结合蛋白结构表征与分子互作解析风味影响机制。**【结果】**研究表明，超声辅助漂洗可显著降低鱼糜中醛、醇、酮类挥发性物质含量，且随超声时间延长呈逐渐降低趋势；超声辅助漂洗通过降低不饱和脂肪酸含量，诱导蛋白质二级结构由 α-螺旋向 β-折叠转变、三级结构展开，改变蛋白对腥味物质的结合与释放，改善鱼糜整体风味。**【结论】本**研究可为高品质淡水鱼糜的绿色加工生产提供理论参考。

关键词：超声辅助漂洗；鱼糜；腥味；风味

资助项目：国家自然科学基金青年项目：超声场下鱼糜肌原纤维蛋白与关键腥味物质的量子化学作用机制（32502252）

第一作者：肖乃勇，男，博士，副教授，主要从事水产品加工与风味品质调控研究。

电话：13017692264；E-mail: nyxiao@gdou.edu.cn

超声改性火麻仁蛋白对金线鱼鱼糜凝胶特性的影响

祁红丽，陈敬鑫，仪淑敏，李学鹏，米红波[1]

渤海大学 食品科学与工程学院，国家鱼糜及鱼糜制品加工技术研发中心，生鲜农产品贮藏加工及安全控制技术国家地方联合工程研究中心，辽宁 锦州 121013

摘要：基于超声空化效应，探究不同超声功率改性火麻仁蛋白对其性质与微观结构的影响，并阐明改性蛋白对金线鱼糜凝胶品质的调控规律及内在机制。采用 0、300、400、500、600 W 五种超声功率处理火麻仁蛋白，测定粒径、溶解度及二级结构；将 400 W 改性火麻仁蛋白添加至金线鱼糜凝胶中，测定持水性、白度、凝胶强度、质构特性、水分分布、流变学特性、二级结构、化学作用力，并结合扫描电镜分析凝胶网络结构。400 W 超声处理使火麻仁蛋白粒径降至 13.06 nm，溶解度升至 24.51%。鱼糜凝胶中，添加 400 W 改性蛋白后持水性达 72.65%，白度 81.30，凝胶强度 2841.71 g·mm，储能模量显著升高，蛋白质二级结构由 α 螺旋向 β 折叠转变，形成致密凝胶网络。400 W 超声改性优化了火麻仁蛋白结构，显著提升了鱼糜凝胶品质，为产品开发提供理论依据。

关键词：鱼糜；火麻仁蛋白；超声空化；凝胶特性；蛋白质结构

Effect of ultrasonic-modified hemp seed protein on the gel properties of Nemipterus virgatus surimi

Qi Hongli, Chen Jingxin, Yi Shumin, Li Xuepeng, Mi Hongbo*

(College of Food Science and Engineering, Bohai University, National & Local Joint Engineering Research Center of Storage, Processing and Safety Control Technology for Fresh Agricultural Products, Jinzhou 121013, Liaoning, China)

Abstract: Based on the ultrasonic cavitation effect, this study explored the effects of hemp seed protein modified

基金项目：辽宁省“兴辽英才计划”青年拔尖人才项目（XLYC2503063），锦州市“锦绣英才”青年拔尖人才项目（JXYC240101）

作者简介：祁红丽（1999—），女，汉族，硕士研究生，研究方向：水产品贮藏及加工。

[1] 通讯作者：米红波（1986—），女，汉族，博士研究生，教授，研究方向：水产品贮藏及加工。

by different ultrasonic powers on its properties and microstructure, and clarified the regulation rules and internal mechanisms of the modified protein on the gel quality of *Nemipterus virgatus* surimi. Five ultrasonic powers of 0, 300, 400, 500, and 600 W were used to treat hemp seed protein, and the particle size, solubility, and secondary structure were measured. The 400 W modified hemp seed protein was added to the *Nemipterus virgatus* surimi gel, and the water-holding capacity, whiteness, gel strength, and storage modulus (G') were measured. The gel network structure was analyzed by SEM. The 400 W ultrasonic treatment reduced the particle size of hemp seed protein to 13.06 nm and increased the solubility to 24.51%. In the surimi gel, after adding the 400 W modified protein, the water-holding capacity reached 72.65%, the whiteness was 81.30, the gel strength was 2841.71 g·mm, the storage modulus increased significantly, the secondary structure of the protein changed from α-helix to β-sheet, and a dense gel network was formed. The 400 W ultrasonic modification optimized the structure of hemp seed protein and significantly improved the quality of surimi gel, providing a theoretical basis for product development.

Key words: Surimi; Hemp seed protein; Ultrasonic cavitation effect; Gel properties; Protein structure

超声和酶解预处理诱导豌豆蛋白形成新型原纤维以实现虾青素的高效递送

王逢秋节，张龙，王锡昌，陶宁萍*

上海海洋大学食品学院，上海，201306

摘要：与天然蛋白质不同，蛋白质原纤维具有优异的化学稳定性、活性反应基团和递送性能，但其应用过程面临纤维化进程缓慢、转化效率低等挑战。本文探究超声与酶解预处理对豌豆蛋白在纤维化过程中的构象及理化性质的影响，并构建了一种新型的虾青素递送体系。结果表明：超声与酶解预处理通过破坏和重构分子间疏水相互作用、二酪氨酸共价键及二硫键，改变纤维化进程。超声处理增强了豌豆蛋白的柔韧性、表面疏水性和分散性。酶解预处理缩短了豌豆蛋白水解时间，并促进更多纤维结构单元的分子折叠与聚集。此外，豌豆蛋白原纤维包埋虾青素后形成无定形复合物，显著提升了虾青素的功能特性。本研究为豌豆蛋白原纤维的功能调控及生物活性物包埋应用提供参考。

关键词：豌豆蛋白原纤维；超声预处理；酶解预处理；纤维化机制；递送生物活性物质

Ultrasound and enzymolysis pretreatment induce pea protein to form new fibrils for efficient delivery of astaxanthin

Fengqiujie Wang, Long Zhang, Xichang Wang, Ningping Tao*

College of Food Science and Technology, Shanghai Ocean University, Shanghai, 201306

Abstract: Unlike natural proteins, protein fibrils exhibit superior chemical stability, reactive functional groups, and delivery properties. However, the application process faces great challenges, such as slow fibrillation processes and low conversion efficiency. This study investigates the effects of ultrasound and enzymolysis pretreatment on the conformation and physicochemical properties of pea protein during the fibrillation process and establishes a novel astaxanthin delivery system. The results indicate that ultrasound and enzymolysis pretreatment alter the fibrillation process by

disrupting and reorganizing intermolecular hydrophobic interactions, covalent disulfide bonds, and di-tyrosine bonds. Ultrasound pretreatment enhanced the flexibility, surface hydrophobicity, and dispersibility of pea protein. Enzymolysis pretreatment shortened the hydrolysis time of pea protein and promoted the molecular folding and aggregation of more fibrillar structural units. Furthermore, the incorporation of astaxanthin into pea protein fibrils resulted in the formation of an amorphous complex, significantly enhancing the functional properties of astaxanthin. This study provides a reference for the functional regulation of pea protein fibrils and their application in the encapsulation of bioactive substances.

Key words: Pea protein fibril; Ultrasound pretreatment; Enzymolysis pretreatment; Fibrillization mechanism; Bioactive substance delivery

资助项目：The National Key Research and Development Program of China (Project No. 2023YFD2401503)

第一作者：王逢秋节，男，博士研究生。研究方向：生物活性物质的递送载体的制备及缓释研究。E-mail：wangfengqiujie@163.com。以第一作者在国际期刊发表 SCI 论文 8 篇，在国内期刊发表论文 2 篇；获得中国发明专利授予权 1 项，软件著作 1 项；获全国大学生生命科学竞赛国家级三等奖，博士研究生国家奖学金等荣誉。

通讯作者：陶宁萍，女，博士，教授。研究方向：食品营养与品质评价。E-mail：nptao@shou.edu.cn。先后主持国家重点研发计划“蓝色粮仓科技创新”专项课题、国家科技支撑计划项目子课题、上海市自然科学基金项目等近 10 项。获农业部、中国商业联合会和上海市浦东新区科技进步三等奖各 1 项，发表学术论文 100 余篇，其中 SCI 收录论文 46 篇；获得中国发明专利授予权 7 项；主编和参编论著 4 部。教育部国家级虚拟仿真实验项目、国家级一流课程负责人；上海市高校外国留学生英语授课示范性课程、上海市一流课程负责人；主编教材获中国轻工业优秀教材二等奖；获上海市教育系统“三八”红旗手等称号。

陈化干鲍来源糖肽的分离及其对 RAW264.7 巨噬细胞免疫稳态的调节作用

奚楚瑜，任中阳，石林凡，翁武银*

集美大学海洋食品与生物工程学院，福建省厦门市，361021

摘要： 本研究以陈化干鲍为原料，经体外模拟胃肠消化制备消化产物，采用 DEAE-52 阴离子交换柱层析和 Sephadex G-15 凝胶过滤进行分离，获得糖肽组分 P2G，并对其理化特征及对 RAW264.7 巨噬细胞免疫调节作用进行分析。结果表明，P2G 的总糖和蛋白质含量分别为 48.45%和 38.15%，由葡萄糖、甘露糖、葡萄糖醛酸和半乳糖组成，氨基酸组成以脯氨酸、精氨酸和羟脯氨酸为主，相对分子量约为 10.29 kDa。以 RAW264.7 巨噬细胞为模型评价 P2G 的免疫调节活性。在静息状态下，80 μg/mL P2G 显著增强细胞吞噬能力，5~80 μg/mL P2G 可剂量依赖性地促进 NO、TNF-α 和 IL-6 释放，20~80 μg/mL P2G 显著上调 CD80、CD86 和 MHC II 表达。在 LPS 诱导的炎症环境中，5 μg/mL P2G 显著抑制 NO、TNF-α 和 IL-6 的过量释放，5~20 μg/mL P2G 可抑制细胞吞噬功能过度增强及 MHC II 表达，但随着浓度升高，部分抑制作用减弱或转变为增强作用。综上，P2G 对巨噬细胞功能具有双向调节作用，在静息状态下主要表现为免疫激活作用，在炎症状态下则以低剂量抑制过度免疫为主。本研究阐明了陈化干鲍糖肽对巨噬细胞免疫稳态的调节作用及分子机制，为揭示陈化干鲍营养功能特性提供依据。

关键词：干鲍；糖肽；分离纯化；RAW264.7 巨噬细胞；免疫调节

通讯作者*：翁武银，男，博士，教授，研究方向：水产品加工与综合利用，E-mail: wwymail@jmu.edu.cn

资助项目：福建省海洋与渔业重点研发计划项目（FJHYZ-2026-10）

臭氧微纳米气泡介导的卵形鲳鲹捕后减菌与脱腥干预：微生态-风味代谢网络的解析

蒲移虹，王迪，相欢，赵永强，岑剑伟，王悦齐，吴燕燕*

单位 中国科学研究院南海水产研究所，地区 广州，邮编 510300

摘要：捕后微生物腐败与腥臭异味的快速积累，是制约卵形鲳鲹（*Trachinotus ovatus*）高值化利用与冷链流转的关键瓶颈。本研究旨在评估臭氧微纳米气泡（OMNB）干预技术对卵形鲳鲹捕后减菌脱腥效应，并解析其潜在的微生态-风味代谢网络调控机制。结果表明，OMNB 处理显著抑制了鱼肉 TVB-N 与 TBARS 的积累，有效维持了肌纤维微观结构完整性与肌肉持水力，使捕后货架期延长了 2~3 天。16S rRNA 测序与 GC-MS 联用分析揭示，OMNB 发挥了显著的靶向减菌效应，重塑了捕后鱼肉的微生态群落演替轨迹，特异性地削弱了以假单胞菌（Pseudomonas）和希瓦氏菌（Shewanella）为代表的核心致腐菌群的优势地位。进一步的微生态-风味网络分析证实，这些核心菌群的受抑，从源头上阻断了三甲胺、吲哚、甲硫醇等关键腥臭与腐败挥发性代谢物的生物合成路径。综上所述，OMNB 干预能够通过调控致腐微生物-异味代谢物的网络互作，实现高效的捕后减菌脱腥，为水产品靶向品质控制提供了重要的理论依据。

关键词：卵形鲳鲹；臭氧微纳米气泡；品质劣变；腥味组分；减菌

资助项目:本研究得到广东省关键技术研发计划（2025B1111140001）、国家自然科学基金（32672869）、国家现代农业产业技术体系专项经费（CARS-46）、广东省青年拔尖人才专项支持计划（NYQN2024004）以及中国水产科学研究院中央级公益性科研院所专项科研经费（2020TD69）的资助。

通讯作者简介：吴燕燕（1969-），女，研究员，博导，从事水产品加工与质量安全控制。E-mail：wuyygd@163.com

从海洋蛋白资源到功能性食品配料：南极磷虾源生物活性肽的研究进展与挑战

范硕[1]，崔纯峰[1]，杨新如[1]，刘海泉[1]，王敬敬[2]，唐世英[1]，赵勇[1,*]

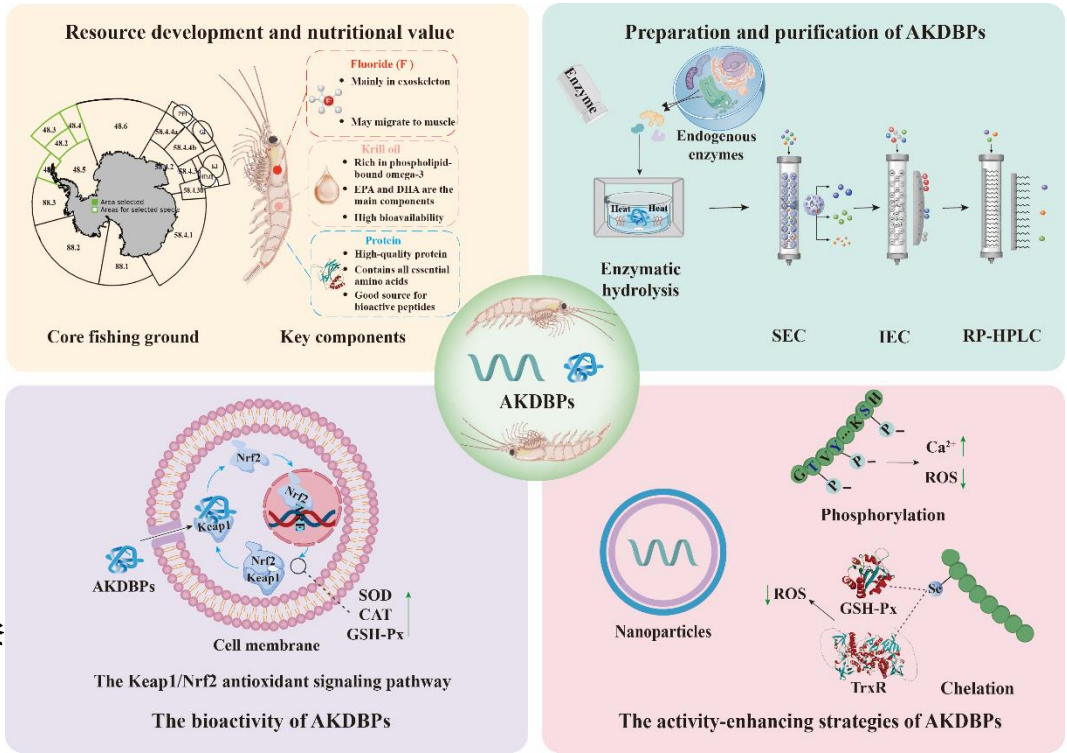
[1]上海海洋大学食品学院，中国上海，201306

[2]佛山大学食品科学系，中国佛山，528225

摘要：南极磷虾（*Euphausia superba*）作为全球重要的海洋动物蛋白资源，具有丰富的蛋白质储量和较高的营养价值，是海洋蛋白质高值化利用的重要原料。近年来，随着酶解、分离纯化和结构表征技术的进步，南极磷虾源生物活性肽（AKDBPs）逐渐成为功能性食品领域的研究热点。本文系统综述了 AKDBPs 的资源特征、制备策略、生物活性、活性增强策略、安全性评价及潜在食品应用。重点阐述了 AKDBPs 的功能效应，包括抗氧化、抗高血压、降血糖、降尿酸、保肝、神经保护和骨保护等活性，并从氨基酸组成、序列特征和分子相互作用等方面探讨了其潜在构效关系。此外，还总结了磷酸化、螯合、纳米颗粒和微胶囊等提高 AKDBPs 稳定性和生物利用度的策略的最新进展。尽管 AKDBPs 已展现出广泛的健康促进作用，但其工业化应用仍受限于生物活性肽组成复杂、质量评价体系不完善、生物利用度过程不明确以及缺乏人体功能验证等因素。未来研究应整合多组学分析、精准筛选技术、递送系统优化和食品功能评价，建立从原料开发到终端应用的系统化路径，从而推动南极磷虾蛋白（AKP）资源向高附加值功能性食品的转化。

关键词：海洋蛋白高值化利用；南极磷虾源生物活性肽；构效关系；生物利用度；功能性食品配料

图形摘要：



资

通讯作者：

赵勇，男，博士，教授，研究方向为食品微生物分子生态学、食品质量安全风险评估以及食品质量安全与系统生物学研究。电话 15692165928，邮箱 yzhao@shou.edu.cn。

从热加工产物到营养活性代谢物：5-HMF 经 5-HMFA 调控机体铁稳态的机制

张玉，李紫硕，吴浩浩*

1. 中国海洋大学食品科学与工程学院，山东 青岛

摘要：目的：阐明热加工产物 5-羟甲基糠醛（5-HMF）调控铁稳态的机制。方法：采用大鼠药代动力学试验、Caco-2 与 HepG2 细胞模型，结合酶动力学和分子对接。结果：口服 5-HMF 经消化道醛脱氢酶转化为 5-羟甲基-2-呋喃甲酸（5-HMFA）入血，未检出 5-SMF；5-HMFA 稳定十二指肠、肝、肾 HIF-2α，上调铁转运基因与肝肾促红细胞生成素，促进肠上皮非血红素铁吸收，抑制炎症所致铁调素过表达；并可混合型抑制 PHD3（IC50 2.62 μM）。结论：5-HMF 经肠首过活化为 5-HMFA，通过抑制 PHD 稳定 HIF-2α，协同调控肠铁吸收与 EPO/铁调素稳态，为富 5-HMF 食物改善铁利用提供依据。

关键词：5-羟甲基糠醛；5-羟甲基-2-呋喃甲酸；脯氨酰羟化酶；低氧诱导因子-2α；铁稳态

From Thermal-Processing Product to Nutritionally Bioactive Metabolite: Mechanism of 5-HMF-Mediated Regulation of Systemic Iron Homeostasis via 5-HMFA

Yu Zhang, Zishuo Li, Haohao Wu*

1. College of Food Science and Engineering, Ocean University of China, Qingdao, China

Abstract: [Objective] To elucidate the in vivo metabolic fate and molecular mechanism by which 5-hydroxymethyl-2-furfural (5-HMF), a typical thermal-processing product, regulates systemic iron homeostasis. [Methods] Pharmacokinetic and tissue-distribution studies were performed in rats with LC-MS/MS quantification, complemented by Caco-2 intestinal epithelial and HepG2 hepatic cell models, RT-qPCR, Western blotting, dual-luciferase reporter assays, recombinant PHD3 enzyme kinetics, and molecular docking simulations. [Results] After oral administration, 5-HMF was rapidly oxidized by gastrointestinal aldehyde dehydrogenases to 5-hydroxymethyl-2-furoic acid (5-HMFA) before systemic entry, with no detectable formation of the genotoxic metabolite 5-sulfooxymethylfurfural (SMF). 5-HMFA stabilized HIF-2α in the duodenum, liver, and kidney, upregulating

duodenal iron-transport genes (Cybrd1, Slc11a2, Slc40a1, and Heph) and hepatic/renal erythropoietin (Epo) transcription. At the cellular level, 5-HMFA promoted non-heme iron uptake and transepithelial transport, increased erythropoietin production under normoxic, hypoxic, and inflammatory conditions, and suppressed inflammation-induced hepcidin overexpression. Enzymatic and docking analyses revealed that 5-HMFA inhibited PHD3 in a mixed-type manner (IC50 = 2.62 μM). [Conclusion] 5-HMF undergoes presystemic bioactivation to 5-HMFA, which stabilizes HIF-2α via PHD inhibition and coordinately regulates intestinal iron absorption and erythropoietin/hepcidin homeostasis, providing a mechanistic basis for improving iron utilization through 5-HMF-rich foods.

Key words: 5-hydroxymethyl-2-furfural; 5-hydroxymethyl-2-furoic acid; prolyl hydroxylase; hypoxia-inducible factor-2α; iron homeostasis

资助项目：国家自然科学基金（No. 32272240）海口市重大科技项目（No. 2025-004）；海南省重点研发计划项目（ZDYF2026XDNY141）；

通讯作者：吴浩浩，教授，研究方向为水产品高值化利用，E-mail：wuhaohao@ouc.edu.cn。

从中华草龟龟甲到创伤护理：具有止血性能的壳聚糖-龟甲胶原复合海绵的制备与表征

李荣杏[1]， 贺雄[1]，林琳[1*]，陆剑锋[1*]

1. 合肥工业大学食品与生物工程学院，安徽合肥，230601；

摘要：【目的】有效止血是治疗创伤的关键步骤。【方法】本研究制备了壳聚糖/戊二醛复合龟甲胶原海绵（C-G-TCS）。通过比较分析探讨了其作为生物医学材料的潜力。【结果】结果表明，C-G-TCS 具有更好的热稳定性和更低的酶解度。另外，经评估，C-G-TCS 和 C-G-PCS 均对细胞生长无毒性。虽然 C-G-TCS 和 C-G-PCS 的血液吸收能力低于 iRE（一种商用胶原海绵），但与 iRE 相比，它们的凝血指数较低，凝血时间相似。据观察，C-G-TCS 处理可将全血细胞最佳地粘附在海绵上。凝血酶原时间和活化部分凝血活酶时间结果表明，C-G-TCS 和 C-G-PCS 可促进外凝血途径的活化。与对照组相比，C-G-TCS 和 C-G-PCS 治疗截尾小鼠的止血时间缩短，失血量与 iRE 治疗相似。【结论】以上结果均表明我们的复合龟甲胶原海绵具备良好的发展前景和潜力。

关键词：龟甲胶原蛋白；胶原海绵；壳聚糖；戊二醛；生物医学材料

资助项目：安徽现代农业产业技术体系项目（AARS-08）；财政部和农业农村部: 国家现代农业产业技术体系项目（CARS-47）；国家重点研发计划（2023YFD2401500）
通讯作者：林琳，女，博士，副教授，研究方向为水产品加工与贮藏，E-mail: linlin@hfut.edu.cn

脆肉与普通罗非鱼复配对鱼糜凝胶品质的影响

谢洁如[1]，唐晓莉[1]，阮景刚[1]，王琳[1]，李川[1]，张龙腾[1]，朱露露[1]，符娜[2]，何燕富[1*]

1. 海南大学食品科学与工程学院，海南 海口 570100；

2. 海南勤富食品股份有限公司，海南 文昌 571399

摘要：为探究两种罗非鱼复配协同改善鱼糜综合品质的可行性及内在机制，实验以不同比例制备鱼糜凝胶，系统分析其凝胶品质，风味和蛋白构象变化。脆肉罗非鱼比例增加可显著提升凝胶强度、持水性及不易流动水比例，改善储能模量与损耗模量；风味物质丰富度逐步提高，醛类、不饱和醇类及特征酯类含量增加。当复配比例为 5:5 时，鱼糜凝胶在质构、保水性与风味均衡性上综合最优，其 β-折叠比例显著升高、无规卷曲减少，内源荧光强度适中，表明蛋白二级与三级结构实现了有序重排。普通与脆肉罗非鱼 5:5 复配可通过诱导肌原纤维蛋白构象重构、优化水分分布及调控关键挥发性风味物质，有效弥补单一原料缺陷，是制备高品质罗非鱼鱼糜制品的有效工艺手段。

关键词：脆肉罗非鱼；鱼糜；凝胶强度；风味特性；蛋白构象

资助项目：国家自然科学基金青年科学基金（32401989）；海南省重点研发专项（ZDYF2024XDNY258，ZDYF2025GXJS195）；海南省国际科技合作研发项目（GHYF2024022）

通讯作者：何燕富，女，博士，副教授，博士生导师，海南省自由贸易港 D 类人才。国家对虾加工技术研发分中心副主任，海南省营养学会烹饪与营养专业委员会委员。主持国家自然科学基金、海南省重点研发、海南省国际科技合作研发等科研项目 10 余项。研究方向为水产品保活保鲜与精深加工、水产品加工副产物综合利用。获海南省科技进步二等奖 1 项，以第一作者/通讯作者在 Carbohydrate Polymers、Trends in Food Science & Technology、Food Chemistry 等期刊上发表论文 20 余篇，入选 ESI 高被引论文 1 篇。联系电话：13719193709；邮箱：heyanfu819@163.com。

等离子体活化乳酸协同高浓度 CO_2气调包装对虹鳟鱼贮藏品质的影响

孙荣雪 [1,2*]，江宁 [1,2]

1. 江苏省农业科学院农产品加工研究所，江苏南京，210014；2. 农业农村部水产品保鲜贮藏加工技术集成科研基地，江苏南京，210014

摘要：虹鳟鱼是我国重要经济鱼类，但储运过程中易腐败变质，制约产业发展。本研究旨在采用等离子体活化乳酸协同高浓度 CO_2气调包装技术提升虹鳟鱼贮藏品质。通过理化指标（pH、TVC、TBARS、TVB-N）、蛋白结构（FT-IR）、水分分布（LF-NMR）、色泽及质构分析，结合高通量测序、游离氨基酸分析、GC-MS 与电子感官技术，综合评价其品质调控作用。结果表明，该技术可有效抑制虹鳟鱼微生物增殖、蛋白劣变及脂质氧化，将货架期由 4 天延长至 14 天，同时稳定鱼肉质构、色泽及蛋白结构，且处理后 T_{22}弛豫时间左移，抑制不易流动水向自由水转化。风味分析表明，该技术可抑制含硫异味物质累积，富集特征醛类物质，同时提升鲜味与甜味氨基酸占比，维持鱼肉新鲜风味。综上，该技术可依托抑菌与抗氧化双重功效提升鱼肉贮藏品质，为易腐水产品绿色保鲜与品质调控提供技术参考。

关键词：虹鳟鱼；等离子体活化乳酸；气调包装；菌群结构；品质；

资助项目：国家重点研发项目（2024YFD2100500）

第一/通讯作者：孙荣雪，女，博士，助理研究员；研究方向：水产品保鲜与加工；

电话：19822613910；E-Mail: sunrongxue187@163.com

Quality Regulation of Rainbow Trout by Plasma-Activated Lactic Acid Combined with High-Concentration CO_2 Modified Atmosphere Packaging

Rongxue Sun[1,2*], Ning Jiang[1,2]

1. Institute of Agricultural Products Processing, Jiangsu Academy of Agricultural Sciences, Nanjing, 210014, Jiangsu; 2. Integrated Scientific Research Base for Preservation, Storage and Processing Technology of Aquatic Products of the Ministry of Agriculture and Rural Affairs, Nanjing, 210014, Jiangsu

Abstract

Rainbow trout is an economically crucial aquatic product in China, whereas its susceptibility to microbial spoilage during storage and transportation severely limits industrial exploitation. This study investigated the effects of plasma-activated lactic acid combined with high-concentration CO_2 modified atmosphere packaging on the quality preservation of refrigerated rainbow trout. The quality-regulating effects of this treatment on rainbow trout were comprehensively evaluated by determining physicochemical indices (pH, TVC, TBARS, TVB-N), protein degradation (FT-IR), water distribution (LF-NMR), color and texture, together with high-throughput sequencing, free amino acid analysis, GC-MS and electronic sensory techniques. The results indicated that the combined treatment significantly inhibited microbial proliferation, protein deterioration, and lipid oxidation, extending the shelf life of rainbow trout from 4 days to 14 days. Furthermore, this treatment effectively stabilized flesh texture, color, and protein structure. A leftward shift in T_{22} relaxation time was observed after treatment, indicating that the treatment inhibited the conversion of immobile water to free water. Flavor analysis revealed that the combined treatment suppressed the accumulation of sulfur-containing off-flavor substances, enriched characteristic aldehydes, and increased the proportions of umami and sweet amino acids, thereby maintaining the fresh sensory quality of rainbow trout. In conclusion, the dual bacteriostatic and antioxidant effects of the treatment efficiently preserve the storage quality of fish products, providing a feasible technical strategy for the green preservation and quality regulation of perishable aquatic products.

Key words: Rainbow Trout; Plasma-Activated Lactic Acid; Modified Atmosphere Packaging; Bacterial Community Structure; Quality Attributes

等离子体活化水暂养对鲫风味及品质的影响

邵诗举[1]，蔡志成[1]，吴征[1]，李杰[1]，林琳[1*]，陆剑锋[1*]

1. 合肥工业大学食品与生物工程学院，安徽合肥，230601

摘要:【目的】探究等离子体活化水（PAW）暂养对鲫氧化应激、微生物群落及风味品质的影响。【方法】检测 PAW 及水体理化性质，测定鲫器官菌落数、血清生化与免疫、氧化应激酶，H.E 染色及电子鼻分析。【结果】PAW 暂养降低鱼体和水体菌落数，抑菌随浓度增强。PAW 中 RONS 引发鲫躁动、撞箱等应激，GSH、MDA 升高，长期应激致 CAT、SOD 下降。H.E 见器官氧化损伤，转氨酶、磷酸酶升高，补体、免疫球蛋白、溶菌酶下降，表明免疫抑制；自来水 6 d 后复常。电子鼻示 PAW 组鱼肉风味下降，醛酮类刺激性挥发物减少。【结论】PAW 暂养可降低鱼体和水体菌落数，氧化分解水中有机代谢废物，氧化损伤可逆，并可在一定程度上改善鲫风味。

关键词：鲫；等离子体活化水；暂养；氧化应激；风味品质

资助项目：安徽现代农业产业技术体系项目（AARS-08）；财政部和农业农村部: 国家现代农业产业技术体系项目（CARS-47）；国家重点研发计划（2023YFD2401500）
通讯作者：陆剑锋，男，博士，教授，研究方向为水产品加工及综合利用，E-mail: lujf@sibs.ac.cn

低分子量褐藻聚糖硫酸酯的结构分析及其体外抗氧化和抗炎活性的研究

李柳 [1], 王晓真 [1], 宿志荥 [1], 曾飞艳 [1], 马艺超 [1,2,3], 刘舒 [1,2,3], 何云海 [1,2,3], 汪秋宽 [1,2,3], 任丹丹 [1,2,3]*

[1] 大连海洋大学食品科学与工程学院，大连，116023

[2] 辽宁省水产品加工与综合利用重点实验室，大连，116023

[3] 国家海藻加工技术研发分中心，大连，116023

摘要：褐藻聚糖硫酸酯是一种从褐藻中提取的化学结构复杂的硫酸化海洋生物多糖，但其分子量大，生物利用率低。然而褐藻聚糖硫酸酯寡糖因其分子量小、容易被吸收，因此成为近年来广泛关注的焦点。本研究以笼目海带褐藻聚糖硫酸酯为原料，采用硫酸降解结合 Bio Gel P4 凝胶柱分离纯化，获得 SPF1、SPF2、SPF3、SPF4 四个组分，通过结构分析、体外抗氧化和抗炎活性研究，为褐藻聚糖硫酸酯寡糖的应用提供理论基础。结果表明，SPF1 为分子量 5～20kDa 的杂多糖，SPF2、SPF3、SPF4 为聚合度 1～3 的硫酸化褐藻聚糖硫酸酯寡糖，硫酸基团连接在 C4 位置上，均含有 α-吡喃糖。SPF4 总糖含量和硫酸基团含量最高。体外实验表明，各组分的抗氧化活性呈浓度依赖性，SPF4 抗氧化效果最强。此外，褐藻聚糖硫酸酯寡糖能增强 RAW264.7 细胞内的抗氧化酶活性，降低氧化应激时细胞内产生的 MDA 和 ROS 水平，具有良好的抗氧化活性。在抗炎方面，400μg/mL 浓度的寡糖组分对细胞释放炎症因子的抑制效果最佳，虽弱于 0.1μg/mL 地塞米松，但能显著抑制 LPS 诱导的 NF-κB p65 亚单位进入细胞核及 MAPK 通路中 p38、ERK、JNK 蛋白的表达。SPF4 因分子量小、硫酸基团含量高而表现出最优的抗氧化和抗炎活性。

关键词：褐藻聚糖硫酸酯寡糖；结构分析；抗氧化；抗炎

通讯作者：任丹丹,女,博士,教授,研究方向:藻类资源利用；办公电话：（0411）84763559，E-mail：rdd@dlou.edu.cn

低聚糖调控鳄鱼蛋白肽美拉德反应产物的风味与抗氧化特性研究

王一帆[1]，李冰心[1]，周勇杰[1]，郑鄢燕[2]，洪惠[1]，谭雨青[1]，罗永康[1*]

1.中国农业大学食品科学与营养工程学院，北京，100083；2. 中国农业科学院食品加工与营养研究所，北京，100097

摘要：为降低鳄鱼肉肽（CMP）的腥味和苦味、改善其整体风味品质，并进一步提升其抗氧化活性，本研究采用木寡糖（XOS）、果寡糖（FOS）、半乳寡糖（GOS）、菊粉（INL）和大豆低聚糖（SBOS）与 CMP 进行美拉德反应（MR）。结果表明，MR 显著改变了 CMP 的分子量分布和氨基酸组成，降低了多种疏水性氨基酸含量，并改善其风味特征。感官评价和电子鼻分析显示，XOS 改性产物在抑制腥味、增强烘烤及焦糖样香气方面表现较佳。各美拉德反应产物（CMP-MRPs）的 DPPH 自由基清除能力、还原力、Fe^{2+}螯合能力及总抗氧化能力均显著提高，其中 XOS 组综合效果较优，相关指标提高至对照组的 1.69～14.25 倍。由此可见，XOS 参与的 MR 可有效实现 CMP 风味和抗氧化性能的协同提升，为鳄鱼肉蛋白资源的高值化利用提供参考。

关键词：鳄鱼蛋白肽；美拉德反应；益生元低聚糖；抗氧化活性；风味改善

资助项目：国家重点研发计划项目（动物源新食物资源营养素稳态化控制与风险因子消减关键技术研究 2023YFF11103804）

通讯作者：罗永康，男，博士，教授，主要从事畜水产品蛋白及活性肽开发、加工副产物高值化利用与水产品加工保鲜研究。电话：13651120311，E-mail：luoyongkang@cau.edu.cn。

低温真空慢煮对鲣鱼品质特性的影响及其贮藏过程中微生物群落与风味变化研究

王露澄[1]，水珊珊[1*]，张宾[1,2]

1.浙江海洋大学食品与药学学院，浙江舟山，316022；2.浙江海洋大学比萨海洋研究生院，浙江舟山，316022

摘要：目的：探究低温真空慢煮（SV）对鲣鱼品质及蛋白结构的作用，筛选最优工艺，解析贮藏劣变机制并建立货架期预测模型。方法：设置 70 ℃下 10、14、18、22 min SV 处理，以传统蒸煮、未加热样品为对照，检测理化质构、蛋白特性、水分迁移及微观结构；最优组分别在-18 ℃、4 ℃、25 ℃贮藏，结合动力学与 Arrhenius 方程构建货架期模型；采用 16S rRNA 测序与 GC-IMS 解析 4 ℃贮藏的微生物及挥发性风味变化。结果：70 ℃ 14 min 处理鲣鱼综合品质最优；温度升高加速品质劣变；4 ℃贮藏时微生物群落演替，风味物质组成发生改变。结论：SV 通过调控肌原纤维蛋白与水分分布改善鲣鱼品质，模型可实现货架期预测，微生物演替是冷藏劣变主要诱因，为鲣鱼加工保鲜提供理论参考。

关键词：鲣鱼；低温真空慢煮；蛋白结构；品质；货架期模型

Study on the Effects of Sous Vide Cooking on Quality Characteristics of Skipjack Tuna and Changes in Microbial Community and Flavor during Storage

Wang Lucheng[1], Shui Shanshan[1*], Zhang Bin[1,2]

1. College of Food and Pharmacy, Zhejiang Ocean University, Zhoushan, 316022, Zhejiang; 2. Pisa Marine Graduate School, Zhejiang Ocean University, Zhoushan, 316022, Zhejiang

Abstract: Objective: To investigate the effects of sous vide (SV) cooking on the quality and protein structure of skipjack tuna, screen the optimal processing condition, analyze the deterioration mechanism during storage, and establish a shelf-life prediction model. Methods: SV treatments were

performed at 70 ℃ for 10, 14, 18 and 22 min, with conventionally cooked and raw samples set as controls. Physicochemical properties, texture, protein characteristics, water migration and microstructure were determined. The optimal group was stored at -18 ℃, 4 ℃ and 25 ℃, respectively. A shelf-life model was constructed based on reaction kinetics and the Arrhenius equation. 16S ribosomal RNA (16S rRNA) sequencing and gas chromatography-ion mobility spectrometry (GC-IMS) were used to characterize the changes in microbial community and volatile flavor compounds during storage at 4 ℃. Results: Skipjack tuna treated by SV at 70 ℃ for 14 min exhibited the best overall quality. Increased storage temperature accelerated quality deterioration. Succession of microbial community and variation of flavor profiles were observed under 4 ℃ storage. Conclusion: SV cooking improves the quality of skipjack tuna by regulating myofibrillar proteins and water distribution. The established model can be used for shelf-life prediction. Microbial succession is the primary cause of quality deterioration under refrigerated storage. This study provides theoretical support for the processing and preservation of skipjack tuna.

Key words: skipjack tuna; sous vide cooking; protein structure; quality; shelf-life model

资助项目：国家重点研发计划项目(2021YFD2100504)；国家自然基金项目（32301972&U23A20263）；浙江省自然基金项目（LRG25C200001）

*通信作者：水珊珊（1989—）（ORCID: 0000-0003-1095-7749），女，副教授，博士，研究方向：水产品加工与贮藏，电话：15958081770，E-mail: shuiss@zjou.edu.cn

电场食品保鲜技术研究进展及开发

董士远，范泽楷，王宁，姜晓明，赵元晖，薛长湖

中国海洋大学食品科学与工程学院，山东青岛，266100

摘要：电场作为新兴的绿色低碳非热食品处理技术，具有促进传热、调控冰晶尺度、杀菌等作用效果，在保鲜、维持冷冻与解冻产品品质、提升加工效率、降低能耗等方面呈现诸多优势。本文分析国内外电场技术发展现状；介绍团队围绕电场高压电源开发、电极应用形式、电场保鲜技术作用效果及产业化应用开展系列探索；结合 Comsol 仿真，分析不同类型电极的电场分布特性；揭示电场加速鱼类等水产品冻结、解冻作用效果及机理；探究不同类型电场的保鲜作用；开发电场促冻结及保鲜水产品技术；展望电场在水产品保鲜领域的发展趋势。

关键词：电场；促冻结；保鲜；电极形式

Research Progress and Development in Electric Field Preservation Technology of Food

Dong Shiyuan, Fan Zekai, Wang Ning, Jiang Xiaoming, Zhao Yuanhui, Xue Changhu

College of Food Science and Engineering, Ocean University of China, Qingdao, 266100, ShanDong

Abstract: As an emerging green and low-carbon non-thermal food processing technology, the electric field exhibits effects such as promoting heat transfer, regulating ice crystal size, and sterilization, demonstrating numerous advantages in preservation, maintaining the quality of frozen and thawed products, improving processing efficiency, and reducing energy consumption. This paper analyzes the current development status of electric field technology both domestically and internationally; introduces a series of explorations conducted by the team on high-voltage power supply development for electric fields, electrode application forms, the effects of electric field preservation technology, and industrial applications; combines Comsol simulations to analyze the electric field distribution characteristics of different types of electrodes; reveals the effects and mechanisms of electric fields in accelerating the freezing and thawing of aquatic products such as fish; investigates the preservation effects of different types of electric fields; develops electric field-assisted freezing and preservation technology for aquatic products; and prospects the future trends of electric field applications in the field of aquatic product preservation.

Key words: Electric field; Assisted-freezing technology; Preservation; Type of electrodes

典型甲壳类水产动物蛋白的消化规律与标志性代谢物鉴定研究

高文羽 尹明雨*

上海海洋大学 食品学院，上海，201306

摘要：以大鼠为实验模型，比较中华绒螯蟹（EM）、南美白对虾（SM）和克氏原螯虾（LM）体肉蛋白的消化利用特性及代谢响应。采用二氧化钛指示剂法测定氮消化率，并结合生长性能、血清生化、肾脏组织病理学、肠道食糜粒径及代谢组学评价。结果表明，三种蛋白均显著促进大鼠体重增长，EM 组蛋白质功效比最高。三组消化率差异不显著；EM 组表观回肠消化率最高，EM 与 SM 组真回肠消化率相近且均显著高于 LM 组。鉴定出 2072 种代谢物，差异代谢物富集于氨基酸代谢及蛋白质消化吸收相关通路。EM、LM 和 SM 组主要影响花生四烯酸、亚油酸和抗坏血酸代谢，SM 和 LM 组氨基酸利用效率降低。综上，EM 蛋白具有较优的消化利用特性，可为甲壳类蛋白的营养评价与高效利用提供理论依据。

关键词：甲壳类动物；蛋白质；体外消化；营养学；代谢

资助项目：国家重点研发计划（2023YFD2401503）

通信作者：尹明雨（1995—），男，博士/博士后，讲师，研究方向为食品营养与品质评价。E-mail: myyin@shou.edu.cn

电子鼻、电子舌、HS-SPME-GC-MS 和机器学习的综合方法解析风干带鱼中气味和滋味协同效应及风味前体

罗 燚[1,2]，林慧敏[1,2*]，张 宾[1,2]

1.浙江海洋大学食品与药学学院，浙江 舟山 316022；2.舟山市海洋食品营养与智能加工重点实验室,浙江 舟山 316000

摘要:为解析风干带鱼风味形成前体物质以及气味与滋味的协同效应，揭示其特色风味本质，该研究采用电子鼻、电子舌、GC-MS、分子对接和机器学习研究滋味物质组成、挥发性风味物质的气味和滋味协同效应及风味前体。结果表明，与新鲜带鱼相比，风干带鱼滋味中呈咸味和鲜味的矿物质含量明显提升，酮类、醇类、醛类 VOCs 显著增加。其中，1-Octen-3-One、2-Nonenal、2,4-Decadienal 和 Trans-2,Cis-6-Nonadienal 是风干带鱼风味的核心贡献成分。分子对接表明，2,4-Decadienal 和 2,4-Nonadienal 可以增强咸味和甜味的滋味感知。机器学习结果揭示 13 种核心风味物质由不饱和脂肪酸和亮氨酸风味前体氧化产生。该研究阐明风干带鱼中特定的挥发性醛类可能通过嗅觉-味觉跨模态协同，直接增强咸味和甜味的感知强度。

关键词：*Trichiurus lepturus*；HS-SPME-GC-MS；挥发性有机化合物；分子对接；机器学习

Analysis of flavour precursors and the synergy between odour and taste in air-dried hairtail using an integrated strategy combining electronic nose, electronic tongue, HS-SPME-GC-MS and machine learning

LUO Yi[1,2], LIN Huimin[1,2]*, ZHANG Bin[1,2]

1. Food and Pharmacy College, Zhejiang Ocean University, Zhoushan, 316022, Zhejiang; 2. Zhoushan Key Laboratory of Marine Food Nutrition and Intelligent Processing, Zhoushan, 316022, Zhejiang

Abstract: To analyze the precursor compounds governing flavour formation in air-dried ribbonfish,

as well as the synergistic interactions between odour and taste, this study adopted electronic nose, electronic tongue, GC-MS, molecular docking, and machine learning to characterise flavour compound profiles, the cross-modal synergy of volatile compounds on odour and taste perception, and flavour precursors, to elucidate the origin of its unique flavour. The results showed that air-dried ribbonfish had significantly higher levels of minerals contributing to saltiness and umami than fresh ribbonfish; meanwhile, volatile organic compounds (VOCs), including ketones, alcohols, and aldehydes, were also present at elevated concentrations. Among these volatiles, 1-octen-3-one, 2-nonenal, 2,4-decadienal and trans-2,cis-6-nonadienal were identified as key flavour-active compounds shaping the flavour profile of air-dried ribbonfish. Molecular docking demonstrated that 2,4-decadienal and 2,4-nonadienal could potentiate salty and sweet taste perception. Machine learning modelling revealed that 13 core flavour compounds originated from the oxidation of unsaturated fatty acids and the breakdown of the flavour precursor leucine. This work shows that selected volatile aldehydes in air-dried ribbonfish can directly increase perceived saltiness and sweetness through olfactory gustatory cross-modal synergy.

Key words: *Trichiurus lepturus*; HS-SPME-GC-MS; Volatile organic compounds; Molecular docking; Machine learning

资助项目：国家重点研发计划资助（2020YFD0900900）

第一作者简介：罗燚（2001—）（ORCID: 0009-0001-5201-491X），男，硕士研究生，研究方向为水产品加工与贮藏。E-mail: l_yi168@163.com

*通信作者简介：林慧敏（1979—）（ORCID: 0000-0003-2098-0352），女，教授，博士，研究方向为水产品加工及贮藏。E-mail: linhuixiaomin@126.com

丁香油和薄荷油对克氏原螯虾有水保活后肌肉品质的影响

李佳雨，陈敬鑫，刘超，李学鹏，米红波[1]

（渤海大学 食品科学与工程学院，国家鱼糜及鱼糜制品加工技术研发中心，生鲜农产品贮藏加工及安全控制技术国家地方联合工程研究中心，辽宁 锦州 121013）

摘要：为探究丁香油与薄荷油复配能否在降低用量的同时增强克氏原螯虾保活效果，并揭示其对保活后肌肉品质的影响及协同机制，本研究在温度 20℃、密度 0.092 g/cm³条件下，分别添加不同浓度薄荷油、丁香油及二者 1:1 复配精油，经 3 d 保活后筛选存活率较高的浓度进行肌肉品质测定。结果显示，30 μL/L 薄荷油、30 μL/L 丁香油及 20 μL/L 复配精油在保活第 5 天的存活率分别为 52.5%、75.83%和 83.33%。对照组肌肉 pH、硬度、持水性、粗蛋白、结合水和不易流动水持续下降，蒸煮损失和自由水持续升高，肌纤维断裂严重，不良风味产生。与对照组相比，20 μL/L 的复配精油各品质指标均显著优于对照组（$P < 0.05$），变化幅度较小。综上，添加 20 μL/L 复配精油可有效维持克氏原螯虾肌肉品质，抑制水分迁移与营养流失，延缓品质劣变。

关键词：丁香油；薄荷油；克氏原螯虾；保活；存活率；肌肉品质

Effects of clove oil and peppermint oil on the muscle quality of Procambarus clarkii subjected to water-based live transportation.

Li Jiayu, Chen Jingxin, Liu Chao, Li Xuepeng, Mi Hongbo*

(College of Food Science and Engineering, Bohai University, National & Local Joint Engineering Research Center

---

基金项目：辽宁省“兴辽英才计划”青年拔尖人才项目（XLYC2503063），锦州市“锦绣英才”青年拔尖人才项目（JXYC240101）

[1]通讯作者：米红波（1986—），女，博士研究生，教授，研究方向：水产品贮藏及加工，18841671266，mihongbo1001@163.com。

of Storage, Processing and Safety Control Technology for Fresh Agricultural Products, Jinzhou 121013, Liaoning, China)

Abstract: To investigate whether the combination of clove oil and peppermint oil can enhance the keep-alive efficacy of Procambarus clarkii while reducing the dosage, and to reveal its effects on post-keep-alive muscle quality and the underlying synergistic mechanism, this study was conducted under conditions of 20 °C and a density of 0.092 g/cm³, with different concentrations of peppermint oil, clove oil, and their 1:1 compound essential oil added. After 3 days of keep-alive, the concentrations with higher survival rates were selected for muscle quality determination. The results showed that the survival rates on day 5 were 52.5%, 75.83%, and 83.33% for 30 μL/L peppermint oil, 30 μL/L clove oil, and 20 μL/L compound oil, respectively. In the control group, muscle pH, hardness, water-holding capacity, crude protein, bound water, and immobilized water continuously decreased, while cooking loss and free water continuously increased; severe myofiber disruption and off-flavor compounds were observed. Compared with the control group, the 20 μL/L compound oil group showed significantly superior quality indicators ($P < 0.05$), with smaller changes. In conclusion, adding 20 μL/L compound essential oil can effectively maintain the muscle quality of Procambarus clarkii, inhibit water migration and nutrient loss, and delay quality deterioration.

Keywords： *Procambarus clarkii*; Clove oil; Peppermint oil; Live preservation; Survival rate; Muscle quality

冻藏复热烤金鲳鱼中腥味与过熟异味的挥发性物质组成及呈味特性差异研究

唐晓莉，何燕富*，李川

海南大学食品科学与工程学院，海南 海口 570100；

摘要：为探究冻藏及复热对烤金鲳鱼风味品质的影响，并区分腥味与过熟异味挥发性物质，采用电子鼻、电子舌和 GC–MS 分析样品，结合 OAV 和 PLSR 筛选关键物质。结果表明，冻藏及复热改变了烤鱼气味和滋味轮廓，且共检出 194 种挥发性物质。结合 VIP 值、回归系数、OAV 及复热前后变化趋势，筛选出 24 种腥味、20 种过熟异味和 25 种香气相关物质。腥味与过熟异味共有 15 种，另有 5 种过熟异味特有物质和 9 种腥味特有物质，表明两类异味相关物质组成重叠较高。1-辛烯-3-醇、壬醛和 2-正戊基呋喃等共有物质与过熟异味关联更强，由此推测，冻藏复热过程中腥味向过熟异味的转变主要与共有气味活性物质含量及感官关联程度变化有关。本研究为阐明冻藏烤鱼复热过程中风味劣变及过熟异味形成机制提供了理论依据。

关键词： 烤金鲳鱼；冻藏；复热；腥味；过熟味

资助项目：国家自然科学基金地区基金项目(32560619)

通讯作者：何燕富，女，博士，副教授，博士生导师，海南省自由贸易港 D 类人才。国家对虾加工技术研发分中心副主任，海南省营养学会烹饪与营养专业委员会委员。主持国家自然科学基金、海南省重点研发、海南省国际科技合作研发等科研项目 10 余项。研究方向为水产品保活保鲜与精深加工、水产品加工副产物综合利用。获海南省科技进步二等奖 2 项，以第一作者/通讯作者在 Carbohydrate Polymers、Trends in Food Science & Technology、Food Chemistry 等期刊上发表论文 20 余篇，入选 ESI 高被引论文 1 篇。联系电话：13719193709；邮箱：heyanfu819@163.com。

冻融对凡纳滨对虾冷藏黑变及血淋巴酚氧化酶系统的影响

何琛，林端权*

集美大学海洋食品与生物工程学院，福建厦门，361021

摘要:探讨反复冻融对凡纳滨对虾黑变及血淋巴酚氧化系统的影响，设置未冻融组（control）、冻融 1 次组（FT1）和冻融 2 次组（FT2），分析 4°C 冷藏期间黑变、血细胞状态及酚氧化酶（PO）和丝氨酸蛋白酶（SP）活性的变化，并结合多巴活性染色、LC-MS/MS 及血浆-血细胞重组与胰蛋白酶激活实验进行分析。结果表明，冻融促进黑变并破坏血细胞完整性；FT1 组 PO 活性较早升高，FT2 组后期维持较高水平，SP 活性总体呈升高趋势。活性区域中鉴定到酚氧化酶原 3（proPO3）及多种免疫和凝固相关蛋白。血浆中还存在可被进一步激活的酚氧化相关组分。综上所述，反复冻融可能通过损伤血细胞及改变酚氧化酶原/酚氧化酶（proPO/PO）的活化状态而促进凡纳滨对虾的黑变。

关键词：凡纳滨对虾；冻融；黑变；酚氧化酶；血细胞

通讯作者：林端权，男，工学博士，副教授，主要研究方向为水产品加工贮藏。联系方式：15606066383，dq.lin@jmu.edu.cn

冻融过程中肌球蛋白质基脂肪球超分子动态组装机制

王禹骁，翁武银，石林凡，赵源，任中阳*

集美大学海洋食品与生物工程学院，福建省厦门市集美区，361021

摘要：通过研究冻融过程中肌球蛋白空间构象与价键特征的演变，解析肌球蛋白—虾油组分相互作用对脂肪球超分子组装的影响机制。以 2%南美白对虾肌球蛋白与南极磷虾油制备的脂肪球体系为对象，分析其经 1、3、5 和 7 次冻融循环后的变化。经 7 次冻融后，脂肪球平均粒径增大 73.55%，絮凝指数增加；Zeta 电位绝对值显著降低。傅里叶红外光谱显示，界面蛋白质空间构象改变，α-螺旋结构减少。低场核磁共振表明，脂肪球中结合水向自由水转化。多重光散射分析显示，背散射光强度值和稳定性指数斜率逐步增大，表明脂肪球稳定性下降。冻融胁迫下，肌球蛋白二级结构变化导致分子展开、疏水基团暴露，静电斥力减弱，脂肪球聚集、粒径增大，并导致水分迁移和体系稳定性下降。

关键词：肌球蛋白；脂肪球；冻融循环；水分迁移

资助项目：国家自然科学基金项目（32572649）和福建省自然科学基金项目（2025J01864）资助。

通讯作者：任中阳，男，博士，副教授，水产品加工与综合利用，电话：15622273558，E-mail：rzy0529@jmu.edu.cn

冻融模式对预制烤鱼复热前后杂环胺与晚期糖基化终末产物生成的影响

许哲源[1]，许艳顺[1]，姜启兴[1]，余达威[1,*]

[1]江南大学食品学院、食品科学与资源挖掘全国重点实验室，江苏 无锡，214122

摘要：【目的】探究冻融模式对预制烤鱼复热前后杂环胺（HAs）与晚期糖基化终末产物（AGEs）生成的影响。【方法】将 250 ℃烤制至中心 50、80 ℃的烤鱼速冻于-20 ℃，在 96 h 流通期内设置 0、1、3 次完全冻融及不完全冻融（融化终点-4 ℃），复热后测定 HAs、AGEs、氧化与前体物指标，结合偏最小二乘回归分析。【结果】HAs 以蛋白结合态为主（占 98%以上），80 ℃组结合态 HAs 随冻融次数增至 719.31 ng/g；50 ℃组复热新增 AGEs 随冻融次数增加 86%，80 ℃组仅增 15%。AGEs 格局在冻融阶段基本定型（Q^2 0.928→0.953），HAs 主要在复热阶段生成（Q^2 0.748→0.85），总巯基、葡萄糖与肌酸为关键驱动因子；不完全冻融可同步降低两类危害物。【结论】AGEs 管控重心在冻融阶段、HAs 在复热环节，控制冻融次数与融化深度可有效减害。

关键词：预制烤鱼；冻融；杂环胺；晚期糖基化终末产物；复热

资助项目：国家重点研发计划项目（项目编号：2023YFF1104904）、国家大宗淡水鱼体系（项目编号：CARS-45-28）

通讯作者：余达威，男，博士，副研究员，主要从事食品智能包装与保鲜、水生资源深加工等方面研究。联系方式：18206180106，邮箱 yudawei90@126.com。

Effects of Freeze-Thaw Patterns on the Formation of Heterocyclic Amines and Advanced Glycation End-Products in Prefabricated Roasted Fish Before and After Reheating

Xu Zheyuan[1], Xu Yanshun[1], Jiang Qixing[1], Yu Dawei[1,*]

[1]State Key Laboratory of Food Science and Resource Utilization, School of Food Science, Jiangnan University, Wuxi, Jiangsu, 214122, China

Abstract: [Objective] This study aimed to clarify the effects of different freeze-thaw (FT) patterns on the formation of heterocyclic amines (HAs) and advanced glycation end-products (AGEs) in prefabricated roasted fish before and after reheating. [Methods] Fish roasted at 250 °C to core temperatures of 50 or 80 °C were rapidly frozen at -20 °C and, during a 96-h circulation period, subjected to 0, 1, or 3 complete FT cycles (thawed at 4 °C) or incomplete FT (thawing endpoint -4 °C). After reheating, HAs, AGEs, oxidation markers and precursors were determined, and partial least squares regression (PLSR) was applied. [Results] HAs were predominantly protein-bound (>98%); bound HAs in the 80 °C group increased to 719.31 ng/g with FT cycles. The reheating-induced AGEs increased by 86% with FT cycles in the 50 °C group but by only 15% in the 80 °C group. PLSR showed that the AGE profile was largely established during the FT stage (Q^2, 0.928 to 0.953), whereas HAs were mainly formed during reheating (Q^2, 0.748 to 0.85); total sulfhydryl, glucose and creatine were key drivers. Incomplete FT reduced both hazards. [Conclusion] AGEs should be controlled mainly during the FT stage and HAs during reheating; limiting FT cycles and thawing depth effectively mitigates these hazards.

Key words: prefabricated roasted fish; freeze-thaw; heterocyclic amines; advanced glycation end-products; reheating

短期冻藏扇贝闭壳肌凝胶波动特性的外源调控及作用机制

王萍萍[1]，常珂欣[1]，李萌[*]

（1. 大连海洋大学 食品科学与工程学院，辽宁 大连 116000; 2. 辽宁省海洋健康食品工程中心，辽宁 大连 116000; 3. 大连市特色海洋功效成分开发与高值化利用重点实验室，辽宁 大连 116000）

摘要：为改善短期冻藏扇贝闭壳肌凝胶性能的波动性变化，以冻藏0、1、7和14 d的海湾扇贝闭壳肌为原料，添加羟丙基木薯淀粉（HPTS）、TG酶及其复配物制备贝糜凝胶，并以未添加组为对照。结果表明，对照组凝胶强度、质构和持水力随冻藏时间延长呈波动变化；HPTS和TG酶单独或协同添加均显著改善凝胶性能（$P<0.05$），其中复配组第14 d凝胶强度达300.32 g·cm，持水力达94.04%，且全程较稳定。添加处理可减缓贝糜肌原纤维蛋白小片化指数及可溶性肽的增加，但巯基和表面疏水性仍存在波动。复配处理显著提高体外消化率（$P<0.05$），但其优势随冻藏时间延长而下降。综上，HPTS/TG酶可通过物理填充及调控蛋白聚集改善凝胶稳定性，但随着冻藏过程中蛋白结构持续变化，其改善效果逐渐受到限制。

关键词：海湾扇贝;短期冷冻储存;凝胶特性;羟丙基木薯淀粉;转谷氨酰胺酶

Exogenous Regulation and Mechanisms of Action on the Fluctuating Characteristics of Frozen Scallop Adductor Muscles

Wang Pingping[1]，Chang Kexin[1]，Li Meng[*]

1.College of Food Science and Engineering, Dalian Ocean University, Dalian 116000, Liaoning, China; 2.Liaoning Provincial Engineering Research Center for Marine Health Foods, Dalian 116000, Liaoning, China; 3.Dalian Key Laboratory for Development and High-Value Utilization of Characteristic Marine Functional Ingredients, Dalian 116000, Liaoning, China）

Abstract :To ameliorate the fluctuations in gel performance of short-term frozen scallop adductor muscle, non-rinsed surimi gels were prepared from *Argopecten irradians* adductor muscles frozen for 0, 1, 7, and 14 days with hydroxypropyl tapioca starch (HPTS), transglutaminase (TGase), or their combination, while an additive-free group served as the control. The results showed that the gel strength, texture properties, and water-holding capacity (WHC) of the control group fluctuated

with prolonged frozen storage. The addition of HPTS and TGase, either individually or in combination, significantly improved gel performance ($P<0.05$). In particular, the combination group achieved a gel strength of 300.32 g·cm and a WHC of 94.04% on day 14, while maintaining relatively stable WHC throughout the storage period. The addition treatments retarded the increases in the myofibrillar fragmentation index and soluble peptide content, although the sulfhydryl content and surface hydrophobicity still exhibited fluctuations. Moreover, the combined addition significantly enhanced the in vitro digestibility of the gels ($P<0.05$), although this advantage gradually decreased with prolonged frozen storage. Overall, the combination of HPTS and TGase improved the gel stability of short-term frozen scallop adductor muscle through physical filling and regulation of protein aggregation; however, its beneficial effects were gradually constrained by the continuous structural changes in proteins during frozen storage.

Key words:*Argopecten irradians*; frozen storage; gelling properties; hydroxypropyl tapioca starch; transglutaminase

多层界面构建对虾青素乳液稳定性及抗氧化活性的影响

周宁[1]，刘荔[2]，夏光华[*]

（单位：海南大学食品科学与工程学院，地区：海南 海口，邮编：570228）

摘要：本研究以酪蛋白酸钠、果胶和壳聚糖为界面材料，采用逐层静电沉积法构建虾青素多层乳液，探讨界面结构对乳液稳定性、虾青素保留率及生物可及性的影响。结果表明，相较于单层乳液，多层乳液在 pH 和盐浓度变化下的粒径变化较小，其中三层乳液在储藏及冻融处理后表现出最佳的物理稳定性。经热处理、冻融、储藏和紫外照射后，多层乳液的虾青素保留率显著提高。体外消化结果显示，多层乳液能延缓脂质消化并提高虾青素的生物可及性。此外，多层界面构建有效增强了乳液的体外自由基清除能力，三层乳液表现出最佳的抗氧化活性。综上，多层界面构建能显著改善虾青素乳液的稳定性、抗氧化及递送性能。

关键词： 虾青素；多层乳液；稳定性；抗氧化活性；生物可及性

Effects of Multilayer Interface Construction on the Stability and Antioxidant Activity of Astaxanthin Emulsions

Zhou Ning[1], Liu Li[2], Xia Guanghua[*]

1.School of Food Science and Engineering, Hainan University, Haikou 570228, Hainan, China

Abstract: Astaxanthin multilayer emulsions were prepared using sodium caseinate, pectin, and chitosan through layer-by-layer electrostatic deposition to investigate the effects of interfacial structure on emulsion stability, retention, and bioaccessibility. Compared with single-layer emulsions, multilayer emulsions exhibited smaller droplet size variations under varying pH and salt concentrations, with triple-layer emulsions showing the optimal physical stability after storage and freeze–thaw treatments. Astaxanthin retention increased significantly in multilayer emulsions following heating, freeze–thaw cycles, storage, and UV irradiation. In vitro digestion results indicated that multilayer emulsions delayed lipid digestion and improved astaxanthin

bioaccessibility. Furthermore, multilayer interface construction effectively enhanced the in vitro free radical scavenging capacity of the emulsions, with the triple-layer emulsion exhibiting the highest antioxidant activity. Overall, multilayer interface construction significantly improved the stability, antioxidant properties, and delivery performance of astaxanthin emulsions.

Key words: Astaxanthin; Multilayer emulsions; Stability; Antioxidant activity; Bioaccessibility

二十碳五烯酸乙酯逐层封装微胶囊的制备及表征

竺桢孚[1,2]，张小菁[1,3]，吴靖娜[4]，陈晓婷[1]，陈婷茹[1]，潘南[1,*]，林河通[2]，刘智禹[1,*]

1. 福建省水产研究所，国家海水鱼类加工技术研发分中心 福建厦门，361013；2. 福建农林大学食品科学学院，福建福州，350007；3. 福建师范大学生命科学学院，福建福州，350117; 4. 厦门医学院，福建厦门，361023

摘要：二十碳五烯酸乙酯（EPA）存在易氧化、稳定性差等问题，而传统单层微胶囊壁材保护不足，难以有效阻碍氧气与消化酶作用。研究提出逐层包封微囊化策略，以 EPA（纯度≥90%）为芯材，羟乙基-*β*-环糊精（CD）、DSPC（PL）、海藻酸钠（SA）为封装壁材，Ca^{2+}为交联剂，采用“高压均质-三流体同轴喷雾干燥-海藻酸盐原位交联微囊化（CAM）”技术，构建微胶囊 EPA@CD/PL-CAM，并通过单因素试验优化关键制备工艺，开展结构表征及体外模拟胃肠消化评价。结果表明，最优条件下微胶囊包埋率 92%、载药量 40.53%，结块率 3.2%；SEM 显示逐层封装可有效抑制微胶囊表面破裂及孔洞现象的发生；ATR-FTIR 及 XPS 证实 Ca^{2+}与 SA 成功形成交联蛋壳结构，有效包封 EPA；TG 结果证实逐层封装显著提升 EPA 的热稳定性；体外模拟消化显示微胶囊在胃消化阶段保持稳定、几乎无释放，而在肠道消化阶段缓慢释放，缓释效果显著。因此，逐层封装策略有效解决了传统单层微胶囊保护不足的问题，显著提升了 EPA 的稳定性。研究为 EPA 的稳态化及控制释放提供了有效路径，对提高其在加工、贮藏和消化过程中的稳定性具有重要意义。

关键词：二十碳五烯酸乙酯；微胶囊；喷雾干燥；原位交联；海藻酸钠；模拟胃肠消化

资助项目：厦门市自然科学基金项目(3502Z202573301)；福建省海洋与渔业综合服务专项资金项目(FYZF-KTYJ-2025-18)

通讯作者：
潘南，博士，助理研究员，水产品加工与综合利用，pannancn@163.com
刘智禹，博士，教授级高级工程师，水产品加工与综合利用研究，13906008638@163.com

凡纳滨对虾空气暴露下滋味品质调控：从 AMPK 代谢重塑到 HSF1 上游调控

管维良[1,*]，崔馨予[1]

1.广西大学 轻工与食品工程学院，广西壮族自治区南宁市，50004

摘要：目的：空气暴露是凡纳滨对虾无水活体运输过程中的主要胁迫因素，可引起能量代谢紊乱并进一步影响肌肉滋味品质。本研究围绕空气暴露条件下对虾代谢调控途径及滋味形成机制，从 AMPK 介导的代谢重塑及其上游 HSF1 调控两个层面开展研究，旨在阐明空气暴露下能量代谢重塑与滋味品质变化的内在联系及其上游调控机制。

方法：前期研究系统分析空气暴露过程中 Ca^{2+}信号、AMP/ATP 比值、AMPK 通路、糖酵解、ATP 降解及氨基酸代谢的时序变化，并结合电子舌和等效鲜味浓度评价肌肉滋味特征。在此基础上，采用短时冷激诱导 HSF1 表达，并通过 HSF1 沉默和外源重组 HSF1 补充调控 HSF1 水平，分析 AMPK 磷酸化、糖酵解相关指标、TCA 循环相关代谢物、ATP 降解产物及游离氨基酸组成的变化；进一步采用双向 Co-IP 分析 HSF1 与 AMPKα 的关联，并利用 AlphaFold 3 预测其潜在相互作用界面。

结果：空气暴露导致细胞质 Ca^{2+}和 AMP/ATP 比值升高，并伴随 AMPK 相关指标在转录和蛋白水平上调，且肌肉 AMPK 响应早于肝胰腺。AMPK 表达在空气暴露 8 h 达到较高水平，并伴随糖酵解增强、ATP 降解和蛋白质分解，促进 IMP 及游离氨基酸等滋味物质积累。电子舌和等效鲜味浓度分析表明，空气暴露 4 h 时肌肉呈现较优的滋味特征，表现为鲜味和甜味增强、苦味降低。进一步研究发现，短时冷激可诱导肌肉 HSF1 表达，HSF1 mRNA 和蛋白分别在恢复 0.5 h 和 2 h 达到峰值。HSF1 沉默增强 AMPK 磷酸化，并伴随糖原和葡萄糖消耗增加、乳酸积累、TCA 循环相关代谢改变及 ATP 降解加快；相反，外源 HSF1 补充限制 AMPK 过度活化，减缓能量底物消耗和 ATP 及其关联产物（IMP 和 GMP）降解，提高等效鲜味浓度（EUC），并维持较高的鲜甜味的游离氨基酸组成。双向 Co-IP 表明 HSF1 与 AMPKα 存在关联，AlphaFold 3 进一步预测了潜在相互作用界面及候选作用位点。

结论：AMPK 是连接空气暴露应激、能量代谢重塑与肌肉滋味变化的重要调控节点。适度的 AMPK 介导的代谢重塑有利于鲜味物质形成，而持续或过度激活可能加速能量及滋味前体物质消耗；冷激诱导的 HSF1 可进一步限制过度 AMPK 活化，从而有助于维持代谢稳态和滋味相关物质。研究实现了从 AMPK 介导的代谢重塑向 HSF1 对 AMPK 的上游调控的机制延伸，为理解对虾胁迫适应与滋味品质形成之间的关系及优化无水活体运输品质调控提供了理论依据。[i]

关键词：凡纳滨对虾；空气暴露胁迫；HSF1；AMPK；滋味品质

*通讯作者：管维良（E-mail: wlguan@gxu.edu.cn），男，博士，副教授，主要从事水产品贮运保鲜相关研究。
基金项目：国家自然科学基金（32302154）；广西自然科学基金（2025GXNSFBA069013）。

风味组学与机器学习关联三文鱼加工副产物美拉德反应体系的挥发性物质谱与感官属性

葛新宇，洪惠*

中国农业大学食品科学与营养工程学院食品质量与安全北京实验室，北京, 100083

摘要：三文鱼加工副产物富含风味前体物质，但热加工过程中复杂的香气形成过程限制了其作为风味配料的应用。本研究考察了 pH、木糖浓度和温度对三文鱼加工副产物美拉德反应体系中挥发性物质谱及感官属性的影响。采用电子鼻、顶空固相微萃取结合气相色谱–质谱联用技术（HS-SPME-GC-MS）、气味活度值（OAV）、定量描述分析、多元统计分析及机器学习，对 18 组处理进行分析。HS-SPME-GC-MS 共检测到 917 个挥发性特征峰，并筛选出 68 种平均 OAV ≥ 1 的化合物作为候选香气活性物质。温度是驱动挥发性物质谱差异的主要因素，pH 和木糖浓度则进一步调节特定类别化合物的组成。不同处理组的烘烤香、鱼腥味、花香、甜香和清新感评分均存在显著差异。以 OAV 排名前 10 的化合物及工艺参数为输入变量构建的随机森林模型，其决定系数（R^2）为 0.63–0.93，均方根误差（RMSE）为 0.75–1.27。SHAP 分析识别了与感官属性变化相关的预测变量。

关键词：三文鱼加工副产物；美拉德反应；风味组学；机器学习；感官品质预测

资助项目： 国家重点研发计划（2024YFD2101201）；现代农业产业技术体系专项资金（CARS-45）。

通讯作者简介： 洪惠，男，博士，教授，主要从事水产品营养品质、贮藏保鲜与加工、动物蛋白资源高值化利用及生物活性肽研究。电话：010-62737385；E-mail：hhong@cau.edu.cn

Flavoromics and Machine Learning Link Volatile Profiles to Sensory Attributes in Salmon By-Product Maillard Reaction Systems

Xinyu Ge, Hui Hong*

Beijing Laboratory for Food Quality and Safety, College of Food Science and Nutritional Engineering, China Agricultural University, Beijing, 100083

Abstract :Salmon by-products are rich in flavor precursors, yet their use as flavor ingredients is limited by complex

aroma formation during thermal processing. This study examined how pH, xylose concentration, and temperature shaped volatile profiles and sensory attributes in salmon by-product Maillard reaction systems. Eighteen treatments were analyzed using electronic nose, HS-SPME-GC-MS, odor activity value (OAV), quantitative descriptive analysis, multivariate statistics, and machine learning. HS-SPME-GC-MS detected 917 volatile features, and 68 compounds with mean OAV ≥ 1 were screened as aroma-active candidates. Temperature was the main driver of volatile differentiation, while pH and xylose concentration further modulated selected compound groups. Sensory scores differed significantly among treatments for roasty, fishy, floral, sweet, and fresh attributes. Random Forest models based on the top 10 OAV-ranked compounds and process parameters achieved R^2 values of 0.63–0.93 and RMSE values of 0.75–1.27. SHAP analysis identified predictors associated with sensory variation.

Key words: Salmon by-products; Maillard reaction; flavoromics; machine learning; sensory quality prediction;

Funding: This work was supported by the National Key R&D Program of China (2024YFD2101201) and the Earmarked Fund for China Agriculture Research System (CARS-45).

Corresponding author: Hong Hui, male, Ph.D., Professor. His research focuses on the nutritional quality, storage, preservation, and processing of aquatic products, as well as the high-value utilization of animal protein resources and bioactive peptides. Tel.: +86-10-62737385; E-mail: hhong@cau.edu.cn.

复合保水剂浸泡预处理优化及其对蒸制鱿鱼足嫩化效果的影响

王雅丽，任中阳，石林凡，赵　源，翁武银*

集美大学海洋食品与生物工程学院，福建厦门 361021

摘要：为提升蒸制鱿鱼足的嫩度，本研究通过单因素与正交试验优化了复合保水剂配方，并探究其对鱿鱼足保水性、质构特性、微观结构、蛋白质特性及感官品质的影响。结果表明，各因素对品质影响的主次顺序为碳酸钠 > 多聚磷酸盐 > 柠檬酸钠，最优配方为多聚磷酸盐 2.0%、柠檬酸钠 2.0%、碳酸钠 3.0%。经最优配方处理的实验组鱿鱼足蒸煮损失率显著降至 18.25%，而水分含量、持水性和不易流动水比例分别上升至 81.33 %、94.60%和 81.47%。质构分析表明，实验组硬度和咀嚼性分别为 381.01 g 和 326.86 g，均显著低于对照组；且感官评分在色泽、风味、外观及口感方面均优于对照组。微观结构观察结果显示，复合保水剂处理使鱿鱼足肌纤维膨胀疏松、肌纤维间隙增大。傅里叶变换红外光谱和十二烷基硫酸钠-聚丙烯酰胺凝胶电泳的结果显示，复合保水剂处理会导致蛋白质二级结构中 α-螺旋和 β-折叠含量降低，而 β-转角含量升高，同时引起肌球蛋白重链降解。因此，利用优化的复合保水剂预处理可协同提升蒸制鱿鱼足的保水性能和嫩化效果，为高品质鱿鱼足制品的生产提供理论依据与技术支撑。

关键词：鱿鱼足；复合保水剂；保水性能；嫩化效果；结构

通信作者*：翁武银（1974-），男，博士，教授，研究方向：食品加工及其副产物综合利用，E-mail：wwymail@jmu.edu.cn。

资助项目：福州市科技重大项目（2024-ZD-023）

复合生物保鲜剂对即食蟹肉产品保鲜影响及货架期预测

吴征[1,2]，蔡志成[1,2]，李杰[1,2]，林琳[1,2,*]，陆剑锋[1,2,*]

1. 合肥工业大学食品与生物工程学院，安徽合肥，230601；2. 安徽省农产品现代加工重点实验室，安徽合肥，230601

摘要:【目的】为延长即食蟹肉产品的货架期，对其复合生物保鲜剂配方进行复配优化。【方法】以 ε-聚赖氨酸（ε-poly-L-lysine，ε-PL）、溶菌酶和乳酸链球菌素为研究对象，确定最佳复配比例。基于 Arrhenius 模型，将样品分别于 12 ℃、18 ℃及 25 ℃条件下进行贮藏试验，拟合品质劣变速率常数与温度的相关性，并在 4 ℃贮藏条件下进行品质验证实验。【结果】ε-聚赖氨酸、溶菌酶与乳酸链球菌素的最佳复配比例为：0.2、0.4、0.3 g/kg，经优化处理的即食蟹肉产品在 4 ℃冷藏条件下的理论货架期可达 50.6 d，与实际货架期相比误差仅为 9.6 %。【结论】复合生物保鲜剂处理可有效延缓即食蟹肉产品在 4 ℃贮藏条件下的品质劣变，结合阿伦尼乌斯模型可有效预测其在 4 ℃贮藏条件下的货架期。

关键词：即食蟹肉；复合生物保鲜剂；货架期预测；动力学模型

资助项目：安徽现代农业产业技术体系项目（AARS-08）；财政部和农业农村部: 国家现代农业产业技术体系项目（CARS-47）；国家重点研发计划（2023YFD2401500）
通讯作者：陆剑锋，男，博士，教授，研究方向为水产品加工及综合利用，E-mail: lujf@sibs.ac.cn

复合诱变选育高产脱腥酶菌株及海带脱腥效果研究

颜婷美[1,2,3]，王致君[1,2,3]，于瑞[1,2,3]，刘舒[1,2,3]，张晗[1,2,3]，马艺超[1,2,3]，任丹丹[1,2,3]，汪秋宽[1,2,3]，何云海[1,2,3*]

1.大连海洋大学 食品科学与工程学院，辽宁 大连 116023；2.国家海藻加工技术研发分中心，辽宁 大连 116023；3.辽宁省水产品加工及综合利用重点实验室，辽宁 大连 116023

摘要：海带作为我国最重要的海洋经济藻类，其固有特征腥味制约其精深加工的发展，而传统脱腥技术存在明显短板，因此本研究采用复合诱变技术改造商业菌株，以期获得高产脱腥酶突变菌株，为海带绿色高值化加工提供理论与技术支撑。本研究以商业菌株为出发菌株进行复合诱变处理，以脱腥酶活力为筛选指标，定向选育性能优良突变株，进一步优化培养条件，对目标突变株进行发酵制备粗酶液，评价粗酶对海带的脱腥效果。

研究结果表明，经复合诱变及培养条件优化后，突变菌株产脱腥酶的酶活力显著提升，较原始菌株提升 20 倍。采用该突变株发酵粗酶处理海带样品，样品感官腥味明显下降。因此复合诱变是选育高产脱腥酶菌株的有效途径，该突变菌株所产粗酶具备较强的海带脱腥能力，在海带绿色脱腥加工中具备良好应用潜力。

关键词：复合诱变；生物脱腥；海带；菌株产酶；脱腥酶

Screening of a High-Yield Deodorization Enzyme Strain by Combined Mutagenesis and Its Deodorization Effect on Kelp

Tingmei Yan[1,2,3],Zhijun Wang [1,2,3],Rui Yu[1,2,3],Shu Liu[1,2,3], Han Zhang[1,2,3], Yichao Ma[1,2,3],Dandan Ren[1,2,3],Qiukuan Wang[1,2,3],Yunhai He[1,2,3]*

1. College of Food Science and Engineering；2. National R&D Branch Center For Seaweed Processing；3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian Ocean University , Dalian 116023, China

Abstract: Kelp is the most important marine economic alga in China, but its inherent characteristic fishy odor severely limits the development of its deep processing, while conventional deodorization methods have obvious shortcomings. Therefore, in this study, combined mutagenesis was used to modify a commercial strain in order to obtain a mutant strain with high deodorization enzyme production, providing theoretical and technical support for the green and high-value processing of kelp. The commercial strain was used as the starting strain and subjected to combined mutagenesis treatment. With deodorization enzyme activity as the screening indicator, a superior mutant was directionally selected, after which culture conditions were further optimized. The target mutant was fermented to prepare a crude enzyme solution, and its deodorization effect on kelp was evaluated. The results showed that after combined mutagenesis and culture condition optimization, the deodorization enzyme activity of the mutant was significantly improved, reaching a 20-fold increase compared with the original strain. Treatment of kelp samples with the crude enzyme fermented by this mutant markedly reduced the sensory fishy odor. In conclusion, combined mutagenesis is an effective approach for breeding high-yield deodorization enzyme strains. The crude enzyme produced by the mutant exhibits strong kelp deodorization capability and shows promising application potential in green kelp deodorization processing.

Keywords: combined mutagenesis; biological deodorization; kelp; strain enzyme production; deodorization enzyme

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）

通讯作者：何云海，男，教授，藻类加工及资源利用，13840847973，hyh@dlou.edu.cn

负载河鲀鱼皮蛋白水解物乳液的制备及其修复受损头发作用研究

李博岩 [1]，李雨桐 [1]，黎俊杰 [1]，许长华 [1, 2*]

1.上海海洋大学 食品学院，上海 201306； 2. 国家淡水水产品加工技术研发分中心(上海) ，上海 201306 ；

摘要：化学漂染易造成毛鳞片破损、角蛋白降解和脂质屏障破坏，开发绿色海洋源护发材料具有重要意义。本研究以暗纹东方鲀鱼皮蛋白水解物（TSPH）为活性组分，复配鱼明胶和山茶油制备 TSPH/FG-CMO 乳液，并评价其对漂、染受损发丝的修复作用。经优化，乳液适宜制备条件为均质 120 s、pH 7、油水比 5:5。连续处理 7 d 后，6-10 mg/mL 乳液可改善发丝柔顺性、抗静电、抗毛躁和拉伸性能，促进毛鳞片闭合并减少碎屑及氧化损伤孔洞，整体效果优于商业小麦蛋白护发素。红外透射成像、二维相关红外光谱及差示扫描量热结果表明，乳液中的肽/蛋白可向皮质层渗透，改善蛋白质分布，促进角蛋白 α-螺旋构象、肽键和二硫键重新排列，增强 α-角蛋白稳定性，其中 6 mg/mL 组修复效果最佳。该乳液通过表面成膜与内部渗透协同修复受损发丝，为河鲀加工副产物高值化利用及天然护发产品开发提供依据。

关键词：暗纹东方鲀；鱼皮蛋白水解物；乳液；受损发丝；修复

项目资助：国家自然科学基金面上项目（32371321）；绿色健康食品关键技术研发专项（D-8006-26-0194）

通讯作者：许长华，男，博士，教授，食品快检研究，118516275495，chxu@shou.edu.cn

Preparation and Hair Restorative Activity of Takifugu obscurus Skin Protein Hydrolysate-Loaded Emulsion

Boyan Li [1], YutongLi[1], Junjie Li[1], Changhua Xu[1, 2*]

1.College of Food Science & Technology, Shanghai Ocean University, Shanghai 201306, PR China; 2. National R&D Branch Center for Freshwater Aquatic Products Processing Technology (Shanghai), Shanghai 201306, China;

Abstract： Chemical bleaching and dyeing can disrupt hair cuticles, degrade keratin, and damage the lipid barrier, highlighting the need for green marine-derived hair-care materials. In this study, *Takifugu obscurus* skin protein hydrolysate (TSPH) was incorporated with fish gelatin and camellia oil to prepare a TSPH/FG-CMO emulsion, and its repairing effects on bleached and dyed hair were evaluated. Suitable preparation conditions were identified as 120 s homogenization, pH 7, and an oil-to-water ratio of 5:5. After continuous treatment for 7 days, emulsions containing 6-10 mg/mL TSPH improved hair smoothness, antistatic properties, frizz resistance, and tensile performance, promoted cuticle closure, and reduced surface debris and oxidative-damage cavities; the overall performance was superior to that of a commercial wheat-protein conditioner. Infrared transmission imaging, two-dimensional correlation infrared spectroscopy, and differential scanning calorimetry indicated that peptides/proteins in the emulsion could penetrate into the cortex, improve protein distribution, promote rearrangement of keratin α-helical conformations, peptide bonds, and disulfide bonds, and enhance α-keratin stability. The 6 mg/mL formulation showed the best overall repair effect. These findings suggest that the TSPH/FG-CMO emulsion repairs damaged hair through synergistic surface film formation and internal penetration, providing a basis for the high-value utilization of pufferfish processing by-products and the development of natural hair-care products.

Keywords: Takifugu obscurus; skin protein hydrolysate; emulsion; damaged hair; hair repair

负载绿原酸的纳米淀粉/壳聚糖复合水凝胶的制备及其对凡纳滨对虾黑变的抑制作用

黄丽璇 [1]，夏文 [1]，刘书成*[1]

1、广东海洋大学食品科学与技术学院、广东省水产品加工与安全重点实验室、广东省海洋生物制品工程实验室、广东省海产品工程技术研究中心、广东省预制海产品加工与质量控制工程技术研究中心，中国湛江，524088

摘要：凡纳滨对虾在贮藏运输中易酶促黑变，造成品质劣变与经济损失，绿色保鲜材料需求迫切。壳聚糖生物相容、可降解，但纯壳聚糖凝胶的机械性能与抗氧化能力不足，难以有效抑制黑变。研究以超微粉碎木薯淀粉为原料，超声制备负载绿原酸（CA）的纳米淀粉作为填料，与壳聚糖复合制备水凝胶涂膜。结果表明，超声 12 min 制备的 CA/US-CWCS$_{12}$ 性能最优，包埋率 93.78%、络合率 75.00%，粒径 68.93 nm，PDI 为 0.395，DPPH、ABTS 自由基清除率分别为 78.30%、86.62%；TEM 中颗粒呈类圆形、分散均匀，无游离 CA 晶体；FTIR 与 XRD 证实 CA 以氢键结合于淀粉无定形区呈无定形态。其与壳聚糖 1:1 复配时，凝胶储能模量最高、损耗因子最低，呈弹性主导三维网络。4℃贮藏 10 d，复合组抑制黑变效果优于游离 CA 组及纯壳聚糖组，为壳聚糖基水凝胶性能优化及天然淀粉载体的水产保鲜应用提供了依据。

关键词：纳米淀粉；绿原酸；壳聚糖水凝胶；凡纳滨对虾；黑变抑制

通讯作者：刘书成（1979—），博士，教授，研究方向为海洋食品保鲜与加工，

E-mail： Lsc771017@163.com

资助项目：广东省重点研发计划项目（2025B1111140001）及广东海洋大学科研启动资金（项目编号：060302042309）

Preparation of Chlorogenic Acid-Loaded Nanostarch/Chitosan Composite Hydrogels and Their Inhibitory Effect on Melanosis in Pacific White Shrimp (Litopenaeus vannamei)

Lixuan Huang[1], Wen Xia[1]，Shucheng Liu[*1]

1. College of Food Science and Technology, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Guangdong Province Engineering Laboratory for Marine Biological Products, Guangdong Provincial Engineering Technology Research Center of Seafood, Guangdong Provincial Engineering Technology Research Center of Prefabricated Seafood Processing and Quality Control, Guangdong Ocean University, Zhanjiang, 524088，China;

Abstract :Litopenaeus vannamei is susceptible to melanosis during storage and transportation, causing quality deterioration and economic losses. Neat chitosan hydrogels, despite excellent biocompatibility and biodegradability, possess poor mechanical properties and insufficient antioxidant capacity, limiting their anti-melanosis efficacy. Chlorogenic acid (CA)-loaded nano-starch was prepared from micronized cassava starch via ultrasonication and incorporated as a functional filler into a chitosan-based hydrogel coating. The sample obtained at 12 min of ultrasonication exhibited the optimal physicochemical performance: encapsulation efficiency 93.78%, complexation rate 75.00%, average particle size 68.93 nm, and PDI 0.395, with DPPH and ABTS radical scavenging activities of 78.30% and 86.62%, respectively. TEM verified the uniform dispersion of quasi-spherical particles without free CA crystals. FTIR and XRD analyses confirmed that CA was immobilized via hydrogen bonding within the amorphous regions of starch in an amorphous state. Blending the composite particles with chitosan at a 1:1 mass ratio yielded an elasticity-dominated three-dimensional hydrogel network with the maximum storage modulus (G′) and the minimum loss tangent (tan δ). The composite coating exhibited stronger melanosis inhibition than that of the free CA and neat chitosan groups after 10-day storage at 4℃. These findings provide a theoretical basis for the performance optimization of chitosan-based hydrogels and the application of natural starch carriers in aquatic product preservation.

Key words: Nano starch; chlorogenic acid; chitosan hydrogel; Litopenaeus vannamei; melanin inhibition

Corresponding Author: Shucheng Liu (1979 -), Doctor, Professor, Research Focus: Preservation and Processing of Marine Food Products E-mail： Lsc771017@163.com

Funding Project: Guangdong Key R&D Program Project (2025B1111140001) and the scientific research start-up funds of Guangdong Ocean University (grant number 060302042309).

钙离子-阿魏酸稳态化花色苷智能膜构建及其对水产品储运品质衰变的预测应用

凌歆，黄佳茵*

集美大学 海洋食品与生物工程学院，福建 厦门，361021

摘要：本研究以聚乙烯醇（PVA）和羧甲基纤维素钠（CMC-Na）为复合膜基材，引入 Ca^{2+}、阿魏酸与黑加仑花色苷构建智能包装体系，探究 Ca^{2+}对花色苷稳定性及膜性能的调控机制，并建立膜颜色与明虾品质的关联。结果表明，Ca^{2+}可改善体系呈色稳定性、pH 响应性及膜机械与疏水性能，0.24 g/100 mL Ca^{2+}颜色响应最佳，0.36 g/100 mL Ca^{2+}显著提升稳定性、氨响应及抗氧化活性。该膜应用于明虾储藏可延缓 TVB-N 和 TVC 升高，膜颜色与鲜度指标显著相关，实现品质可视化监测与早期预警。研究为天然活性色素智能包装开发及食品储运品质衰变预测提供了理论依据与技术参考。

关键词：花色苷；钙离子；稳态化；智能包装膜；鲜度可视化

资助项目：国家重点研发计划重点专项项目 2024YFD2401900、福建省自然科学基金面上项目 2025J01339

通讯作者介绍：黄佳茵，女，工学博士，副教授。研究方向包括水产品贮藏与保鲜、多功能食品包装、水产品资源高值化利用等。联系方式：18559595533，huangjiayin45@126.com

Construction of a Calcium Ion-Ferulic Acid Stabilized Anthocyanin Intelligent Packaging Film for Predicting Quality Deterioration of Aquatic Products during Storage and Transportation

Xin Ling, Jia-yin Huang*

College of Ocean Food and Biological Engineering, Jimei University,Xiamen, 361021,Fujian

Abstract: In this study, a smart packaging system was constructed using polyvinyl alcohol (PVA) and sodium carboxymethyl cellulose (CMC-Na) as composite film substrates, incorporated with Ca^{2+}, ferulic acid, and blackcurrant anthocyanins. The regulatory mechanism of Ca^{2+} on anthocyanin stability and film properties was

investigated, and the correlation between film color and shrimp quality was established. The results showed that Ca^{2+} improved the color stability, pH responsiveness, and mechanical and hydrophobic properties of the system. The 0.24 g/100 mL Ca^{2+} system exhibited the optimal color response, while 0.36 g/100 mL Ca^{2+} significantly enhanced film stability, ammonia responsiveness, and antioxidant activity. When applied to shrimp storage, the film effectively delayed the increases in TVB-N and TVC, and the film color was significantly correlated with freshness indicators, enabling visual monitoring and early warning of quality deterioration. This study provides a theoretical basis and technical reference for the development of smart packaging materials based on natural active pigments and for predicting quality deterioration during food storage and transportation.

Key words: Anthocyanins; calcium ions; stabilization; intelligent film; freshness visualization

干式发酵大黄鱼品质与风味演变及调控研究

汪瑞，任中阳，翁武银*

集美大学海洋食品与生物工程学院，福建省厦门市，361021

摘要： 为改善干式发酵大黄鱼的品质，本研究考察了发酵时间和发酵辅料对鱼肉品质与风味特征的影响。结果表明，在 15 ℃75%条件下发酵至 120 h 时，鱼肉水分、粗脂肪和 pH 值分别降至 67.58%、28.71%和 6.60，粗蛋白含量升至 19.49%。随着发酵时间延长，鱼肉硬度呈先下降后上升趋势，并在 48 h 时达到最低值（303.81 g）。电子舌分析显示，发酵 48 h 的鱼肉苦味、涩味和咸味响应值较低，总体接受度较高。在 48 h 发酵条件下，大米曲发酵的鱼肉挥发性盐基氮和硫代巴比妥酸反应物值最低，大米曲与鱼露复配发酵的鱼肉硬度为 356.82 g，显著低于其他样品，且电子鼻、电子舌分析结合感官评价表明，复配发酵的鱼肉感官品质优于其他样品。因此，大黄鱼干式发酵的适宜时间为 48 h，大米曲与鱼露复配使用更有利于改善鱼肉质构和风味。

关键词：大黄鱼；干式发酵；品质调控；米曲霉；发酵组分

通讯作者*：翁武银，男，博士，教授，研究方向：水产品加工与综合利用，E-mail: wwymail@jmu.edu.cn

资助项目：福建省科技计划项目（2025N5014）

甘油一酯的酶法制备及其对复合凝聚鱼油微胶囊理化特性的影响

周子倩[1]，林锦霞[1]，王鲲鹏[1]，韩宗元[123]，张俊[123]，王泽富[123]，刘书成[123]，夏秋瑜[123*]

广东海洋大学食品科学与技术学院，广东省水产品加工与安全重点实验室，广东省海洋生物制品工程实验室，广东省海鲜工程技术研究中心，湛江市 524088

摘要：以鱼油为原料，采用脂肪酶催化法制备甘油一酯，并在0.5%添加浓度下将其应用于鱼油乳液及复合凝聚微胶囊的制备，研究甘油一酯对复合凝聚鱼油微胶囊理化特性的影响。通过正交试验优化甘油一酯制备工艺，并结合薄层色谱、脂质组成分析、红外光谱和热分析等方法对产物进行表征。结果表明，优化条件下可获得较高含量的甘油一酯，纯化后产物纯度显著提高。添加甘油一酯后，鱼油乳液粒径显著减小，多分散性降低，ζ-电位和乳液稳定性得到改善。进一步制备的复合凝聚微胶囊表面油含量显著降低，包埋率明显提高，并表现出较好的热稳定性和氧化稳定性。体外消化结果表明，甘油一酯能够显著促进鱼油脂质的释放，其中纯化甘油一酯组的最终游离脂肪酸释放率显著高于鱼油对照组。综上，酶法制备的甘油一酯能够改善鱼油乳液的界面稳定性，增强复合凝聚微胶囊对鱼油的包埋和保护作用，并促进鱼油脂质在消化过程中的释放，为鱼油功能脂质递送体系的开发提供理论依据。

关键词：甘油一酯；酶法制备；复合凝聚；微胶囊；稳定性；体外消化

通讯作者：夏秋瑜（1978-），男，博士，教授，研究方向：海洋脂质研发与稳定递送，E-mail:qiuyuxia@163.com。

基金项目：国家自然科学基金（32172252）；广东省普通高校重点领域专项（2022ZDZX2028）

干燥方式对淡水鱼鱼鳔理化特性及品质的影响

王柳清[1,2]，李宇洁[1,2]，陈季旺*[1,2]

(1.武汉轻工大学食品科学与工程学院，湖北 武汉 430023；

2.农产品加工与转化湖北省重点实验室（武汉轻工大学），湖北 武汉 430023)

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）、冷冻干燥（FD）对鲴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，阐明不同干燥条件下鱼鳔风味物质的演变规律，综合表述干制对鲴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%，其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 1-辛烯-3-醇等鱼鳔的特征风味化合物，减少了脂质氧化产物。FD 为鲴鱼鱼鳔的高质量干制提供了新的思路，具有较强的应用前景。

关键词：鱼鳔；干燥特性；水分状态；胶原蛋白；风味物质

资助项目：湖北省重点研发计划（编号：2025BBB071），武汉轻工大学引进人才科研启动项目（编号：2025R2025)；武汉轻工大学 2025 年度校立科研项目（编号：2025Y21）

第一作者：王柳清，女，博士研究生，讲师，研究方向为水产品加工技术，18610657213，wlq1015@whpu.edu.cn

The effects of drying methods on the drying characteristics and quality attributes of freshwater fish swim bladder

Liuqing Wang[1,2], Yujie Li[1], Jiwang Chen[1,2]

(1. College of Food Science and Engineering, Wuhan Polytechnic University, Wuhan 430023, China; 2. Hubei Key Laboratory for Processing and Transformation of Agricultural Products (Wuhan Polytechnic University), Wuhan 430023, China)

Abstract: Fish swim bladders (FSBs) are rich in collagen and low in fat. As nourishing food with high nutritional value, FSBs are mostly sold as dried products. To explore high-quality and high-efficiency drying methods for FSBs, the effects of natural drying (ND), hot-air drying (HD) and freeze drying (FD) on physicochemical properties and quality of channel catfish FSBs were investigated. Physicochemical properties of dried FSBs were characterized by determining indicators including water state, rehydration ratio, texture and microstructure. GC-IMS and E-tongue were applied to illustrate the evolution of flavor compounds in FSBs under different drying conditions, and the quality regulation effect of drying on channel catfish FSBs was comprehensively described. The results showed that FD FSBs showed white surface with moisture content below 6%, and a loose and porous structure was formed. ND and HD FSBs showed yellow and translucent appearance with moisture content higher than 12%, and the collapse of their microstructure reduced the drying rate in the middle and late drying stages. Regression fitting of drying kinetic models verified that the Page model can describe the water variation during different drying processes. FD effectively preserves collagen in FSBs, with a content of 0.79 g/g, higher than those of the ND and HD groups. FD FSBs possess a high rehydration ratio and soft texture after rehydration, showing desirable edible quality. Compared with the ND and HD groups, FD FSBs contain higher concentrations of characteristic flavor compounds such as 1-octen-3-ol and fewer lipid oxidation products. FD provides a new strategy for high-quality drying for FSBs and exhibits great application potential.

Keywords: fish swim bladder; drying characteristics; water state; collagen; flavor compounds

高压脉冲电场对皱纹盘鲍冷藏期间品质的影响

陈丹丹[1]，林昭铭[2]，孙乐常*

集美大学海洋食品与生物工程学院，福建省厦门市，361021

摘要：本研究针对高压脉冲电场（PEF）在皱纹盘鲍冷藏保鲜领域研究不足的现状，探究PEF对皱纹盘鲍冷藏品质劣变及微生物群落演变的调控效应。采用0、10、20、30 kV电压的PEF处理鲍鱼，测定其在4 ℃冷藏过程中的理化品质、内源酶活性、肌肉结构、蛋白组分及微生物等指标的变化规律，考察不同电压处理对冷藏过程中鲍鱼品质的影响。结果表明，PEF可延缓pH下降与硬度降低，提升持水力，维持天然色泽与肌肉组织结构完整性；21 d时30 kV组菌落总数为8.53 Log CFU/g，低于对照组的8.84 Log CFU/g；20、30 kV组21 d挥发性盐基氮维持在20 mg/100g左右；同时显著抑制TBARS、蛋白质羰基及TCA可溶性肽积累；抑制水溶性与盐溶性蛋白降解。综上，PEF可有效延缓皱纹盘鲍在冷藏过程中的品质劣变，本研究的结果可为鲍鱼冷藏保鲜及PEF在水产品加工领域的应用提供理论指导。

关键词：高压脉冲电场；皱纹盘鲍；冷藏保鲜；品质劣变

作者简介：陈丹丹（2003-），女，硕士研究生，研究方向：食品资源开发与利用，E-mail：1848235219@qq.com。

*通信作者：孙乐常（1985-），男，博士，教授，研究方向：水产品加工与贮藏，E-mail：sunlechang@163.com。

Effects of Pulsed Electric Field on Quality of Haliotis discus hannai During Refrigerated Storage

CHEN Dandan[1], LIN Zhaoming[2], SUN Lechang*

College of Ocean Food and Biological Engineering, Jimei University, Xiamen 361021, Fujian, China

Abstract: Aiming at the insufficient research on pulsed electric field (PEF) applied to the refrigerated preservation of Haliotis discus hannai, this study explored the regulatory effect of PEF on the quality deterioration and microbial community evolution of Haliotis discus hannai during cold storage, in which abalones were treated with PEF at 0, 10, 20 and 30 kV, and the variation patterns of physicochemical quality, endogenous enzyme activity, muscle structure, protein components and microbial indexes during refrigeration at 4 ℃ were determined to investigate the effects of different voltage treatments on abalone quality during refrigeration; the results showed that PEF could delay the decline of pH and hardness, improve water holding capacity, and maintain natural color and the integrity of muscle tissue structure, on the 21st day of storage, the total viable count (TVC) of the 30 kV group was 8.53 Log CFU/g, lower than 8.84 Log CFU/g of the control group, and the total volatile basic nitrogen (TVB-N) of the 20 kV and 30 kV groups remained at around 20 mg/100 g, meanwhile, PEF significantly inhibited the accumulation of TBARS, protein carbonyl and TCA-soluble peptides, and suppressed the degradation of water-soluble and salt-soluble proteins; in conclusion, PEF can effectively delay the quality deterioration of Haliotis discus hannai during refrigeration, and the results of this study can provide theoretical guidance for the refrigerated preservation of abalone and the application of PEF in the field of aquatic product processing.

Key words: Pulsed electric field; Haliotis discus hannai; Refrigerated preservation; Quality deterioration

龟甲抗氧化肽的酶解制备及其体外抗氧化活性与理化特性

李欣飞[1]，李荣杏[1]，姜绍通[1,2]，陆剑锋[1,2,3]，林 琳[1,2,3*]

1. 合肥工业大学食品与生物工程学院，安徽合肥，230601；2. 安徽省农产品现代加工重点实验室，安徽合肥，230601；3. 农产品生物化工教育部工程研究中心，安徽合肥，230601

摘要：【目的】优化中华草龟龟甲活性肽的制备工艺，评价其体外抗氧化活性与理化特性。【方法】筛选蛋白酶，以水解度、肽含量、DPPH 自由基清除率、ABTS 阳离子自由基清除率及电子舌评价酶解效果；采用响应面法优化酶解工艺，经超滤分级后测定各组分抗氧化活性，并进行氨基酸组成及微观结构分析。【结果】碱性蛋白酶与胰蛋白酶同步酶解效果最佳，优化条件为 pH 7.5、50 ℃、4 h、加酶量 3000 U/g，水解度和肽含量分别为（18.59±0.42）%和（15.57±0.31）mg/mL。＜3 kDa 组分在 5 mg/mL 时抗氧化活性最强，活性肽富含甘氨酸和脯氨酸。【结论】优化工艺可制得抗氧化活性较好的龟甲肽，具有应用于功能性食品及龟甲资源高值化开发的潜力。

关键词：中华草龟；龟甲；活性肽；酶解；抗氧化

资助项目：国家重点研发计划（2023YFD2401500）；国家现代农业产业技术体系项目（CARS-47）；安徽现代农业产业技术体系项目（AARS-08）
通讯作者：林琳，女，博士，副教授，研究方向为水产品加工与贮藏，E-mail: linlin@hfut.edu.cn

过热蒸汽技术在水产加工中的应用

刘斌雄、林伦洲、李长城、方婷*

福建农林大学食品科学学院，福州，福建，350002

摘要：过热蒸汽技术具有传热传质效率高、脱水快、节能和杀菌等优势，在水产干燥与杀菌中有应用潜力。研究表明，脱水条斑紫菜经 150℃过热蒸汽处理 3 min，可完全灭活 7.6CFU/g 耐热菌，且基本保持烤紫菜色泽和水分活度。采用 115℃过热蒸汽预干燥鲍鱼 2 h 后转 25℃低温干燥，可缩短干燥时间，改善干鲍收缩率、质构、色泽和感官品质。此外，团队研制的连续式过热蒸汽节能干燥水产饲料生产线，与履带式热风干燥相比，去除单位水分能耗降低 61.05%，干燥成本降低 53.56%，实现了连续化、节能与杀菌一体化。过热蒸汽通过强化传热、快速脱水和微生物失活，可提高水产品安全性与加工效率。

关键词：过热蒸汽；水产品加工；干燥；微生物控制

资助项目：福建省科技厅重大专项专题项目（2021NZ033018），福建省科技厅高校产学合作项目（2021N5011），福建省海洋经济发展专项资金项目（FJHJF-L-2021-2）

通讯作者：方婷、女、博士研究生、教授、食品加工及微生物安全、13489115641，fangting930@163.com

海蓬子植物盐的感官特性、风味感知及其在鲟鱼子酱中的减钠替代与品质调控研究

张唯嘉[1]，赵元晖[1]，徐新星[1*]

[1] 中国海洋大学食品科学与工程学院　山东青岛　266003

摘要：海蓬子植物盐（*Salicornia bigelovii*）富含 K、Mg 等矿物元素及多种生物活性成分，具有显著的减钠潜力。本研究系统解析海蓬子植物盐的感官特性及其在鲟鱼子酱中的减钠替代效应。基于电子舌响应构建等效咸度标准曲线（R^2=0.9969）和换算模型（R^2=0.9909），实现仪器信号向感官咸味的精准映射。发现电子舌等效咸度（100-167 mmol/L NaCl）显著高于感官值（36-92 mmol/L），表明其具有味觉增强效应。在鲟鱼子酱中确定 40%为最佳替代水平，可实现约 60%的钠含量降低且保持良好接受度。机制研究表明，海蓬子植物盐能显著抑制腐败菌（对 *Shewanella baltica* 抑制率达 98.41%），通过破坏细胞膜完整性、增加通透性及抑制生物膜形成发挥抑菌作用；同时降低脂质过氧化和丙二醛含量，维持肌原纤维蛋白巯基含量并抑制羰基化，延缓蛋白质氧化。关键风味化合物（己醛、（E）-2-己烯醛、（Z）-4-庚烯醛、3-甲基-1-丁醇）与富含不饱和脂肪酸的磷脂酰胆碱和磷脂酰乙醇胺呈显著正相关。

关键词：鲟鱼子酱；海蓬子；植物盐；减钠；品质调控

Research on the Sensory Characteristics, Flavor Perception of Salicornia Plant Salt, and its Sodium Reduction Substitution and Quality Control in Sturgeon Caviar

Weijia Zhang[1], Yuanhui Zhao[1], Xinxing Xu[1*]

[1] College of Food Science and Engineering, Ocean University of China, Qingdao, Shandong, 266003

Abstract: *Salicornia bigelovii* is rich in mineral elements such as potassium and magnesium, as well as various bioactive components, conferring substantial sodium-reduction potential. In this study, we systematically characterized the sensory properties of *S. bigelovii* salt and evaluated its sodium-

replacement efficacy and quality-modulating effects in sturgeon caviar. Based on the quantitative relationship between electronic tongue responses and NaCl concentrations, a highly correlated standard curve (R^2 = 0.9969) was constructed, and a conversion model for the equivalent saltiness of *S. bigelovii* salt was further established (R^2 = 0.9909), enabling accurate mapping from instrumental signals to sensory saltiness intensity. The electronic tongue-derived equivalent saltiness of *S. bigelovii* salt ranged from 100 to 167 mmol/L NaCl, significantly higher than the sensory evaluation results (36–92 mmol/L NaCl), indicating an enhanced gustatory stimulatory effect. In low-sodium substitution applications, incorporation of *S. bigelovii* salt into the sturgeon caviar processing system identified 40% as the optimal substitution level, achieving approximately 60% sodium reduction while maintaining favorable sensory acceptability. Mechanistically, *S. bigelovii* salt markedly inhibited the growth of spoilage microorganisms, with an inhibition rate of 98.41% against *Shewanella baltica*, primarily through disruption of cell membrane integrity, increased membrane permeability, and suppression of biofilm formation, thereby effectively reducing bacterial viability. Regarding oxidative stability, it significantly decreased lipid peroxidation levels and malondialdehyde content, and delayed protein oxidative degradation by maintaining myofibrillar protein sulfhydryl content and inhibiting carbonylation. Key volatile flavor compounds, including hexanal, (*E*)-2-hexenal, (*Z*)-4-heptenal, and 3-methyl-1-butanol, exhibited significant positive correlations with phosphatidylcholine and phosphatidylethanolamine species containing oleic acid, α-linolenic acid, arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid.

Key words: Sturgeon caviar; *Salicornia bigelovii*; Plant salt; Sodium reduction; Quality control

第一作者：张唯嘉，女，目前就读于中国海洋大学食品科学与工程学院，2024 级学术型博士研究生，研究方向为水产品风味化学，目前以第一作者在 *Trends in Food Science and Technology*、*Food Chemistry*、*Food Research International* 等期刊上发表 SCI 论文 8 篇，申请国家专利 2 项，获得国家奖学金、优秀研究生等荣誉。

通讯作者：徐新星，女，中国海洋大学食品科学与工程学院副教授，研究方向风味化学，18801290977，freshstar129@163.com。

海葡萄酸性多糖的成骨作用：结构-活性关系及分子机制

卢紫腈，王冬雪，胡亚芹*

海南热带海洋学院食品科学与工程学院，海南三亚，572022

摘要：目的：本研究聚焦海葡萄酸性多糖（*Caulerpa lentillifera* acidic polysaccharides, CLAP）的结构特性，并探究其成骨效应及潜在分子机制。方法：通过傅里叶变换红外光谱、单糖组成和分子量测定对 CLAP 的结构特征进行分析；采用体外模型量化成骨效应指标，包括碱性磷酸酶活性、矿化结节形成及骨相关基因表达；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；并探究其通过调控 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。结果：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 可增强斑马鱼的矿化能力，促进软骨形成，增加骨钙素的合成。结论：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

基金项目：海南热带海洋学院高层次人才项目（RHDRC202117）；海南热带海洋学院青年人才项目（RHDRC202307).

通讯作者：胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，15868109010，1004346262@qq.com.

通讯作者：胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，15868109010，1004346262@qq.com.

Unraveling the osteogenic activity of Caulerpa lentillifera acidic polysaccharides: from structural features to molecular targets

Zijing Lu, Dongxue Wang, Yaqin Hu*

College of Food Science and Engineering, Hainan Tropical Ocean University, Sanya 572022, China

Abstract: [Objective] This study focused on the structural characteristics of *Caulerpa lentillifera* acidic polysaccharides (CLAP) and investigated their osteogenic effects and potential molecular mechanisms. [Methods] 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. [Results] 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. [Conclusion] 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

海洋生物活性物质抗过敏作用机制研究

张自业 [1]

（1．中国海洋大学食品科学与工程学院，山东 青岛 266500）

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，但难以彻底消除，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，但其具体抗过敏机制尚未系统阐明。本研究旨在系统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。【方法】本研究通过体外实验、细胞实验和小鼠动物模型，系统分析了海洋动植物（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。重点探讨了这些成分通过调控 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，并评估了其在体外实验、动物模型及临床前研究中的有效性。具体而言，研究涵盖了海藻多酚、海带岩藻多糖及其降解产物、微藻蛋白酶解多肽及鱼类副产物酶解多肽等多种海洋活性物质，并综合运用了层析分离纯化、光谱分析、体外模拟消化、细胞模型及小鼠模型等多种技术手段。【结果】研究表明，海藻多酚可通过与虾原肌球蛋白（TM）结合，改变其分子结构，从而掩盖或破坏其构象表位，显著降低 TM 的 IgG/IgE 结合能力，并抑制 RBL-2H3 细胞脱颗粒及组胺、IL-4 等过敏介质的释放。同时，多酚还能通过调节 Th1/Th2 细胞平衡、抑制 MAPK 和 NF-κB 信号通路发挥免疫调节作用。海带岩藻多糖经可控降解后，其抗过敏活性显著增强，低分子量岩藻多糖（DLJF）能更有效地抑制肥大细胞脱颗粒和炎症因子分泌，并通过调节肠道菌群组成、增加有益菌丰度来缓解过敏症状。此外，岩藻多糖还可通过 TLR4/NF-κB 信号通路抑制巨噬细胞炎症反应。微藻蛋白酶解多肽和鱼类副产物酶解多肽均能有效抑制透明质酸酶活性，并通过抑制 RBL-2H3 细胞脱颗粒释放 β-氨基己糖苷酶来发挥抗过敏作用。其中，从鱼副产物中鉴定出的新型多肽 TPEVHIAVDKF 具有明确的抗过敏活性。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食物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。本研究系统阐明了海洋多酚、多糖及多肽通过消减过敏原致敏性、免疫调节及重塑肠道

[1]资助项目：国家自然科学基金（32572710）
通讯作者：张自业，E-mail: zhangziye@ouc.edu.cn.

菌群等多途径协同发挥抗过敏作用的机制，为开发新型、安全、高效的抗过敏功能食品和天然干预制剂提供了坚实的理论依据与实验支撑。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；抗过敏；机制研究

The Anti-allergic Mechanisms of Marine Bioactive Substances

Ziye Zhang [1]

(1. *College of Food Science and Engineering, Ocean University of China, Qingdao 266500, China*)

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. The aim of this study is to systematically explore the anti-allergic effects and mechanisms of marine-derived active substances (such as polyphenols, polysaccharides, and peptides), in order to provide a theoretical basis for the development of new anti-allergic functional foods. **[Methods]** In this study, the bioactive substances with anti-allergic potential in marine animals and plants (e.g., algae, fish) were systematically analyzed through *in vitro* experiments, cell experiments, and mouse animal models, including their physicochemical characteristics, extraction methods, and targets of action. The study focused 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, and regulating gut microbiota, and evaluated their effectiveness in in vitro experiments, animal models, and preclinical studies. Specifically, the research covered various marine active substances such as seaweed polyphenols, *Laminaria japonica* fucoidan and its degraded products, microalgae protein hydrolysates, and fish byproduct hydrolysates. A variety of techniques were comprehensively employed, including chromatographic separation and purification, spectroscopic analysis, in vitro simulated digestion, cell models, and mouse models. **[Results]** Research has shown that algal polyphenols can bind to shrimp tropomyosin (TM), alter its molecular structure, thereby masking or destroying its conformational epitopes, significantly reducing the IgG/IgE binding capacity of TM, and inhibiting RBL-2H3 cell degranulation and the release of allergic mediators such as histamine and IL-4. Meanwhile, polyphenols can also exert immunomodulatory effects by regulating the Th1/Th2 cell balance and inhibiting the MAPK and NF-κB signaling pathways. After controlled degradation, the anti-allergic

activity of *Laminaria japonica* fucoidan was significantly enhanced. Low-molecular-weight fucoidan (DLJF) could more effectively inhibit mast cell degranulation and inflammatory factor secretion, and alleviate allergic symptoms by regulating gut microbiota composition and increasing the abundance of beneficial bacteria. In addition, fucoidan could also inhibit macrophage inflammatory responses through the TLR4/NF-κB signaling pathway. Both microalgae protein hydrolysates and fish byproduct hydrolysates could effectively inhibit hyaluronidase activity and exert anti-allergic effects by inhibiting the release of β-hexosaminidase from RBL-2H3 cell degranulation. Among them, a novel peptide TPEVHIAVDKF identified from fish byproducts exhibited definite anti-allergic activity. 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. This study systematically elucidated the mechanisms by which marine polyphenols, polysaccharides, and peptides exert anti-allergic effects through multiple synergistic pathways, including reducing allergen sensitization, immunomodulation, and remodeling gut microbiota, providing a solid theoretical basis and experimental support for the development of novel, safe, and efficient anti-allergic functional foods and natural intervention agents. 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; Anti-allergy; Mechanism study

海洋食品功能因子精准挖掘与生物制造及靶向营养健康应用

应锐*，赵元晖，毛相朝

中国海洋大学食品科学与工程学院，中国青岛，266000

摘要：海洋食品中丰富的功能营养成分与活性因子是构成膳食营养、促进健康的重要物质基础。目的：针对水产食品功能成分潜在的构效机制与调控途径，实施功能因子的定向修饰转化，是提升其功效效价、实现精准营养的重要途径。方法：本研究以大宗海藻为研究对象，围绕“靶向挖掘—构效解析—机制阐明—提质增效”全链条开展工作：建立活性高通量筛选体系，实现目标功能因子高效挖掘；系统评估活性水平，解析分子构效机制；结合“全基因组分析-功能因子结构鉴定-途径蛋白功能解析”的专用酶挖掘策略，完成目标因子的定向转化与生物合成。结果和结论：研究以建立特定结构功能因子的精准挖掘与制造为目标，从加工端提升其效价水平，推动海洋食品资源在膳食优化、促进健康方面的高值化利用。

关键词：海洋食品功能因子；定向生物转化；构效机制；精准营养；高值化利用

Precise Excavation, Bioproduction and Targeted Nutrition Health Application of Marine Food Functional Factors

Rui Ying[1], Yuanhui Zhao[2], Xiangzhao Mao

College of Food Science and Engineering, Ocean University of China, Qingdao 266000, Shandong

Abstract: Marine foods are abundant in functional nutrients and bioactive factors that play critical roles in human health regulation. Objective：Elucidating the structure-activity relationships of these components and realizing targeted transformation and biosynthesis of specific functional factors is an essential pathway to enhance their potency and achieve precision nutrition. Methods：This study takes bulk seaweed resources as the research object, and constructs a complete technical framework covering "targeted mining of functional factors - molecular structure-activity elucidation -

mechanism dissection - efficacy improvement". A high-throughput screening system for seaweed anti-hypoxia activity was established for efficient mining of target functional factors, followed by systematic activity evaluation and structure-activity relationship analysis. By integrating the high-throughput mining strategy for aquatic processing-specific enzymes, which combines whole-genome analysis, component identification and pathway protein functional annotation, the targeted transformation and biosynthesis of specific functional factors were achieved. Results and Conclusion： This work establishes a novel technical system for the discovery and precision manufacturing of structure-specified marine functional factors, and promotes the high-value utilization of marine food resources in dietary optimization and health improvement.

Key words: Marine food functional factors; Targeted biotransformation; Structure-activity mechanism; Precision nutrition; High-value utilization

褐藻-白菜复配泡菜的发酵品质特征及机制研究

王莺臻，启航*

大连工业大学，辽宁省大连市，116034

摘要：针对单一褐藻发酵存在可利用底物不足、品质调控难度大等问题，本研究构建白菜 - 海带、白菜 - 裙带菜复配发酵体系，系统考察复配发酵对褐藻色泽、质构及挥发性风味的影响，明确其品质提升特征；并通过解析微生物群落结构，阐释发酵品质改良机制。结果表明，复配发酵能够加快褐藻发酵酸化速率，促进体系还原糖降解，显著优化发酵褐藻的硬度、弹性与咀嚼度；同时重塑风味轮廓，提升清香、果香类挥发性组分含量，降低刺激性物质累积。白菜的引入驱动发酵体系微生物群落重构，促进乳球菌富集并抑制杂菌增殖。综上，白菜 - 褐藻复配发酵可通过调控微生物群落结构改善发酵褐藻综合品质，为高品质褐藻发酵制品的开发与应用提供理论依据和技术支撑。

关键词：褐藻；白菜；复配发酵；质构特性；挥发性风味；微生物群落

资助项目：“十四五”国家重点研发计划项目（2023YFD2100600）“食品制造与农产品物流科技支撑”专项下属，“藻类食品品质提升与增值加工关键技术研究及集成应用”。

通讯作者：

启航，男，博士，教授；研究方向：藻类高值化深加工技术、藻类营养功效因子制备与活性评价；电话：13804082670；E-mail：qihang@dlpu.edu.cn。

褐藻表面黏液多糖制备、表征及对炎症性肠病小鼠的保护作用

郭亚慧[1,2,3]，刘艺涵[1,2,3]，张弛[1,2,3]，张展宏[1,2,3]，刘舒[1,2,3]，张晗[1,2,3]，马艺超[1,2,3]，任丹丹[1,2,3]，汪秋宽[1,2,3]，何云海[1,2,3*]

1.大连海洋大学 食品科学与工程学院，辽宁 大连 116023；2.国家海藻加工技术研发分中心，辽宁 大连 116023；3.辽宁省水产品加工及综合利用重点实验室，辽宁 大连 116023

摘要：褐藻表面黏液富含相对易释放的表面多糖，与细胞壁基质中结合较紧密的多糖相比，更适于在温和条件下进行分离与利用。以笼目海带（*Kjellmaniella crassifolia*, Kc）为原料，建立常温低浓度碱性分离体系，并分别制备黏液冻干粉（MLP）和黏液来源岩藻多糖（MF）。经单因素试验和响应面法优化，Kc-MLP 总糖含量为 5.17%；Kc-MF 总糖含量为 51.90%。进一步采用常温低浓度碱性分离体系对裙带菜孢子叶（*Undaria pinnatifida* sporophylls, Ups）和海带（*Laminaria japonica*, Lj）进行制备，MF 总糖含量分别为 40.65%和 26.71%，表明该工艺具有一定原料适用性。表面黏液分离后的藻体经匀浆和复合酶解进一步提取，获得藻体来源常规岩藻多糖（CF），基于组成、理化特征及体外抗氧化活性的综合评价，选取 Kc-MF、Kc-CF、Ups-MF 和 Ups-CF 进一步开展葡聚糖硫酸钠（DSS）诱导小鼠结肠炎干预试验。结果表明，MF 与 CF 均可不同程度缓解体重下降、疾病活动指数评分升高、结肠缩短、脾脏肿大及结肠组织氧化应激损伤，总体干预效果相近，其中 MF 在部分指标上表现出一定优势。综上，褐藻表面黏液可作为岩藻多糖温和制备的潜在来源，黏液来源 MF 具有肠道炎症干预潜力，为褐藻表面黏液高值化利用及功能性海洋多糖开发提供了新思路。

关键词：褐藻表面黏液；提取；岩藻多糖；结构表征；结肠炎

Preparation and Characterization of Brown Algal Surface Mucilage Polysaccharides and Their Protective Effects in Mice with Colitis

Yahui Guo[1,2,3], Yihan Liu[1,2,3], Chi Zhang[1,2,3], Zhanhong Zhang[1,2,3], Shu Liu[1,2,3], Han Zhang[1,2,3], Yichao Ma[1,2,3], Dandan Ren[1,2,3], Qiukuan Wang[1,2,3], Yunhai He[1,2,3*]

1. College of Food Science and Engineering; 2. National R&D Branch Center for Seaweed Processing;3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian Ocean University, Dalian 116023, China

Abstract: Brown algal surface mucilage is rich in readily releasable surface-associated polysaccharides and, compared with polysaccharides more tightly bound within the cell-wall matrix, is more amenable to separation and utilization under mild conditions. Using *Kjellmaniella crassifolia* (Kc) as the raw material, a low-concentration alkaline separation system operated at room temperature was established to prepare mucilage lyophilized powder (MLP) and mucilage-derived fucoidan (MF). Following optimization by single-factor experiments and response surface methodology, the total sugar contents of Kc-MLP and Kc-MF were 5.17% and 51.90%, respectively. The same low-concentration alkaline separation system was further applied to *Undaria pinnatifida* sporophylls (Ups) and *Laminaria japonica* (Lj), yielding MF samples with total sugar contents of 40.65% and 26.71%, respectively, indicating a certain degree of applicability of this process to different brown algal materials. After removal of the surface mucilage, the remaining algal thalli were homogenized and subjected to combined enzymatic hydrolysis to obtain conventional fucoidan (CF). Based on an integrated evaluation of composition, physicochemical characteristics, and in vitro antioxidant activity, Kc-MF, Kc-CF, Ups-MF, and Ups-CF were selected for further evaluation in a dextran sulfate sodium (DSS)-induced mouse model of colitis. The results showed that both MF and CF alleviated, to varying extents, DSS-induced body weight loss, elevated disease activity index scores, colon shortening, splenic enlargement, and oxidative stress in colonic tissues. Their overall intervention effects were comparable, although MF showed certain advantages in several indicators. In conclusion, brown algal surface mucilage represents a potential source for the mild preparation of fucoidan, and mucilage-derived MF shows potential for the intervention of intestinal inflammation. These findings provide a new perspective for the high-value utilization of brown algal surface mucilage and the development of functional marine polysaccharides.

Keywords: brown algal surface mucilage; extraction; fucoidan; structural characterization; colitis

项目：国家重点研发计划项目（2025YFD2400200），国家藻类产业技术体系岗位科学家项目（CARS-50）

通讯作者：何云海，男，教授，藻类加工及资源利用，13840847973，hyh@dlou.edu.cn

褐藻聚糖硫酸酯配伍中药制剂改善 T2DM 小鼠胰岛素抵抗的研究

李文倩[1,2,3]，岑枝美[1,2,3]，贺叶琳[1,2,3]，马铭蕊[1,2,3]，魏轩[1,2,3]，武帅兵[1,2,3]，何云海[1,2,3]，张晗[1,2,3]，马艺超[1,2,3]，任丹丹[1,2,3]，汪秋宽[1,2,3]，刘舒[1,2,3*]

1.大连海洋大学 食品科学与工程学院，辽宁 大连 116023；2.国家海藻加工技术研发分中心，辽宁 大连 116023；3.辽宁省水产品加工及综合利用重点实验室，辽宁 大连 116023

摘要：褐藻聚糖硫酸酯可靶向调控糖代谢通路，与中药复方针对糖尿病的多靶点作用形成互补，二者复配有望协同降糖，优化糖尿病治疗方案。本研究旨在探究褐藻聚糖硫酸酯与中药复配物改善 2 型糖尿病（T2DM）小鼠胰岛素抵抗的协同降糖效应。通过 α-葡萄糖苷酶活性抑制试验进行体外筛选配伍方案，构建高脂饮食联合 STZ 诱导的 T2DM 小鼠模型开展体内验证实验。结果表明褐藻聚糖硫酸酯与葛根、消渴方分别复配均表现出显著的协同降糖效应，褐藻聚糖硫酸酯-中药复配组在血糖调控、胰岛素抵抗改善方面的作用显著优于褐藻聚糖硫酸酯单独给药组。该复配体系可发挥良好协同增效作用，有望降低传统降糖药物带来的副作用。研究成果可为海洋生物与中药资源高值化利用、功能食品及天然降糖制剂开发提供实验依据。

关键词： 褐藻聚糖硫酸酯；中药复配；2 型糖尿病；胰岛素抵抗；协同增效

Fucoidan Combined with Traditional Chinese Medicine Preparations Ameliorates Insulin Resistance in T2DM Mice

Wenqian Li[1,2,3], Zhimei Cen[1,2,3], Yelin He[1,2,3], Mingrui Ma[1,2,3], Xuan Wei[1,2,3], Shuaibing Wu[1,2,3], Yunhai He[1,2,3], Han Zhang[1,2,3], Yichao Ma[1,2,3], Dandan Ren[1,2,3], Qiukuan Wang[1,2,3], Shu Liu[1,2,3*]

1. College of Food Science and Engineering；2. National R&D Branch Center For Seaweed Processing；3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian Ocean University, Dalian 116023, China

Abstract: Fucoidan can regulate glucose metabolic pathways in a targeted manner and complement the multi-target effects of traditional Chinese medicine (TCM) formulas against diabetes. Their combination is expected to produce synergistic hypoglycemic effects and optimize diabetes treatment regimens. This study aimed to investigate the synergistic hypoglycemic effects of fucoidan-TCM combinations on improving insulin resistance in type 2 diabetes mellitus (T2DM) mice. In vitro screening of combination regimens was performed using an α-glucosidase inhibitory activity assay, and in vivo validation was conducted in a high-fat diet (HFD)/streptozotocin (STZ)-induced T2DM mouse model. The results showed that both fucoidan-Gegen and fucoidan-Xiaoke Formula combinations exhibited significant synergistic hypoglycemic effects. The fucoidan-TCM combination groups were significantly superior to the fucoidan monotherapy group in blood glucose regulation and improvement of insulin resistance. This combination system can exert favorable synergistic effects and is expected to reduce the side effects associated with conventional hypoglycemic drugs. These findings provide experimental evidence for the high-value utilization of marine biological and TCM resources, as well as for the development of functional foods and natural hypoglycemic preparations.

Keywords: Fucoidan; Traditional Chinese medicine formula; Type 2 diabetes mellitus; Insulin resistance; Synergistic effect

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），海洋食品加工与安全控制全国重点实验室开放基金（SKL202414）。

通讯作者：刘舒，女，博士，高级实验师，研究方向：水生生物活性资源利用与水产品加工，重点开展海藻活性物质的开发利用、结构表征及功能评价；电话：13909845380，E-mail：liushu@dlou.edu.cn

褐藻盐渍加工与熟制过程中颜色变化规律及机制研究

张彦爽[1,2,3]，刘婧怡[1,2,3]，刘舒[1,2,3]，张晗[1,2,3]，马艺超[1,2,3]，任丹丹[1,2,3]，汪秋宽[1,2,3]，何云海[1,2,3*]

1.大连海洋大学 食品科学与工程学院，辽宁 大连 116023；2.国家海藻加工技术研发分中心，辽宁 大连 116023；3.辽宁省水产品加工及综合利用重点实验室，辽宁 大连 116023

摘要：针对海带、裙带菜在加工与贮藏过程中因色素降解导致的色泽劣变及品质下降问题，本研究旨在揭示其色泽变化的内在机制，明确品质控制的关键技术要点。以海带、裙带菜为研究对象，系统检测盐渍加工各工序品质指标，借助色谱技术分析色素变化，构建冻藏色泽劣变动力学与 Arrhenius 模型，并对比四种熟制工艺的品质差异。结果表明，两种褐藻加工整体呈现漂烫显绿、盐渍暗化、脱盐色泽回弹的规律，裙带菜加工色素敏感性更高，叶绿素脱镁反应是其色泽劣变的核心途径；优化得到海带，裙带菜的最优漂烫参数。低温冻藏可延缓色泽劣变，叶绿素可作为货架期核心判定指标，冻藏可大幅延长二者货架期。不同熟制工艺适配性差异显著，海带适宜短时水煮或真空低温处理，裙带菜更适配微波熟制。本研究阐明了褐藻加工、贮藏、熟制全过程色泽劣变机制与控制要点，可为盐渍褐藻工艺优化、品质调控及即食产品开发提供理论支撑与实践依据。

关键词：海带和裙带菜；盐渍加工；色泽变化；动力学模型；熟制方式

Study on the Color Change Patterns and Mechanisms During the Processing and Cooking of Brown Algae Salts

Yanshuang Zhang[1,2,3], Jingyi Liu[1,2,3] ， Shu Liu[1,2,3], Han Zhang [1,2,3], Yichao Ma[1,2,3], Dandan Ren[1,2,3], Qiukuan Wang[1,2,3], Yunhai He[1,2,3*]

1. College of Food Science and Engineering，;2. National R＆D Branch Center For Seaweed Processing;3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian Ocean University , Dalian 116023, China

Abstract :This study aims to elucidate the underlying mechanisms responsible for the discol oration and quality degradation of *Saccharina japonica* and *Undaria pinnatifida* during pro cessing and storage due to pigment degradation, and to identify the key technical aspects for quality control. Using *Saccharina japonica* and *Undaria pinnatifida* as research subject s, the study systematically examines the quality indicators at each stage of the salting pro cess, employs chromatographic techniques to analyze pigment changes, develops a kinetic model for color deterioration during frozen storage based on the **Arrhenius** equation, and compares the quality differences among four cooking methods. The results indicate that th e processing of both brown algae generally follows a pattern of blanching-induced green c oloration, darkening upon salting, and color rebound after desalination. *Undaria pinnatifida* exhibits higher pigment sensitivity, with chlorophyll demagnesation as the core pathway res ponsible for its color deterioration. The optimal blanching parameters were determined for *Saccharina japonica* and for *Undaria pinnatifida*. Low-temperature frozen storage can dela y color deterioration, and chlorophyll can serve as a key indicator for determining shelf li fe; frozen storage can significantly extend the shelf life of both products. There are nota ble differences in the suitability of various cooking methods: *Saccharina japonica* is best s uited for short-duration boiling or vacuum low-temperature treatment, whereas *Undaria pin natifida* is more suitable for microwave cooking. This study clarifies the mechanisms and key control points for color deterioration throughout the entire process of brown algae pro cessing, storage, and cooking, providing theoretical support and practical guidance for opti mizing the processing of salted brown algae, regulating product quality, and developing rea dy-to-eat products.

Key words: *Saccharina japonica* and *Undaria pinnatifida*; salting process; color change; kinetic model; cooking method

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）

通讯作者：何云海，男，教授，藻类加工及资源利用，13840847973，hyh@dlou.edu.cn

胡椒碱复合液通过氧化损伤与膜破坏抑制热氏假单胞菌的效应研究

文教辉[1]，梁瑞润[1]，王泽富[1]，刘阳[1]，夏文[1]，殷燕涛[1]，刘书成[1]，魏帅[1*]

1.广东海洋大学 食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研发中心，广东省海洋生物制品工程重点实验室，水产品深加工广东普通高校重点实验室，广东 湛江 524088

摘要：为探究胡椒碱复合溶液(HPP)对凡纳滨对虾冷藏腐败菌——热氏假单胞菌的抗菌机制及保鲜应用潜力。以 5 mg/mL HPP 处理该菌，检测细胞活性、抗氧化酶(SOD、CAT)、膜损伤标志物(AKPase、LDHase)、生物膜形成与清除、毒力基因(*rpoD*、*gltA)*表达，并观察形态变化。HPP 使活菌数下降 51%，存活细胞数下降了 16.8%；SOD、CAT 活性明显降低，AKPase、LDHase 水平升高，表明氧化应激增强与膜完整性破坏。生物膜抑制率达 65.84%，清除率 44.08%，群体迁移运动受抑，毒力基因表达下调，电镜显示菌体形态显著改变。胡椒碱通过氧化损伤、膜破坏、抑制生物膜和群体感应等多靶点协同作用，有效抑制热氏假单胞菌，为开发对虾天然冷藏保鲜剂提供了理论依据。

关键词：胡椒碱；热氏假单胞菌；抑菌机制；凡纳滨对虾

基金项目：国家重点研发计划项目课题(2023YFD2401502)；广东省重点研发计划项目(2025B1111140001)；国家虾蟹产业技术体系(CARS-48)

***通讯作者：**魏帅，男，博士，教授，研究方向为水产品绿色加工与安全控制，0759-2383143，E-mail：weishuaiws@126.com

Effects of Piperine Composite Solution on Pseudomonas gessardii via Oxidative Damage and Membrane Disruption

Jiaohui Wen[1], Ruirun Liang[1],Zefu Wang[1], Yang Liu[1], Wen Xia[1], Yantao Yin[1], Shucheng Liu[1],Shuai Wei[1,*]

[1] College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Guangdong Province Engineering Laboratory for Marine Biological Products, Guangdong Provincial Engineering Technology Research Center of Seafood, Key Laboratory of

Advanced Processing of Aquatic Product of Guangdong Higher Education Institution, Zhanjiang, 524088, China.

Abstract:The aim of this study was to investigate the antibacterial mechanism and preservation potential of piperine composite solution (HPP) against *Pseudomonas gessardii*, a specific spoilage organism in refrigerated *Litopenaeus vannamei*. The bacteria were treated with 5 mg/mL HPP, and cell viability, antioxidant enzyme (superoxide dismutase, SOD; catalase, CAT) activities, membrane damage markers (alkaline phosphatase, AKPase; lactate dehydrogenase, LDHase), biofilm formation and eradication, expression of virulence genes (*rpoD* and *gltA*), and morphological changes were examined. Results showed that HPP reduced viable cell counts by 51% and decreased the number of surviving cells by 16.8%. SOD and CAT activities decreased significantly, while AKPase and LDHase levels increased, indicating enhanced oxidative stress and impaired membrane integrity. Biofilm inhibition and eradication rates reached 65.84% and 44.08%, respectively, and swarming motility was suppressed. Virulence gene expression was downregulated, and electron microscopy revealed obvious morphological alterations. Collectively, piperine exerts synergistic antibacterial effects via oxidative damage, membrane disruption, biofilm inhibition, and interference with quorum sensing, thereby effectively controlling *P. gessardii* and providing a theoretical basis for developing natural preservatives for chilled shrimp.

Key words: Piperine; *P. gessardii*; Antibacterial mechanism; *Litopenaeus vannamei*

华贵栉孔扇贝酶解蛋白粉对小麦面团体系多尺度调控效应

王禹鸥 [1,2]，张烘煜 [1,2]，刘 玉 [1,2]，谭明堂 [1,2]，陈忠琴 [1,2]，陈 铭 [1,2]，郑惠娜 [1,2]，高加龙 [1,2]， 曹文红 [1,2*]

1.广东海洋大学食品科技学院，广东省水产品加工与安全重点实验室，广东湛江，524088；2.国家贝类加工技术研发分中心，广东湛江，524088

摘要：本研究以华贵栉孔扇贝酶解蛋白粉（SP）为功能改良因子，系统解析其对低筋面团体系多尺度结构及品质特性的调控效应。将 SP 按照 0.0%-5.0%的梯度添加至低筋面粉基质，综合运用流变学、低场核磁共振、扫描电子显微镜、激光共聚焦扫描显微镜、傅里叶变换红外光谱与 X 射线衍射等多维度表征技术，揭示 SP 介导的面团结构演变规律。结果显示：3.0%-4.0%的 SP 添加可显著改善面团黏弹行为，强化面筋网络结构稳定性，促进体系内强结合水向弱结合水发生迁移转化，弱结合水占比最高可达 82.52%，进而驱动致密谷蛋白-淀粉复合交联结构的构建；该添加水平下体系分子间氢键发生扰动，淀粉相对结晶度提升至 53.0%，同时诱导谷蛋白二级构象发生重排。当 SP 添加量升高至 5.0%时，体系出现组分过度聚集与相分离现象，面团宏观与微观结构发生劣化。综上，SP 可实现低筋面团多尺度结构的有效优化，为扇贝资源高值化利用以及海洋源蛋白在面制品中的应用开发提供理论依据与技术支撑。

关键词：扇贝酶解蛋白粉；面团流变学；多尺度结构；水分分布；蛋白-淀粉相互作用

基金项目：国家重点研发计划课题（2024YFD2401902）；国家现代农业产业技术体系（CARS-49）；广东省现代农业产业技术体系贝类藻类产业创新团队项目（2024CXTD23）

***通讯作者**：曹文红（1977-），男，博士，教授，博士生导师，研究方向为海洋生物资源利用。E-mail: cchunlin@163.com

Multi-scale regulatory effect of Chlamys nobilis protein hydrolysate powder on wheat dough system

Yuou Wang[1, 2], Hongyu Zhang[1, 2], Yu Liu [1, 2],Mingtang Tan [1, 2], Zhongqin Chen[1, 2], Ming Chen[1, 2], Huina Zheng [1, 2], Jialong Gao [1, 2], Wenhong Cao [1, 2, *]

1.College of Food Science and Technology, Guangdong Ocean University, Zhanjiang 524088, China; 2.National Research and Development Branch Center for Shellfish Processing, Zhanjiang 524088, China.

Abstract: This study took *Chlamys nobilis* protein hydrolysate powder (SP) as a functional modifier to systematically analyze its regulatory effects on the multi-scale structure and quality properties of the low-gluten dough system. SP was incorporated into the low-gluten flour matrix at gradient levels ranging from 0.0% to 5.0%. Multiple characterization techniques including rheology, low-field NMR, scanning electron microscopy (SEM), confocal laser scanning microscopy (CLSM), Fourier-transform infrared spectroscopy (FTIR), and X-ray diffraction (XRD) were adopted to unravel the SP-mediated structural evolution of dough. The results demonstrated that SP addition at 3.0%-4.0% remarkably improved the viscoelastic behaviors of dough and strengthened the stability of gluten network. It facilitated the conversion of tightly bound water to weakly bound water, with the maximum proportion of weakly bound water reaching 82.52%, which further promoted the formation of compact cross-linked gluten-starch composite structures. At this dosage level, intermolecular hydrogen bonds within the system were disturbed, the relative crystallinity of starch was increased to 53.0%, and the secondary conformational rearrangement of gluten was induced. When the SP addition level rose to 5.0%, excessive component aggregation and phase separation occurred in the system, leading to the deterioration of both macroscopic and microscopic structures of dough. In conclusion, SP can achieve effective optimization of the multi-scale structure of low-gluten dough. This work provides a theoretical basis and technical support for the high-value utilization of scallop resources and the application and development of marine-derived proteins in flour-based food products.

Keywords: *Chlamys nobilis* protein hydrolysate powder; dough rheology; multi-scale structure;

water distribution; protein-starch interaction

Funding: This work was supported by the National Key R&D Program of China (2024YFD2401902), the earmarked fund for China Agriculture Research System (CARS-49), and the Shellfish & Algae Industry Innovation Team of Guangdong Modern Agricultural Technology System (No. 2024CXTD23).

** Correspondence author: Wenhong Cao (1977-), Ph.D., Professor, College of Food Science and Technology, Guangdong Ocean University, Zhanjiang, China. Research interest: utilization of marine biological resources. E-mail: cchunlin@163.com*

花胶肽功能性凝胶软糖的研制及降糖活性评估

汪明慧，黄涛*

宁波大学食品科学与工程学院，浙江宁波 315800

摘要：本研究以花胶高温蒸煮副产物蒸煮液为原料，酶解制备花胶肽，开发功能性凝胶软糖。采用单因素结合响应面试验优化软糖制备工艺，确定最优配方：复合凝胶剂中鱼明胶占比86.73%、复合凝胶剂添加量 9.39%、麦芽糖醇 10.22%、花胶肽 0.32%。该条件下软糖感官评分为 94.6 分，符合国标，其硬度、内聚性、咀嚼性等质构特性得到改善。利用体外模拟消化模型评价活性，胃肠消化后软糖具备较强降血糖活性；质量浓度 6 mg·mL^{-1} 时，α- 葡萄糖苷酶、α- 淀粉酶抑制率分别为 90.85% 和 70.69%。贮藏实验证实软糖稳定性良好，基于 Q10 模型预测室温理论货架期为 64.2 d。本研究提升了花胶加工副产物利用价值，为花胶肽功能性软糖开发提供技术参考。

关键词：花胶肽；凝胶软糖；降血糖活性；贮藏稳定性；功能特性

通信作者：黄涛（1987−），男，博士，特聘研究员，研究方向：水产品资源高值化综合利用，E-mail：huantao@nbu.edu.cn。

基金项目：国家重点研发计划 (2024YFD2401602)

花青素基智能双层膜的制备及其对池沼公鱼保鲜与新鲜度指示研究

李娜 1，毕诗杰* 2

新疆农业大学，新疆维吾尔自治区乌鲁木齐市，830052

摘要：本研究以海藻酸钠（SA）为内层负载紫甘蓝花青素（PCA），壳聚糖（CS）为外层构建抗菌阻隔屏障，采用溶液浇铸法制备不同 PCA 添加量的 CS/SA/PCA 双层智能指示膜，系统评价其结构、理化性能、抗氧化活性、pH 响应性及池沼公鱼冷藏保鲜效果。结构表征证实三者通过氢键形成稳定复合结构，15% PCA 添加量下膜微观结构最均匀致密。PCA 引入改善了膜的阻水、耐水及光阻隔性能，显著提升抗氧化活性；该膜在不同 pH 下呈明显颜色变化，具备良好 pH 响应敏感性，并确定 15% PCA 为最优添加量。4℃冷藏池沼公鱼保鲜中，该膜可延长货架期约 2 d，颜色随新鲜度下降由灰紫色渐变为灰褐色，与 TVB-N 和 pH 变化趋势吻合。结果表明，该双层膜兼具保鲜与新鲜度可视化监测双重功能，在鱼肉保鲜领域具有潜在应用价值。

关键词：池沼公鱼；紫甘蓝花青素；海藻酸钠；壳聚糖；智能包装

资助项目：博斯腾湖生态渔业加工技术研发与集成（项目编号：2023B02037）

通讯作者：毕诗杰，女，博士，副教授

电话：17881179058

邮箱：bsj19941001@163.com

研究领域：主要从事水产品加工及贮藏保鲜研究，主持国家自然基金 1 项，自治区重点研发项目 1 项，厅局级项目 3 项，参与国家重点研发项目 2 项，省部级重点研发项目 4 项，入选新疆维吾尔自治区“天池英才-青年博士”，发表论文 20 余篇。

化学改性坛紫菜多糖的 α-淀粉酶抑制活性分析及结构表征

任娅楠[1,2]，让一峰[2,*]，陈胜军[2,*]

1.中国海洋大学食品科学与工程学院，山东青岛，266000；

2.中国水产科学研究院南海水产研究所，广东广州 510300

摘要：为提高坛紫菜多糖（PHP）的 α-淀粉酶抑制活性，采用硫酸化、锌化、硒化和过氧化氢降解 4 种方法改性 PHP，并对活性最高的产物进行 IC_{50} 测定、抑制动力学分析、稳定性评价及结构表征。结果表明，PHP 在 10 mg/mL 下无抑制活性，除硒化外其余改性均显著提高其活性，其中硫酸化 PHP（S-PHP）活性最高，IC_{50} 为 4.73 mg/mL，表现为可逆竞争性抑制，且经 40～70℃、pH 3.0～10.0 处理 20 min 及模拟胃肠道消化 240 min 后活性无显著变化。S-PHP 的硫酸酯取代度由 0.14 增至 0.42，以半乳糖和葡萄糖为主（摩尔比约 2:1），主要组分分子量为 109 995 Da，硫酸基团红外吸收增强。硫酸化改性可有效提高 PHP 的 α-淀粉酶抑制活性，为高活性、高热稳定性 α-淀粉酶抑制剂的制备提供理论依据。

关键词：坛紫菜；多糖；化学改性；α-淀粉酶抑制活性；稳定性

资助项目：国家重点研发计划资助（2025YFD2400200）；国家藻类产业技术体系（CARS-49）；中国水产科学研究院基本科研业务费资助项目（2023TD74，2023TD78）。

作者简介：任娅楠，女，硕士研究生，研究方向：水产品加工，E-mail：renyanan@stu.ouc.edu.cn。

*通讯作者：让一峰，男，博士，助理研究员，研究方向：水产品加工，E-mail：rangyifeng@scsfri.ac.cn。

**通讯作者：陈胜军，男，博士，研究员，研究方向：水产品加工与质量安全控制，E-mail：chenshengjun@scsfri.ac.cn。

黄渤海海洋牧场增殖与网箱养殖许氏平鲉营养品质及风味特征比较

赵庆臣 1

1 大连海洋大学水产与生命学院，辽宁 大连，116023

摘要：本研究旨在对黄渤海海洋牧场增殖的许氏平鲉（*Sebastes schlegelii*）与网箱养殖的许氏平鲉进行营养品质的综合评价，并探讨其资源利用价值。通过比较两种养殖方式中许氏平鲉的肌肉基本营养成分、氨基酸组成、脂肪酸组成及挥发性风味物质，分析不同养殖环境对许氏平鲉肉质的影响。研究结果表明，海洋牧场增殖的许氏平鲉相较于网箱养殖的许氏平鲉，其水分和灰分含量显著更高，粗蛋白略高而粗脂肪显著较低。氨基酸分析显示，海洋牧场许氏平鲉的氨基酸总量和必需氨基酸比例较高，蛋白质的营养价值优于网箱养殖许氏平鲉。脂肪酸分析进一步证实，海洋牧场许氏平鲉中 EPA 和 DHA 的含量显著高于网箱养殖样本。此外，挥发性风味物质的成分与比例在两者之间也有显著差异，海洋牧场许氏平鲉表现出更优的风味特征。研究结果表明，海洋牧场增殖的许氏平鲉在渔业资源保护和水域生态修复方面具有较高的资源利用潜力，为渔业资源的可持续利用与水域生态高质量发展提供了重要的科学依据。

关键词：许氏平鲉；海洋牧场；网箱养殖；营养评价；渔业资源

作者简介：赵庆臣（2001—），男，硕士研究生，研究方向：海洋牧场水产品营养品质评价，手机：18369078009，E-mail：zqc078009@163.com。

肌球蛋白 Pickering 乳液纳微球构建及其组分的相互作用

杨腾腾 ，翁武银，石林凡，赵源，任中阳*

集美大学海洋食品与生物工程学院，福建 厦门 361021

摘要：为明确肌球蛋白 Pickering 乳液纳微球相态演变机制，本研究以体积分数 50 %南极磷虾油为油相，用糜蛋白酶处理南美白对虾肌球蛋白构建 Pickering 乳液纳微球，探究不同酶解程度对乳液理化特性的影响。SDS-PAGE 显示，随酶解时间延长，肌球蛋白重链条带逐渐减弱并生成重酶解肌球蛋白（HMM）、轻酶解肌球蛋白（LMM）等片段；粒径从 1044.9 nm 降至 384 nm。酶解 0-50 min 表面疏水性持续升高，内源荧光强度逐步增强。活性巯基在酶解 40 min 达 50 μmol/g，酶解后肌球蛋白 β-折叠含量升高。乳液微观结果显示 0-30 min 液滴分布逐渐均匀，40-60 min 排布更致密。综上，糜蛋白酶通过调控肌球蛋白分子结构，改变 Pickering 乳液纳微球微观形态。本研究阐明了酶解条件下肌球蛋白 Pickering 乳液纳微球的变化规律，为其相态变化提供分子基础。

关键词：南美白对虾；肌球蛋白；南极磷虾油；糜蛋白酶；Pickering 乳液

资助项目：国家自然科学基金项目（32572649）和福建省自然科学基金项目（2025J01864）资助。

通讯作者：任中阳，男，博士，副教授，水产品加工与综合利用，电话：15622273558，E-mail：rzy0529@jmu.edu.cn

基于 COMSOL 的凡纳滨对虾液氮速冻工艺优化：品质保持与液氮消耗协同调控

陈思思，闫文达，孙钦秀，宋文奎，刘书成*

广东海洋大学食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋生物制品工程实验室，广东省海洋食品工程技术研究中心，广东省水产预制食品加工与品质控制工程技术研究中心，广东湛江，524088.

摘要：为提高凡纳滨对虾液氮速冻效率并降低液氮消耗，以凡纳滨对虾为研究对象，比较不同液氮温度及二段式温度组合对其冻结特性、肌肉品质和液氮消耗的影响，并采用 COMSOL 对冻结过程温度变化进行数值模拟。结果表明，随着冻结温度降低，冻结时间缩短，但过低温度不利于产品品质保持，其中-95 ℃处理可较好维持虾肉持水性、硬度及微观结构。以-95 ℃为第一阶段冻结温度时，降低第二阶段温度可进一步缩短总冻结时间并改善部分品质指标。综合冻结特性、肌肉品质和液氮消耗，-95 ℃/-75 ℃二段式液氮速冻模式表现较优，较持续-95 ℃速冻减少 17.49%的液氮消耗。数值模拟能够较好预测冻结过程中的关键温度节点。二段式液氮速冻可在保持凡纳滨对虾品质的同时提高液氮利用效率，为水产品低能耗、精准速冻工艺优化提供参考。

关键词：凡纳滨对虾；二段式液氮速冻；冻结特性；液氮利用效率；数值模拟

通讯作者：刘书成，liusc@gdou.edu.cn

基金项目：广东省重点研发领域研发计划项目(2025B1111140001)；国家虾蟹产业技术体系（CARS-47）；广东省普通高校青年创新人才项目（2023KQNCX025）

Optimization of Liquid Nitrogen Quick-Freezing Process for Litopenaeus vannamei Based on COMSOL Numerical Simulation: Synergistic Regulation of Quality Retention and Liquid Nitrogen Consumption

Sisi Chen, Wenda Yan, Qinxiu Sun, Wenkui Song, Shucheng Liu*

College of Food Science and Technology, Guangdong Ocean University; Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety; Guangdong Provincial Engineering Laboratory for Marine Biological

Products; Guangdong Provincial Engineering Technology Research Center for Marine Food; Guangdong Provincial Engineering Technology Research Center for Processing and Quality Control of Prepared Aquatic Foods, Zhanjiang 524088, Guangdong, China

Abstract:To improve the freezing efficiency of Litopenaeus vannamei while reducing liquid nitrogen consumption, the effects of different liquid nitrogen temperatures and two-stage temperature combinations on freezing characteristics, muscle quality, and liquid nitrogen consumption were investigated, and COMSOL was used to simulate temperature changes during the freezing process. The results showed that lowering the freezing temperature shortened the freezing time, whereas excessively low temperatures were unfavorable for quality retention. Freezing at -95 °C better maintained the water-holding capacity, hardness, and microstructure of shrimp muscle. When -95 °C was used as the first-stage freezing temperature, lowering the second-stage temperature further shortened the total freezing time and improved some quality attributes. Considering freezing characteristics, muscle quality, and liquid nitrogen consumption, the -95 °C/-75 °C two-stage freezing mode showed better overall performance and reduced liquid nitrogen consumption by 17.49% compared with continuous freezing at -95 °C. The numerical simulation effectively predicted key temperature nodes during freezing. These results indicate that two-stage liquid nitrogen quick-freezing can improve liquid nitrogen utilization efficiency while maintaining the quality of L. vannamei, providing a reference for low-energy and precise quick-freezing of aquatic products.

Key words: *Litopenaeus vannamei*; two-stage liquid nitrogen quick-freezing; freezing characteristics; liquid nitrogen utilization efficiency; numerical simulation

Corresponding authors: Liu Shucheng, liusc@gdou.edu.cn

Funding: Guangdong Provincial Key R&D Program (2025B1111140001); National Shrimp and Crab Industry Technology System (CARS-47); Guangdong Province Young Innovative Talent Project for General Universities (2023KQNCX025)

基于 Fe_3O_4@PDA 磁性材料富集鲅鳙鱼内源性肽及其功能鉴定

李佳佳，罗晓诺，汪舟扬，占涵，李高尚，杨文鸽*

宁波大学食品科学与工程学院，浙江 宁波 315211

摘要：现有鱼源活性肽研究多集中于蛋白酶解肽，对内源性肽的系统挖掘较少。针对内源性肽丰度低、鱼肉基质复杂的问题，本研究构建 Fe_3O_4@PDA 磁性材料并富集鲅鳙鱼内源性肽，结合 LC-MS/MS、分子对接和细胞模型评价富集肽的功能特性。结果表明，在 pH 6、PDA 聚合 24 h 时，材料粒径为 243 nm，Zeta 电位为−24.6 mV，内源性肽富集量达到最大值，并显示较高的 DPPH 自由基清除率、Fe^{2+}螯合率和羟基自由基清除率。共鉴定到 41 条肽，候选肽与 Keap1 和 TLR2 表现出潜在结合能力。与模型组相比，富集肽可显著降低 HepG2 细胞 ROS 及 RAW264.7 细胞炎症因子水平，提高 SOD、CAT 和 GSH-Px 活性。结论：Fe_3O_4@PDA 可高效富集鲅鳙鱼内源性肽，所得肽具有显著的抗炎和抗氧化潜力。

关键词： Fe_3O_4@PDA；鲅鳙鱼；内源性肽；磁性富集；抗氧化与抗炎活性

资助项目：国家重点研发计划课题，2024YFD2401601

通讯作者：杨文鸽，女，工学博士，教授、博士生导师，研究方向为水产食品化学、水产品保鲜与精深加工及水产食品营养与健康；

电话：139 5820 8678

E-mail：yangwenge@nbu.edu.cn。

基于分子对接和光谱技术探究酚类物质对金鲳鱼脂氧合酶（LOX）的抑制作用

罗翠霞[1]，孙钦秀[1*]

1.广东海洋大学 食品科技学院，广东省水产品加工与安全重点实验室，广东 湛江 524088

摘要：本实验探究绿原酸（CGA）、没食子酸（GA）、熊果苷（Arbutin）和羟基酪醇（DOPET）对金鲳鱼脂质氧化关键酶-脂氧合酶（LOX）的抑制作用和构象影响。鱼肉中 LOX 经纯化后活力提升 8.07 倍，在 pH5.5 条件下测得最适底物浓度为 6.4 mM，*K*m 为 0.98 mM。抑制结果表明，CGA 对 LOX 的抑制能力显著强于 GA 、Arbutin 和 DOPET（$P < 0.05$）：其 *KI* 值为 0.31 mg/mL；并表现为混合型抑制；在 3 mg/mL 时抑制率比 DOPET 高 38.57%。UV-Vis 显示 CGA 使 LOX 吸收峰出现红移且强度显著增强，说明 CGA 能与 LOX 形成稳定复合物并改变其三级结构；CD 显示 CGA 和 GA 的α-螺旋含量下降 4.18% 和 5.33%（$P < 0.05$），表明 CGA 和 GA 均能让 LOX 二级结构无序化程度变高，导致其三级结构舒展。分子对接结果证明 CGA 能占据 LOX 活性中心更多的结合位点，阻止脂肪酸和酶的结合。KI 值和分子对接均表明 CGA 比 GA 更易结合活性中心并抑制底物氧化，显著降低 LOX 活性，因此 CGA 更具成为天然 LOX 抑制剂的潜力。

关键词：金鲳鱼；酚类物质；脂氧合酶；光谱技术；分子对接

基金项目：国家重点研发计划项目 （2023YFD2401402-2）；

*通讯作者：孙钦秀，女，博士后，教授，研究方向为海洋食品贮藏与加工

E-mail: sunqinxiugo@163.com

Inhibitory Effects of Phenolic Compounds on Lipoxygenase (LOX) from Golden Pompano (Trachinotus ovatus) Investigated by Spectroscopic Techniques

Cuixia Luo[1], Qinxiu Sun[1,*]

[1] College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Zhanjiang, 524088, China.

Abstract: In this study, the inhibitory effects and conformational impacts of chlorogenic acid (CGA), gallic acid (GA), arbutin, and hydroxytyrosol (DOPET) on lipoxygenase (LOX) from golden pompano were investigated. After purification, LOX activity was increased 8.07-fold, and the optimal substrate concentration and Km were determined to be 6.4 mM and 0.98 mM, respectively, at pH 5.5. CGA was found to exhibit significantly stronger inhibition than GA, arbutin, and DOPET ($P < 0.05$), with a KI of 0.31 mg/mL, and was identified as a mixed-type inhibitor, with an inhibition rate 38.57% higher than that of DOPET at 3 mg/mL. UV-VIS analysis revealed that a red shift and enhanced absorption of LOX were induced by CGA, indicating that a stable complex was formed and the tertiary structure was altered. CD analysis showed that the α-helix contents of LOX treated with CGA and GA were decreased by 4.18% and 5.33%, respectively, indicating increased structural disorder and unfolding of the enzyme. Molecular docking confirmed that more active center binding sites were occupied by CGA, preventing substrate binding. Therefore, CGA was suggested to have greater potential as a natural LOX inhibitor.

Key words: *Trachinotus blochii*; phenolic compounds; lipoxygenase; spectroscopic techniques; molecular docking

基于空位修饰 $Ti_3C_2T_x$ 量子点@SnS_2 肖特基异质结用于电化学发光检测黄曲霉毒素 B_1

花梅芳[1]，陈全胜*[1]

集美大学海洋食品与生物工程学院，福建厦门，361021

摘要：MXene 量子点（MQD）作为新兴的电化学发光（ECL）发光体，在实际应用中受到限制，原因是其发光强度较弱。为解决这一问题，通过将 MQD 固定在 SnS_2 纳米花上制备了 S 缺位修饰的 MQD@SnS_2，以提高其 ECL 性能。SnS_2 与 MQD 形成肖特基异质结，并为界面提供快速的电子传输通道，促进电子-空穴分离和界面电荷转移，从而有助于提高电化学性能。S 缺位的引入作为电子陷阱，显著增强了 MQD 的 ECL 发射，通过吸引电荷载流子并降低反应能量来实现。在概念验证的 ECL 应用中，开发了一种快速、灵敏且高效的生物传感器用于检测黄曲霉毒素 B_1（AFB_1），表现出良好的选择性，检测范围为 0.001~100 μg/kg，检测限为 1.24×10^{-4} μg/kg。这项工作为高性能 ECL 发光体的设计和合成提供了新的视角，为灵敏且高度稳定的 ECL 传感器的发展提供了新的机遇。

关键词：电化学发光；适配体传感器；$Ti_3C_2T_x$ 量子点；硫空位；黄曲霉毒素 B_1

S vacancy-modified Ti3C2Tx quantum dot@SnS2 schottky heterojunction for electrochemiluminescence detection of aflatoxin B1

Meifang Hua[1], Quansheng Chen*[1]

1. College of Ocean Food and Biological Engineering, Jimei University, Xiamen 361021, China.

Abstract: MXene quantum dots (MQD), as emerging electrochemiluminescence (ECL) emitters, are constrained in practical applications due to their weak luminescence intensity. To address this limitation, the S-vacancy modified MQD@SnS_2 was prepared by anchoring MQD on SnS_2 nanoflowers to improve their ECL performance. The SnS_2 generates a Schottky heterojunction with MQD and provides a fast electron transport channel across the interface, promotes electron-hole separation and interfacial charge transfer and contributes to the improved electrochemical performance. The introduction of S vacancies, acting as electron traps significantly enhances the ECL emission from

MQD by attracting charge carriers and lowering the reaction energy. In a proof-of-concept ECL application, a rapid, sensitive and efficient biosensor was developed for the detection of aflatoxin B_1 (AFB_1) and exhibited good selectivity with a wide detection range of 0.001~100 μg/kg with a low limit of detection of 1.24×10^{-4} μg/kg. This work provides a novel perspective for the design and synthesis of high-performance ECL emitters, offering new opportunities for the advancement of sensitive and highly stable ECL sensors.

Key words: Electrochemiluminescence; aptasensor; $Ti_3C_2T_x$ quantum dots; S vacancy; aflatoxin B_1

基于喹醛酰氯衍生化策略的超高效液相色谱-高分辨质谱法检测鱼南极磷虾油中的氯丙醇酯

孔聪[1]*，赵依凡[1]

1.中国水产科学研究院东海水产研究所，上海，200090

摘要：氯丙醇酯是油脂精炼过程中形成的一类食品加工污染物，可在体内水解为具有肾毒性、生殖毒性和潜在致癌性的游离氯丙醇。本研究旨在建立基于喹醛酰氯衍生化策略的 UHPLC-HRMS 方法，用于检测南极磷虾油中的氯丙醇酯。样品经 BCL 脂肪酶水解，释放的 2-MCPD 和 3-MCPD 经 PPR 柱净化、乙酸乙酯萃取、3A 分子筛除水后，与喹醛酰氯室温反应 30 min。方法线性良好（R≥0.9996），LOD 和 LOQ 为 1 和 2 μg/kg，回收率 74%–129%，RSD<10.4%，并实现 2-MCPD 与 3-MCPD 同分异构体的基线分离。检测 10 份市售磷虾油，3-MCPDE 检出率 40%（11.9–489.1 μg/kg），2-MCPDE 检出率 50%（6.1–225.6 μg/kg）。本研究首次将喹醛酰氯衍生化策略用于南极磷虾油中氯丙醇酯的检测，克服了传统 GC-MS/MS 法前处理繁琐、易污染仪器的局限，为南极磷虾油中氯丙醇酯的检测提供了新策略。

关键词：氯丙醇酯；衍生化；高分辨质谱；脂肪酶；磷虾油

资助项目：中央级公益性科研院所基本科研业务费专项资金项目（2024YC03）

通讯作者：孔聪，男，博士，副研究员；研究方向：水产品加工与质量安全控制；手机：15121038844；E-mail：kongc@ecsf.ac.cn

基于氯化胆碱-乳酸低共熔溶剂的南美白对虾虾头总脂质提取工艺优化及组成分析

刘小芳[1]，李向阳[1,2]，宫占波[1,3]，于源[1]，王西西[1]，孙慧慧[1]，李福后[2]，曹荣[1,*]

1. 中国水产科学研究院黄海水产研究所 农业农村部极地渔业可持续利用重点实验室, 山东青岛, 266071;

2. 江苏海洋大学海洋食品与生物工程学院 江苏省海洋生物资源与环境重点实验室, 江苏连云港, 222005;

3. 上海海洋大学食品学院, 上海, 201306

摘要：为建立南美白对虾虾头总脂质的绿色提取工艺并明确其组成特征，本研究采用低共熔溶剂氯化胆碱-乳酸为提取剂，以总脂质得率为评价指标，系统考察并优化了提取条件，并对所得总脂质的基本组成、磷脂组成、脂肪酸组成进行分析。结果表明：采用氯化胆碱-乳酸摩尔比 1:3、含水量 15%的低共熔溶剂体系，在料液比 1:10 (g/mL)、提取次数 3 次、萃取次数 4 次的处理条件下，从南美白对虾虾头中提取总脂质的得率最高，达到 9.72 ± 0.06 g/100 g DW；该提取效果接近氯仿-甲醇 (2:1, *v/v*) (11.16 ± 0.13 g/100 g DW)和乙醇 (10.71 ± 0.08 g/100 g DW)，优于正己烷(4.09 ± 0.11 g/100 g DW)和丙酮(4.87 ± 0.05 g/100 g DW)。南美白对虾虾头总脂质中磷脂的占比较高，且磷脂主要为磷脂酰胆碱和磷脂酰乙醇胺；此外，南美白对虾虾头总脂质中多不饱和脂肪酸（特别是二十碳五烯酸和二十二碳六烯酸）含量丰富，且主要以磷脂形式存在。采用氯化胆碱-乳酸低共熔溶剂从南美白对虾虾头中提取总脂质，提取效果良好；所得总脂质组成优异，具有开发为新型功能性油脂原料的潜力。

关键词：南美白对虾虾头；低共熔溶剂；总脂质得率；磷脂；多不饱和脂肪酸

基金项目：国家重点研发计划项目（2024YFD2402100）

通信作者：曹荣，男，博士，研究员，研究方向：水产品加工与综合利用，Tel.：18661641071，E-mail：caorong@ysfri.ac.cn

Extraction and Composition Analysis of Lipids from Pacific White Shrimp (Litopenaeus vannamei) Heads using a Choline Chloride-Lactic Acid Deep Eutectic Solvent

Xiaofang Liu[1], Xiangyang Li[1,2], Zhanbo Gong[1,3], Yuan Yu[1], Xixi Wang[1], Huihui Sun[1], Fuhou Li[2],

Rong Cao[1,*]

1. Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Key Laboratory of Sustainable Development of Polar Fisheries, Ministry of Agriculture and Rural Affairs, Qingdao 266071, China;

2. Jiangsu Ocean University, School of Ocean Food and Biological Engineering, Jiangsu Key Laboratory of Marine Biotechnology, Lianyungang 222005, China;

3. College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China

Abstract: To establish a green extraction process for total lipids from Pacific white shrimp (*Litopenaeus vannamei*) heads and elucidate the compositional characteristics, a deep eutectic solvent (DES) system composed of choline chloride and lactic acid was employed in the present study. Using total lipids yield as the evaluation index, the extraction parameters were systematically optimized, and the basic composition, phospholipids profile, and fatty acids composition of the obtained total lipids were comprehensively analyzed. The results indicated that the optimal DES system, featuring a choline chloride-lactic acid molar ratio of 1:3 with 15% water content, achieved the highest total lipids yield (9.72 ± 0.06 g/100 g DW) under the following conditions of solid-liquid ratio of 1:10 (g/mL), extraction cycles of 3, and solvent partition times of 4. This performance was comparable to that of conventional solvents, specifically chloroform-methanol (2:1, v/v; 11.16 ± 0.13 g/100 g DW) and ethanol (10.71 ± 0.08 g/100 g DW), while being significantly superior to that of hexane (4.09 ± 0.11 g/100 g DW) and acetone (4.87 ± 0.05 g/100 g DW). Composition analysis revealed that the total lipids were characterized by a high proportion of phospholipids, predominantly phosphatidylcholine and phosphatidylethanolamine. Furthermore, the obtained lipids were abundant in polyunsaturated fatty acids, particularly eicosapentaenoic acid and docosahexaenoic acid, which existed primarily in the form of phospholipids. Overall, the choline chloride–lactic acid DES proved to be an effective and environmentally friendly alternative for lipids extraction from shrimp heads, yielding lipids with excellent nutritional composition that hold great potential for development as novel functional oil ingredients.

Key words: Pacific white shrimp (*Litopenaeus vannamei*) heads, deep eutectic solvent, total lipids yield, phospholipids, polyunsaturated fatty acids.

基于美拉德反应增强鲍鱼肌肉蛋白-菊粉共轭物的油-水界面行为和乳化性能

李晋祯[1]，曹文红[1,2,3]，林海生[1,2,3]，高加龙[1,2,3]，陈忠琴[1,2,3]，郑惠娜[1,2,3*]

1. 广东海洋大学食品科技学院，广东湛江，524088；

2. 广东海洋大学深圳研究院，广东深圳，58120；

3. 国家贝类加工技术研发分中心(湛江)，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研究中心，广东湛江，524088.

摘要：【目的】为开发高品质、界面稳定的功能食品蛋白基料，构建了不同 pH 环境的鲍鱼肌肉蛋白（AMP）-菊粉共轭物。【方法】本研究通过美拉德反应制备了 AMP-菊粉共轭物，考察了中性和碱性 pH 对共轭物结构的影响，并解释不同 pH 对复合物的油水界面行为和乳化性能的调控规律。【结果】结果表明，碱性 pH 有效抑制了共轭物在热处理中的蛋白质聚集行为，提高了柔韧性，且 β-sheet 含量显著降至 15.41%，β-turn 含量上升至 36.13%。与中性 pH 的共轭物相比，碱性 pH 的共轭物的 Zeta 电位绝对值高达 24.57 mV，且具有良好的亲水性能（接触角为 51.73°）。此外，共轭物的构象变化促进了其在油-水界面的快速渗透和分子重排，并形成了抗变形的界面膜。同时，碱性 pH 的共轭物稳定的乳液表现出更均匀的液滴分布和更细小的液滴尺寸（19.99 μm）。相比之下，中性 pH 导致了 AMP 聚集体的形成，并限制了其在油-水界面的吸附行为。【结论】本研究揭示了共轭物多尺度结构与界面行为的内在关联，为开发良好界面性能的海洋食品蛋白基料提供参考依据。

关键词：鲍鱼肌肉蛋白；菊粉；pH 调节；美拉德反应；油-水界面行为

基金项目：国家重点研发专项（2024YFD2401805）；广东省现代农业产业技术体系贝藻创新（2024CXTD23）；广东省基础与应用基础研究基金（2024A1515010955)；现代农业产

业技术体系（CARS-49）

第一作者：李晋祯（1996-），男，在读博士研究生，研究方向为海洋蛋白界面调控与营养利用。E-mail：lijz@gdou.edu.cn

*__通讯作者：__郑惠娜（1979-），女，博士，教授，博士生导师，研究方向为海洋生物资源综合利用。E-mail：zhenghn@gdou.edu.cn

Enhancing oil-water interfacial behavior and emulsion properties of abalone muscle protein -inulin conjugates by Maillard reaction

Li Jinzhen[1], Cao Wenhong[1,2,3], Lin Haisheng[1,2,3], Gao Jialong[1,2,3], Chen Zhongqin[1,2,3], Zheng Huina[1,2,3*]

1. College of Food Science and Technology, Guangdong Ocean University, Zhanjiang 524088, China;

2. Shenzhen Institute of Guangdong Ocean University, Shenzhen 518108, China;

3. National Research and Development Branch Center for Shellfish Processing (Zhanjiang), Guangdong Provincial Key Laboratory of Aquatic Products Processing and Safety, Guangdong Provincial Engineering Technology Research Center of Seafood, Zhanjiang 524088, China.

Abstract: [Objective] To develop high-quality functional food protein ingredients with enhanced interfacial stability, abalone muscle protein (AMP)-inulin conjugates were prepared under different pH conditions. [Methods] AMP-inulin conjugates were produced via the Maillard reaction, and the effects of neutral and alkaline pH on conjugate structure were investigated. The regulatory effects of pH on oil-water interfacial behavior and emulsifying properties were further elucidated. [Results] Alkaline pH effectively inhibited protein aggregation of the conjugates during heat treatment and enhanced molecular flexibility, accompanied by a significant decrease in β-sheet content to 15.41% and an increase in β-turn content to 36.13%. Compared with the conjugates prepared at neutral pH, those prepared under alkaline conditions exhibited a higher absolute zeta potential of 24.57 mV and greater hydrophilicity, with a contact angle of 51.73°. Moreover, the pH-induced conformational changes promoted rapid penetration and molecular rearrangement of the conjugates at the oil-water

interface, facilitating the formation of a deformation-resistant interfacial film. Emulsions stabilized by the alkaline-pH conjugates also exhibited a more uniform droplet distribution and a smaller droplet size of 19.99 μm. In contrast, neutral pH promoted the formation of AMP aggregates and restricted their adsorption at the oil-water interface. [Conclusion] This study reveals the intrinsic relationship between the multiscale structure of AMP-inulin conjugates and their interfacial behavior, providing a theoretical basis for the development of marine-derived food protein ingredients with desirable interfacial properties.

Keywords: Abalone muscle protein; Inulin; pH-shift; Maillard reaction; Oil-water interfacial behavior

基于羟丙基壳聚糖多功能纳米载体实现微藻油双靶向递送以缓解结肠炎症

黄姗

中国水产科学研究院南海水产研究所，广东省广州市海珠区新港西路 231 号，510300

摘要：微藻油富含功能性脂质，具备肠道生理调节潜力，但游离态存在稳定性差、靶向富集能力弱、生物利用率低等问题，极大限制了其肠道调控应用。本研究以羟丙基壳聚糖为基质，通过多重共价修饰与非共价相互作用组装功能组分，构建兼具双靶向、结构稳定及荧光示踪性能的微藻油复合递送体系。结果表明，该体系可有效保护微藻油活性，提升其分散稳定性与结肠炎症靶向富集能力，显著提高生物利用率，减轻结肠炎症损伤、维持肠道生理稳态。本研究为微藻油肠道靶向高效利用提供了新技术思路，为炎症肠道膳食调控及活性脂质功能食品开发提供理论依据。

关键词：微藻油；羟丙基壳聚糖；递送体系；靶向递送；肠道稳态

资助项目：国家重大科技专项 (2024YFD2402103)

通讯作者：赵永强，男，博士，农业农村部水产加工重点实验室教授，研究方向为水产品质量与安全控制， zhaoyq@scsfri.ac.cn、

基于虾壳钙资源的柠檬酸接枝酪蛋白磷酸肽-钙螯合物的构建及其结构与稳定性研究

陶芳[1]，王宏[1]，蔡志成[1]，杨尚玲[1]，林琳[1]，陆剑锋[1*]

1. 食品与生物工程学院，合肥工业大学，安徽 合肥 230601

摘要:【目的】为实现虾壳资源高值化利用并提升肽-钙螯合物性能。【方法】以小龙虾壳提取钙源，构建柠檬酸接枝酪蛋白磷酸肽钙螯合体系（CA-CPP-Ca）。采用 EDC/NHS 偶联反应将柠檬酸接枝至 CPP 分子，并通过 FTIR、UV-Vis、荧光光谱及 XRD 对其结构进行表征，同时评价其钙结合能力、抗氧化活性及稳定性。【结果】柠檬酸接枝显著增强了 CPP 的钙螯合能力，钙结合能力和螯合率分别提高 22.3%和 42.0%，并提升抗氧化活性。结构分析显示 Ca^{2+}主要与羧基、磷酸基等官能团配位。稳定性实验表明，该螯合物在不同环境条件及模拟消化过程中具有较高钙保留率。【结论】本研究为虾壳钙资源的高效利用及新型补钙剂开发提供了理论依据。

关键词：小龙虾壳；柠檬酸接枝；酪蛋白磷酸肽；钙螯合物

通讯作者：陆剑锋，男，教授，博士，研究方向为水产品加工及综合利用。E-Mail：lujf@sibs.ac.cn

基金项目：国家重点研发计划项目（2023YFD2401500）；财政部和农业农村部: 国家现代农业产业技术体系项目（CARS-47）；安徽省农业科研体系计划项目（AARS-08）

基于纤维素纳米材料稳定的草果精油 Pickering 乳液的制备及表征

李加孔[1]，李川[2*]

海南大学食品科学与工程学院，中国海口，570228

摘要：开发以纤维素纳米材料稳定的草果精油 Pickering 乳液，提升精油的水分散性、稳定性及功能活性。草果自然晾干后粉碎，通过水蒸气蒸馏提取其精油，以纤维素纳米晶（CNC）和 TEMPO 氧化纳米纤维素（TOCNF）为复合稳定剂，草果精油为油相，引入低聚丙烯酸钠修饰的纳米 ZnO（PAAS@ZnO），采用高速剪切结合高压微射流均质制备 Pickering 乳液。结果表明，草果精油主要成分为桉叶油醇和香叶醇，其通过缩短细菌的对数生长期来抑制细菌的生长，对细菌细胞形态和细胞完整性具有明显破坏作用。草果精油 Pickering 乳液平均粒径为 561.9 nm，Zeta 电位为-32.056 mV，4°C 储存 30 d 无明显分层，对金黄色葡萄球菌、荧光假单胞菌、希瓦氏菌均表现出明显抑菌活性。综上所述，所制乳液具有良好的稳定性及优异的抗菌性能。

关键词：纤维素纳米晶；TEMPO 氧化纳米纤维素；Pickering 乳液；草果精油；抗菌

Preparation and Characterization of a Pickering Emulsion of Amomun tsao-ko Crevost et Lemaire Essential Oil Stabilized with Cellulose Nanomaterials

Jiakong Li[1], Chuan Li[2*]

1. School of Food Science and Engineering, Hainan University, Haikou 570228, China.

Abstract：Develop a Pickering emulsion stabilized with cellulose nanomaterials to stabilize *Amomun tsao-ko* Crevost et Lemaire essential oil, thereby enhancing the oil's water dispersibility, stability, and functional activity. *Amomun tsao-ko* Crevost et Lemaire was crushed after natural drying, and *Amomun tsao-ko* Crevost et Lemaire Essential Oil was extracted via steam distillation. Cellulose nanocrystals (CNC) and TEMPO-oxidized nanocellulose (TOCNF) were used as composite stabilizers, with *Amomun tsao-ko* Crevost et Lemaire Essential Oil serving as the oil phase, and sodium acrylate-modified nano-ZnO (PAAS@ZnO) was introduced to prepare a Pickering emulsion

using high-shear mixing combined with high-pressure microjet homogenization. The results show that the main components of *Amomun tsao-ko* Crevost et Lemaire essential oil are eucalyptol and geraniol, which inhibit bacterial growth by shortening the logarithmic growth phase and have a significant destructive effect on bacterial cell morphology and cell integrity. The *Amomun tsao-ko* Crevost et Lemaire Essential Oil Pickering emulsion had an average particle size of 561.9 nm and a zeta potential of -32.056 mV. It showed no significant separation after 30 days of storage at 4 ℃ and exhibited significant antibacterial activity against *Staphylococcus aureus*, *Pseudomonas fluorescens*, and *Shewanella species*. In summary, the prepared emulsion exhibits good stability and excellent antibacterial properties.

Key words: Cellulose nanocrystals; TEMPO-oxidized cellulose nanofibrils; Pickering emulsion; *Amomun tsao-ko* Crevost et Lemaire essential oil; Antibacterial

基于相关性网络和差异代谢通路探究多菌株接力发酵对高盐鱼露风味和品质的改善机制

马石尼，李春生*

中国水产科学研究院南海水产研究所，农业农村部水产品加工重点实验室，广州 510300

摘要：传统高盐鱼露的风味独特，但由于高盐对微生物代谢的抑制作用，依靠自然发酵促使鱼露品质和风味形成的过程较为漫长，导致鱼露生产周期过长，严重制约了鱼露产业的发展。本研究模拟传统发酵鱼露微生物群落变化，以产耐盐蛋白酶菌（枯草芽孢杆菌）和鱼露风味形成菌（盐渍四生球菌）接力发酵的方式促进高盐鱼露品质和风味的形成，并以产耐盐蛋白酶菌（BS 组）与鱼露风味形成菌（TM 组）等单菌加菌组和自然发酵组（NF 组）为对照组，系统研究多菌株接力发酵（RF 组）对高盐鱼露风味和品质的影响机制。结果发现，单菌加菌和接力发酵均能够显著降低微生物群落多样性，其中接力发酵微生物群落的丰富度和均匀度最低。BS 组中芽孢杆菌属和 TM 组中四生球菌属在发酵过程中始终占据主导地位，相对丰度分别超过 67.57 %和 74.08%；RF 组中，第 1 个月芽孢杆菌相对丰度达 84.85%，第 2 个月接入盐渍四生球菌后，芽孢杆菌迅速降至 25.29%，四生球菌占据主导（63.94%）并延续至发酵末期，在接力发酵过程中两者总相对丰度超过 88%。嗜冷杆菌属、副球菌属、不动杆菌属和假单胞菌属的生长均受到明显抑制，在 RF 组中尤为显著，这 4 个菌属的总相对丰度由 NF 组的 46.61%降至 3.67%。在 RF 组中，游离氨基酸的含量显著增加，大部分氨基酸，特别是谷氨酸和天冬氨酸的含量明显高于 NF 组和 TM 组；油酸、亚油酸、α-亚麻酸和花生四烯酸等不饱和脂肪酸含量也较 NF 组和 BS 组显著增加。利用挥发性气味组学筛选出 32 种核心挥发性风味物质，其中 RF 组中多数具有愉悦风味物质的含量较 NF 组和 BS 组明显提升，三甲胺和甲硫醇等具有不良风味物质的含量显著下降。组间维度相关性分析表明，两种发酵菌株与大多数具有愉悦风味的挥发性物质、游离氨基酸和游离脂肪酸呈显著正相关，对这些物质的增加贡献最大。本研究构建了高盐鱼露的微生物差异代谢通路，结果表明，接力发酵后油酸、亚油酸、亚麻酸和花生四烯酸等游离脂肪酸含量的提高最明显，这些游离脂肪酸主要通过氧化和代谢途径在改善鱼露气味方面发挥主要作用；且接力发酵后鲜味和甜味氨基酸的增加有助于鱼露滋味的改善。本研究结果为传统高盐鱼露的提质增效提供重要理论依据和技术支撑。

关键词：鱼露；接力发酵；微生物群落；风味；组间维度相关性；差异代谢通路

资助项目：国家自然科学基面上项目（32272348）
通讯作者：李春生，研究员，中国水产科学研究院南海水产研究所，电话：020-89020911，E-mail: lichunsheng@scsfri.ac.cn

基于虚拟筛选制备鲣鱼暗色肉来源的 α-淀粉酶与 α-葡萄糖苷酶双抑制肽

罗晓诺、李佳佳、汪舟扬、李高尚、黄涛、杨文鸽

单位 宁波大学食品科学与工程学院，地区 浙江宁波，邮编 315211

摘要：本研究整合虚拟筛选、酶解、色谱分离、肽组学鉴定及分子模拟技术，系统挖掘鲣鱼（Katsuwonus pelamis）暗色肉来源的α-淀粉酶和α-葡萄糖苷酶双靶点抑制肽。BIOPEP-UWM 数据库分析表明，鲣鱼暗色肉蛋白具有较高的活性肽释放潜力。经胃蛋白酶酶解（37 ℃、pH 3.0、3 h），Sephadex G-25 分离，获得的 F3 组分表现出最强的 α-淀粉酶和 α-葡萄糖苷酶抑制活性，并鉴定获得 179 条肽序列。结合生物活性预测、毒性评估、水溶性分析及分子对接筛选得到 15 条候选活性肽，其中三条肽 DMEKIWHHTF、IEKPMGIF 和 EKIWHHTF 可通过氢键、疏水作用及静电相互作用与两种靶酶形成稳定结合，100 ns 分子动力学模拟进一步验证了其复合物构象稳定性。本研究为鲣鱼暗色肉高值化利用及天然降糖功能因子的开发提供了理论依据。

关键词：鲣鱼暗色肉；α-淀粉酶；α-葡萄糖苷酶；抑制肽；分子动力学模拟

资助项目：国家重点研发计划课题（2024...）

通讯作者：杨文鸽，女，工学博士，教授、博士生导师，研究方向为水产食品化学、水产品保鲜与精深加工及水产食品营养与健康；

电话：13958208678；

E-mail：yangwenge@nbu.edu.cn。

基于鱼骨颗粒制备鱼油基 Pickering 乳液：一种资源回收的双重增值策略

夏梓洋　罗颖颖　刘晏玮　叶贝贝　仪淑敏　励建荣　刘慈坤*　李学鹏*

渤海大学，辽宁锦州，121013

摘要：实现鱼加工副产物的高效回收利用，对推动循环经济具有重要意义。本文提出一种鱼骨与鱼油双重高值化的资源循环策略：利用自上而下球磨法制备的鱼骨颗粒构建鱼油基皮克林乳液，并将其作为品质增强剂用于改善乳化鱼糜凝胶的品质。结果表明：球磨时间由 5 min 延长至 60 min，鱼骨颗粒平均粒径由 1772.9 nm 显著降至 219.7 nm，Zeta 电位绝对值增大。光谱分析证实，鱼骨颗粒主要由天然羟基磷灰石-胶原蛋白复合物构成，且延长球磨时间可破坏矿物-有机复合基质的团聚结构。此外，球磨鱼骨颗粒可作为改性颗粒稳定鱼油基皮克林乳液，乳液稳定性受颗粒浓度与油水比调控。当颗粒质量分数为 3.0 wt%、油水比 0.6 时，球磨 20 min、30 min 的鱼骨颗粒（FBPs-20、FBPs-30）相较其它样品可在油水界面实现更优异的吸附，在乳液液滴周围形成致密微观结构。该界面结构能够抑制水分与鱼油迁移，并赋予乳液独特的黏弹特性。最后，添加 6 wt% FBPs-30 制备的乳液可改善乳化鱼糜凝胶的质构性能，证明其具备作为品质改良剂的应用潜力。综上，本研究促进了鱼类加工副产物的可持续利用，并为开发新型皮克林颗粒提供了参考。

关键词：资源回收；鱼骨颗粒；鱼油；Pickering 乳液；界面结构

项目来源:1、山东省泰山产业创新领军人才项目；2、辽宁省“兴辽英才计划”项目；3、“十四五”国家重点研发计划子课题。

通讯作者 1：刘慈坤，男，博士，讲师。研究方向：水产品绿色加工、食品胶体与界面化学；手机：19850152366；邮箱：LiuCK923@163.com。

通讯作者 2：李学鹏，男，博士，二级教授。研究方向：大宗水产品贮藏加工与高值化利用；手机：15841668528；邮箱：xuepengli8234@163.com。

Fabrication of Fish Bone Particle-Stabilized Fish Oil Pickering Emulsions: A Dual-Valorization Approach for Resource Recovery

Xia Ziyang Luo Yingying Liu Yanwei Ye Beibei Yi Shumin Li Jianrong Liu Cikun* Li Xuepeng*

School of Food Science and Engineering, Bohai University, Jinzhou 121013, Liaoning

ABSTRACT: Effective recycling of fish processing by-products as new high-value resources is of great significance to promoting the circular economy. This study proposes a resource recycling strategy for the dual valorization of fish bone and fish oil: fish bone particles prepared by a top-down ball-milling method were used to construct fish oil-based Pickering emulsions, which were then applied as quality enhancers to improve the quality of emulsified surimi gels (ESGs). Results showed that extending the ball milling duration from 5 to 60 min significantly reduced the average particle size of FBPs from 1772.9 to 219.7 nm and increased their absolute value of zeta potential. Spectroscopic analysis confirmed FBPs composed of native hydroxyapatite-collagen composites, with prolonged ball milling disaggregating the mineral-organic matrix. Additionally, ball-milled FBPs could serve as engineered particles to stabilize fish oil-based Pickering emulsions, with emulsion stability influenced by particle concentration and oil-water ratios. At a particle concentration of 3.0 wt % and an oil-water ratio of 0.6, the FBPs milled for 20 and 30 min (FBPs-20 and FBPs-30) exhibited superior adsorption at the oil-water interface compared to other samples, forming dense microstructures around emulsion droplets. Such interfacial structures limited the migration of water/fish oil and exhibited unique viscoelastic properties. Finally, 6 wt % FBPs-30-based emulsion enhanced the textural attributes of ESGs, illustrating their potential as functional additives. Overall, this study promotes the sustainable utilization of fish processing by-products and provides a reference for the development of novel Pickering particles.

KEYWORDS: recycling; fish bone particles; fish oil; Pickering emulsion; interfacial structure

基于预糊化和油脂填充调控面糊多相胶体网络：对油炸裹糊文蛤品质的提升作用

程雪冰　刘晏玮　叶贝贝　仪淑敏　励建荣　刘慈坤*　李学鹏*

渤海大学，辽宁锦州，121013

摘要：油炸裹糊食品因其独特的酥脆口感和风味特征而受到广泛消费者的青睐，但在油炸后的贮藏过程中仍面临诸多品质问题，其中过量吸油以及质构酥脆性的快速下降是限制其品质保持的主要因素。本研究探讨了预糊化处理和油滴填充对面糊流变特性及胶体网络结构的影响，并进一步分析其对油炸裹糊文蛤色泽、质构、脂肪含量及挥发性风味成分的调控作用。研究结果表明，淀粉-面粉-亲水胶体（亚麻籽胶、瓜尔胶和黄原胶）复合面糊经预糊化处理后，形成了具有脂质锚定微区特征的多相胶体网络，其表观黏度和粘弹性模量均显著提高，进一步增强了面糊体系的多相稳定性。未经处理组（CK）和添加油脂对照组（CKO）的面糊挂糊率分别为 17.4%和 19.3%，而经过预糊化处理、油滴填充并添加亚麻籽胶的处理组（G-FGO）的裹糊率提高至 72.1%。面糊性能的改善主要归因于油滴填充的致密有序网络结构的形成，其可能作为一种稳定的多功能屏障，在油炸过程中调控水分快速蒸发过程。与 CKO 组相比，经过预糊化处理、添加脂质以及亚麻籽胶（G-FGO 组）、瓜尔胶（G-GGO 组）和黄原胶（G-XGO 组）的样品，其吸油量显著降低，断裂力明显提高，表现出更优的质构保持能力。此外，经过上述处理后，油炸裹糊文蛤中特征性风味化合物（己醛、壬醛、（E,E）-2,4-癸二烯醛、E-2-十一烯醛等）的含量显著增加，进一步改善了产品的风味品质。总之，通过预糊化处理和油滴填充调控面糊多相胶体网络结构，可提高油炸水产品品质，实现高品质油炸食品的工业化生产。

关键词：胶体网络结构；预糊化；脂质填充；裹糊油炸文蛤；油脂含量

项目来源:“十四五”国家重点研发计划子课题。

通讯作者 1：刘慈坤，男，博士，讲师。研究方向：水产品绿色加工、食品胶体与界面化学；手机：19850152366；邮箱：LiuCK923@163.com。

通讯作者 2：李学鹏，男，博士，二级教授。研究方向：大宗水产品贮藏加工与高值化利用；手机：15841668528；邮箱：xuepengli8234@163.com。

Tailoring the multiphase colloidal network of batters through controlled pre-gelatinization and oil droplets filling: Enhancement effects on quality of deep-fried battered clams

Cheng Xuebing　Liu Yanwei　Ye Beibei　Yi Shumin　Li Jianrong　Liu Cikun*　Li Xuepeng*

School of Food Science and Engineering, Bohai University, Jinzhou 121013, Liaoning

ABSTRACT: Deep-fried battered foods are widely consumed but face significant quality challenges, primarily excessive oil uptake and the rapid loss of textural crispness during post-frying storage. In this study, effects of targeted pre-gelatinization and oil droplets filling on the rheological properties and colloidal network of batters were investigated, along with their subsequent impact the color, texture, fat content, volatile flavor components of deep-fried battered clams. Results showed that the starch-flour-hydrocolloid (flaxseed, guar, or xanthan gum) based batters with lipid-anchored micro-domains exhibited higher apparent viscosity and viscoelastic moduli after pre-gelatinization, further enhancing the multiphase stability. The pick-up ratios of the batter in the untreated (CK) and oil-added (CKO) controls were 17.4% and 19.3%, respectively, whereas the corresponding value in the pre-gelatinized group with oil droplets filling and flaxseed gum (G-FGO) reached 72.1%. The improvement in the batters was related with the formation of dense and ordered networks filled with oil droplets, which might function as robust multifunctional barriers regulating the rapid evaporation of moisture during frying. The marked reduction in oil uptake and increasement of fracture force were observed in the sample treated with gelatinization, lipid incorporation and flaxseed gum (G-FGO group), guar gum (G-GGO group), or xanthan gum (G-XGO group), when compared to the CKO group. Furthermore, the specific flavor compounds including hexanal, nonanal, (E,E)-2,4-

decadienal, E-2- undecenal, etc., in battered clams increased significantly after treatment. These findings provided us that regulating the multiphase colloidal network of batters via gelatinization and oil droplets filling offers a potential industrial application for the production of high-quality fried seafood.

KEYWORDS: Colloidal network; pre-gelatinization; lipid incorporation; deep-fried battered clams; fat content

减盐水产凝胶食品的基质结构重构与风味协同调控

李德阳

大连工业大学食品学院，辽宁 大连，116034

摘要：针对减盐导致水产凝胶食品肌原纤维蛋白溶出受限、凝胶网络弱化及盐味与风味下降等问题，围绕食品基质重构与钠离子迁移调控开展系统研究。采用超高压、高压均质等物理加工，并引入外源蛋白和多糖调节蛋白构象及分子相互作用，构建蛋白多糖载钠水凝胶。光谱、显微、流变及模拟口腔加工结果表明，蛋白展开及疏水作用、二硫键交联增强促进致密网络形成，改善减盐虾糜和磷虾糜的凝胶强度、持水性及结构稳定性。载钠水凝胶通过构建非均一钠分布并调控口腔释放行为，提高盐味感知效率并延长盐味持续时间；物理场协同外源蛋白还可改善挥发性风味释放。研究揭示了基质结构、钠离子迁移与感官品质之间的关联，为减盐水产凝胶食品品质协同提升提供理论依据。

关键词：减盐水产凝胶食品；基质结构重构；蛋白多糖水凝胶；钠离子迁移；盐味感知

资助项目：“十四五”国家重点研发计划项目子课题-中华传统水产食品工业化生产中特征品质保持技术研究（2024YFD2101504-3）

作者介绍：李德阳，男，博士，副教授。研究方向：水产品加工理论与技术。电话：18742068187。邮箱：dpuldy@163.com

Matrix Structural Remodeling and Coordinated Regulation of Flavor in Reduced-Salt Aquatic Gel Foods

Deyang Li

School of Food Science and Technology, Dalian Polytechnic University, Dalian, 116034, Liaoning

Abstract: Salt reduction in aquatic gel foods often leads to limited myofibrillar protein solubilization, weakened gel networks, and diminished saltiness and flavor. To address these challenges, systematic studies were conducted focusing on food matrix remodeling and sodium ion migration. Ultra-high-pressure processing and high-pressure

homogenization were combined with exogenous proteins and polysaccharides to modulate protein conformation and intermolecular interactions, while protein–polysaccharide sodium-loaded hydrogels were constructed. Spectroscopic, microscopic, rheological, and simulated oral processing analyses demonstrated that protein unfolding, together with enhanced hydrophobic interactions and disulfide cross-linking, promoted the formation of dense gel networks, thereby improving gel strength, water-holding capacity, and structural stability in reduced-salt shrimp surimi and Antarctic krill surimi. The sodium-loaded hydrogels enhanced saltiness perception and prolonged salty taste by creating heterogeneous sodium distributions and regulating sodium release during oral processing. In addition, physical processing in combination with exogenous proteins facilitated the release of volatile flavor compounds. These findings reveal the relationships among matrix structure, sodium ion migration, and sensory quality, providing a theoretical basis for the coordinated improvement of quality in reduced-salt aquatic gel foods.

Key words: Reduced-salt aquatic gel foods; Matrix structural remodeling; Protein–polysaccharide hydrogel; Sodium ion migration; Saltiness perception

交变磁场处理降低中华绒螯蟹原肌球蛋白 IgE 结合活性并保持蟹肉品质

宋媛[1,2]，陆剑锋[1,2,*]，林琳[1,2,*]

1. 合肥工业大学食品与生物工程学院，安徽合肥，230601；2. 安徽省农产品现代加工重点实验室，安徽合肥，230601

摘要：【目的】筛选可降低中华绒螯蟹原肌球蛋白（TM）IgE 结合活性并保持蟹肉品质的非热加工方式。【方法】比较水浸、等离子体活化水、超声、超声联合等离子体活化水、静磁场和交变磁场（AMF）6 种处理，并考察不同 AMF 处理时间，分析 TM IgE 结合活性、结构特性及蟹肉品质。【结果】AMF 效果最佳，6 mT、50 Hz 处理 30 min 后 TM 相对 IgE 结合活性降至 70.19%；同时诱导 TM 聚集并改变表面特性，但未见明显多肽降解。蟹肉主要不易流动水比例维持在 97.63%～97.97%，理化性质、热稳定性、色泽和风味变化较小。【结论】AMF 可在较好保持蟹肉品质的同时降低 TM IgE 结合活性。

关键词：中华绒螯蟹；原肌球蛋白；交变磁场；IgE 结合活性；蟹肉品质

资助项目：国家重点研发计划（2023YFD2401500）；国家现代农业产业技术体系项目（CARS-47）；安徽现代农业产业技术体系项目（AARS-08）
通讯作者：陆剑锋，男，博士，教授，研究方向为水产品加工及综合利用，E-mail: lujf@sibs.ac.cn

交变磁场频率对罗非鱼片冻融过程及贮藏品质的影响

杨智燕 1，冯爱国*2

食品科学与工程学院，海南大学，海口，570228

摘要：为改善罗非鱼片冻融与冻藏品质，探究交变磁场频率的调控作用。在 5 mT 磁场下，以 50~250 Hz 交变磁场辅助罗非鱼片冷冻和解冻，以无磁场为对照，测定冻结曲线、质构、水分及蛋白氧化指标；选取最优频率进行 84 d 冻藏试验，比较全程施磁（FS-MF）、仅冷冻施磁（F-MF）与无磁场（N-MF）三种方式。冷冻以 200 Hz 最优，冻结时间最短，冰晶细小均匀，解冻后质构损失最小；解冻以 250 Hz 最优，解冻时间与损失降低，蛋白氧化受抑制；冻藏全程施磁可减缓水分流失、质构劣变及蛋白与脂质氧化。交变磁场能改善罗非鱼片冻融与冻藏品质，以 200 Hz 冷冻、250 Hz 解冻并全程施磁最优。

关键词：罗非鱼片；交变磁场频率；冻融；贮藏品质；冰晶

本研究得到国家自然科学基金（32460636）；海口市科技项目（编号 2024-010）资助。

通讯作者：冯爱国，男，硕士研究生，副教授，水产品加工及贮藏工程，13648669586，sxfag@163.com。

Effect of Alternating Magnetic Field Frequency on the Freeze-Thaw Process and Storage Quality of Tilapia Fillets

Zhiyan Yang [1],Aiguo Feng*[2]

School of Food Science and Engineering, Hainan University, Haikou 570228, Hainan, China

Abstract: To improve the freeze-thaw and frozen storage quality of tilapia fillets and to clarify the effect of alternating magnetic field (AMF) frequency. Under 5 mT, tilapia fillets were frozen and thawed with an AMF at 50-250 Hz, with no field as the control; the freezing curve, texture, water state and protein oxidation were determined, and the optimal frequency was applied in an 84 d frozen storage experiment with the field applied throughout freezing and storage (FS-MF), only during freezing (F-MF), or not at all (N-MF). Freezing at 200 Hz was optimal, giving the shortest freezing time, small and uniform ice crystals and the least texture loss; thawing at 250 Hz was optimal, reducing thawing time and loss and inhibiting protein oxidation; applying the field throughout storage

retarded water loss, texture deterioration and protein and lipid oxidation. The AMF improves the freeze-thaw and frozen storage quality of tilapia fillets, and freezing at 200 Hz and thawing at 250 Hz with the field applied throughout storage is optimal.

Key words: Tilapia fillets; Alternating magnetic field frequency; Freeze-thaw; Storage quality; Ice crystal

胶原蛋白肽-壳寡糖复合物的构建及表征

潘田娣，林端权*

集美大学海洋食品与生物工程学院，福建厦门，361021

摘要：以鳕鱼皮胶原蛋白肽和壳寡糖为研究对象，考察不同配比对胶原蛋白肽-壳寡糖复合物结构及功能性质的影响。通过静电相互作用制备胶原蛋白肽-壳寡糖复合物，采用傅里叶红外光谱、圆二色谱、接触角测定及抗氧化活性等方法，对复合物的结构、润湿性和抗氧化性进行表征。结果表明：随着壳寡糖质量分数的增加，复合物 Zeta 电位由 4.83 mV 增至 32.13 mV，表明颗粒间静电排斥作用增强；傅里叶变换红外光谱证实胶原蛋白肽与壳寡糖通过氢键成功复合；接触角测定显示胶原蛋白肽具有亲水性，适量壳寡糖可进一步改善其亲水性；抗氧化活性结果显示，复合物对 DPPH 和 $ABTS^{+}$自由基的清除率分别由纯胶原蛋白肽的约 8%和 3.5%提高至约 29.0%和 20.5%，为鳕鱼皮胶原蛋白肽的高值化利用提供了理论依据与应用基础。

关键词：胶原蛋白肽；壳寡糖；复合物；结构表征；抗氧化活性

通讯作者：林端权，男，工学博士，副教授，主要研究方向为水产品加工贮藏。联系方式：15606066383，dq.lin@jmu.edu.cn

胶原蛋白肽通过 AMPK/PGC-1α 与 NRF2/HO-1 双通路改善能量代谢和氧化损伤的抗疲劳机制研究

马晓雨 1，程述震 1*，杜明 1，2*

（1. 大连工业大学食品学院，海洋食品加工与安全控制全国重点实验室，国家海洋食品工程技术研究中心，辽宁 大连 116034

2. 大连海洋大学食品学院，辽宁 大连 116023）

摘要：目的：考察羊皮胶原蛋白肽（SSCPs）的抗运动性疲劳活性并解析其机制，为胶原加工副产物高值化利用提供依据。方法：以 0.128、0.773 g/(kg·d)剂量灌胃小鼠建立力竭游泳模型，检测疲劳及氧化应激相关指标，结合 qRT-PCR、Western blot 及 C2C12 细胞氧化应激模型，解析 AMPK/PGC-1α 与 NRF2/HO-1 通路的调控作用。结果：SSCPs 富含精氨酸和支链氨基酸；灌胃组力竭游泳时间较模型组延长 55%，血清 LD、LDH、CK 显著降低，慢肌纤维比例与 ATP 含量升高，AMPK、PGC-1α 表达上调；同时 NRF2 核易位增强、Keap-1 表达下降，SOD、GSH-Px、HO-1 升高，MDA 及 ROS、8-OHdG 损伤减少，线粒体功能改善。结论：SSCPs 通过 AMPK/PGC-1α 轴促进能量代谢、经 NRF2/HO-1 轴缓解氧化损伤，协同发挥抗疲劳作用，有望开发为新型运动营养补充剂。

关键词：胶原蛋白肽；抗疲劳；能量代谢；氧化应激；线粒体功能

基金项目：大连市高层次创新型人才团队项目（2023RG005）

通讯作者：杜明，男，大连海洋大学，教授，研究方向：蛋白质资源开发与利用，电话：15941154727，邮箱：duming121@163.com；

程述震，男，大连工业大学，副教授，研究方向：海洋活性蛋白肽的结构功能解析与健康调控机制研究，电话：13654980547，邮箱：chengshuzhen0547@yeah.net。

Collagen peptides against exercise-induced fatigue: dual regulation of AMPK/PGC-1α and NRF2/HO-1 signaling

Xiaoyu Ma 1, Shuzhen Cheng 1*, Ming Du 1,2*

(1. School of Food Science and Technology, Dalian Polytechnic University, National Engineering Research Center of Seafood, Dalian 116034, China

2. College of Food Science and Engineering, Dalian Ocean University, Dalian 116023, Liaoning, China)

Abstract: Objective: To investigate the anti-fatigue activity of sheep skin collagen peptides (SSCPs) and elucidate the underlying mechanisms, providing a theoretical basis for the high-value utilization of collagen-rich processing by-products. Methods: A mouse exhaustive swimming model was established with SSCPs gavage at 0.128 and 0.773 g/(kg·d). Fatigue and oxidative stress indices were determined, and the AMPK/PGC-1α and NRF2/HO-1 pathways were dissected using qRT-PCR, Western blotting and an H2O2-induced C2C12 model. Results: SSCPs were rich in arginine and branched-chain amino acids. SSCP administration prolonged exhaustive swimming time by 55%, reduced serum LD, LDH and CK levels, increased slow-twitch fiber proportion and ATP content, and upregulated AMPK and PGC-1α expression. Meanwhile, SSCPs enhanced NRF2 nuclear translocation, downregulated Keap-1, elevated SOD, GSH-Px and HO-1 expression, reduced MDA accumulation, and ameliorated ROS generation, 8-OHdG formation and mitochondrial dysfunction. Conclusion: SSCPs exert anti-fatigue effects by enhancing energy metabolism via the AMPK/PGC-1α axis and attenuating oxidative damage via the NRF2/HO-1 axis, showing potential as novel sports nutritional supplements.

Key words: collagen peptides; anti-fatigue; energy metabolism; oxidative stress; mitochondrial function

胶原蛋白源 Fe^{2+}结合活性肽：结合 Fe^{2+}的关键氨基酸及其提高细胞 Fe^{2+}生物利用度的机制

林善婷

广西壮族自治区农业科学院，广西 南宁，530007

摘要：本研究旨在通过分子动力学模拟技术以及质谱鉴定技术明确胶原蛋白源 Fe^{2+}结合活性肽与 Fe^{2+}结合的关键氨基酸及其结合模式，同时利用多光谱学及形态学表征手段表征其结构与形态差异，并基于 Caco-2 细胞单层模型探索肽-Fe^{2+}结合物增强细胞 Fe^{2+}生物利用度的机制。结果表明，肽链中-Glu-Glu-基序在 Fe^{2+}结合中起着至关重要的作用，采用双齿或多齿结合模式。尽管 N 末端疏水残基（Gly、Leu、Hyp、Pro）没有直接与 Fe^{2+}结合，但它们在稳定肽构象方面发挥了重要作用。肽和肽-Fe^{2+}结合物表现出不同的结构和形态。此外，肽-Fe^{2+}结合物显著提高了细胞内 Fe^{2+}的转运/保留/利用率，增加了细胞内铁蛋白水平，并调节了 DMT1、PCBP2 和 FPN1 蛋白的表达。肽-Fe^{2+}结合物对 Fe^{2+}转运的改善是通过多种途径介导的，包括内吞作用、细胞旁途径和 DMT1。本研究为开发 Fe^{2+}结合活性肽作为潜在的膳食铁补充剂提供有价值的见解。

关键词：Fe^{2+}结合活性肽；关键氨基酸；Fe^{2+}结合模式；结构表征；细胞转运机制

Collagen-derived Fe2+-chelating peptide: Key amino acids for Fe2+ chelating and mechanisms for enhancing cellular Fe2+ bioavailability

Shanting Lin

1. Guangxi Academy of Agricultural Sciences, Nanning, 530007

Abstract: This study aimed to identify the key amino acids and modes for chelation between peptides and Fe^{2+}, characterize the structural and morphological differences, and explore the mechanisms by which peptide-Fe^{2+} complexes enhanced cellular Fe^{2+} bioavailability. The results

demonstrated that the -Glu-Glu- motif played a crucial role in Fe^{2+} chelation, adopting bidentate or multidentate chelating mode. Interestingly, although the C-terminal hydrophobic residues (Gly, Leu, Hyp, Pro) didn't directly chelate with Fe^{2+}, they played an essential role in stabilizing the peptide conformation. Moreover, peptides and peptide-Fe^{2+} complexes exhibited different structures and morphologies. Additionally, peptide-Fe^{2+} complexes significantly enhanced cellular Fe^{2+} transport/retention/utilization rate, increased intracellular ferritin levels, and modulated the expression of DMT1, PCBP2, and FPN1 proteins. The improvement of Fe^{2+} transport by peptide-Fe^{2+} complexes was mediated through multiple pathways including endocytosis, paracellular pathway, and DMT1. These findings can provide valuable insights for the development of Fe^{2+}-chelating peptides as potential dietary iron supplements.

Key words: Fe^{2+}-chelating peptide; key amino acids; Fe^{2+} chelating mode; structural characterization; cellular transport mechanism

交直流电场协同对微冻凡纳滨对虾的保鲜效果及作用机制

范泽楷，李晨，陈兵，王宁，张浩，董士远*

中国海洋大学食品科学与工程学院，山东青岛，266000

摘要 目的：本研究设计并开发了一种高压静电场与交变电场联用（High-voltage static electric field combined with alternating electric field，HS-AEF）的处理模式，并验证其对微冻对虾贮藏品质的改善效果，探讨相关机制。方法：HS-AEF 处理模式为每 24 h 交替施加 SEF 和 AEF，电极板采用芒刺形式，输出电压 3 kV，板间距 10 cm。结果：AEF 的整体保鲜效果优于静电场 SEF，但两者对贮藏损失的作用呈现相反的结果。与单独 HAEF 处理相比，HS-AEF 处理在后期贮藏阶段表现出更优的整体效果，贮藏损失降低 24.36%，同时改善肌肉结构和完整性。HA-SEF 处理显著抑制肌原纤维蛋白的羰基化及 α-螺旋向 β-转角的构象转变，并减少组织蛋白酶的活性。结论：HS-AEF 处理体系有效地减少内源酶、微生物和冰晶对肌肉组织的破坏作用，有助于长期保持微冻对虾的品质。

关键词 交流电场；静电场；肌原纤维蛋白；内源蛋白酶；凡纳滨对虾

本研究由海南省重点研发项目（(ZDYF2025GXJS193）和山东省自然科学基金（ZR2024MC184）的支持。

通讯作者：董士远，男，博士，教授，水产品贮藏与加工，13869845385，dongshiyuan@ouc.edu.cn

介质阻挡放电低温等离子改善三角帆蚌肌原纤维蛋白乳液冻融稳定性：结构修饰及其内在机制

李尚坤 1，史记 1，杨海龙 1，蔡晨 1，施文正 1，2，*

1. 上海海洋大学，中国上海，201306；2. 国家淡水水产品加工技术研发（上海）分中心，中国上海，201306

摘要：本研究旨在探究介质阻挡放电低温等离子（CP）处理对三角帆蚌肌原纤维蛋白（MP）结构、乳化特性及其乳液冻融稳定性的影响，并阐明其内在作用机制。通过分析 MP 的粒径、表面疏水性、巯基含量、二级结构等特性，揭示蛋白结构变化。进一步结合乳液粒径、界面蛋白吸附、微观结构、流变特性评价其乳化功能。适度 CP 处理能够促进 MP 分子展开，暴露内部疏水基团和活性位点。MP 能够更有效地吸附于油–水界面，形成更加致密和稳定的界面层，并增强乳液体系的黏弹性。冻融处理后，改性 MP 稳定的乳液表现出较小的粒径变化和较低的液滴聚集程度。综上所述，适度 CP 处理可通过调控 MP 分子结构及界面行为，提高三角帆蚌 MP 的乳化性能和乳液冻融稳定性。

关键词：三角帆蚌；肌原纤维蛋白；低温等离子体；冻融稳定性

资助项目：国家重点研发计划（2019YFD0902003）；通讯作者：施文正，男，博士，教授，水产品加工与贮藏，15692165859，wzshi@shou.edu.cn。

静磁场辅助液氮与鼓风速冻对罗非鱼品质及蛋白氧化的影响

曾丽仙 1，冯爱国* 2

食品科学与工程学院，海南大学，海口，570228

摘要：本研究探究静磁场辅助液氮速冻与鼓风速冻对冻藏罗非鱼片品质稳定性及肌原纤维蛋白构象的影响。采用 85–105 mT 静磁场分别耦合液氮速冻（LNF）、鼓风速冻（BF）处理罗非鱼片，于−18 ℃冻藏 12 周，测定冻结参数、理化指标与蛋白结构变化。结果表明：静磁场缩短冻结时长与最大冰晶生成阶段，生成细小均匀冰晶，减轻组织损伤、降低汁液流失；85–105 mT 静磁场–LNF 组解冻损失最低（5.41%）、持水性最高（75.46%）。静磁场抑制 TVB-N、TBARS 累积，减缓蛋白羰基化与巯基氧化，维持 α 螺旋结构稳定。总之，静磁场辅助速冻可有效延缓罗非鱼片冻藏品质劣变，在高值水产品保鲜领域具备良好应用前景。

关键词：罗非鱼片；静磁场；速冻；品质；蛋白质氧化

本研究得到国家自然科学基金（32460636）；海口市科技项目（编号2024-010）资助。

通讯作者：冯爱国，男，硕士研究生，副教授，水产品加工及贮藏工程，13648669586，sxfag@163.com。

Effects of static magnetic field-assisted liquid nitrogen and blast freezing on the quality and protein oxidation of tilapia

Lixian[1], Aiguo Feng*[2]

1. School of Food Science and Engineering, Hainan University, Haikuo, 315832, Zhejiang; 2.XX

Abstract : This study investigated the effects of static magnetic field-assisted liquid nitrogen quick freezing and air-blast quick freezing on the quality stability and myofibrillar protein conformation of frozen tilapia fillets. Tilapia fillets were treated with liquid nitrogen quick freezing (LNF) and air-blast freezing (BF) coupled with a static magnetic field of 85–105 mT respectively, and stored at −18 °C for 12 weeks. Freezing parameters, physicochemical indicators and changes in protein

structure were determined. The results showed that the static magnetic field shortened the freezing time and the stage of maximum ice crystal formation, produced fine and uniform ice crystals, alleviated tissue damage and reduced drip loss. The 85–105 mT static magnetic field-LNF group had the lowest thawing loss (5.41%) and the highest water-holding capacity (75.46%). The static magnetic field inhibited the accumulation of TVB-N and TBARS, slowed protein carbonylation and sulfhydryl oxidation, and maintained the stability of the α-helix structure. In conclusion, static magnetic field-assisted quick freezing can effectively delay the quality deterioration of tilapia fillets during frozen storage and has promising application prospects in the preservation of high-value aquatic products.

Key words: Tilapia fillets; Static magnetic field; Quick-freezing; Protein oxidation

This work was financially supported by the National Natural Science Foundation of China (32460636); Science and Technology Project of Haikou City (No.2024-010).

抗冻抗氧化型天然低共熔溶剂通过调控冰晶和抑制脂质/蛋白质氧化保护冻融循环中的金鲳鱼鱼糜

陈瑶[1]，孙钦秀[1*]

1.广东海洋大学 食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研发中心，广东省海洋生物制品工程重点实验室，水产品深加工广东普通高校重点实验室，广东 湛江 524088

摘要：本研究评估了抗冻抗氧化双效的甜菜碱基天然深共晶溶剂（NADES）对冻融循环中鱼糜的保护效果。铁离子还原能力，$ABTS^{+}$自由基清除活性和冰重结晶抑制活性结果表明，在15种三元 NADES中甜菜碱-脯氨酸-葡萄糖（BPG）、甜菜碱-脯氨酸-山梨糖醇（BPS）、甜菜碱-脯氨酸-甘油（BPY）的抗氧化和抑制冰晶效果最优。其中，BPG的玻璃化转变温度最高、T_2弛豫时间最短（$P < 0.05$），表明对水分迁移的限制效果最强。与空白组相比，BPG使鱼糜的解冻损失降低约 22.8%、持水力提高7.5%，冰晶孔隙小且分布均匀，抑制了冰晶对鱼糜品质的破坏。同时BPG组丙二醛含量最低、总巯基含量最高（$P<0.05$），有效抑制鱼糜中脂质与蛋白质的氧化损伤。综上，BPG型NADES是极具前景的冻融鱼糜天然冷保护剂。

关键词：天然低共熔溶剂；金鲳鱼鱼糜；冻融循环；冰晶重结晶；氧化稳定性

基金项目：国家自然科学基金委员会青年项目（32302165）

*通讯作者：孙钦秀，女，博士后，教授，研究方向为海洋食品贮藏与加工，0759-2383143

E-mail：sunqinxiugo@163.com

Cryoprotective and Antioxidative Natural Deep Eutectic Solvents Protect Golden Pompano (Trachinotus ovatus) Surimi During Freeze-Thaw Cycles via Ice Crystal Modulation and Lipid/Protein Oxidation Inhibition

Yao Chen[1], Qinxiu Sun[1,*]

[1] College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Guangdong Province Engineering Laboratory for Marine Biological

Products, Guangdong Provincial Engineering Technology Research Center of Seafood, Key Laboratory of Advanced Processing of Aquatic Product of Guangdong Higher Education Institution, Zhanjiang, 524088, China.

Abstract: This study evaluated the protective effects of betaine-based natural deep eutectic solvents (NADES), which possess both antifreeze and antioxidant properties, on fish paste during freeze-thaw cycles. The iron ion reduction capacity, $ABTS^+$ radical scavenging activity, and ice recrystallization inhibition activity indicated that, among the 15 ternary NADES systems, betaine-proline-glucose (BPG), betaine-proline-sorbitol (BPS), and betaine-proline-glycerol (BPY) exhibited the most effective antioxidant and ice crystal inhibition properties. Among these, BPG demonstrated the highest glass transition temperature and the shortest T_2 relaxation time ($P < 0.05$), indicating the strongest restriction on water migration. Compared with the control group, BPG reduced thawing loss in fish paste by approximately 22.8% and increased water-holding capacity by 7.5%; the ice crystals were smaller and more evenly distributed, thereby minimizing damage to fish paste quality caused by ice crystals. Additionally, the BPG group exhibited the lowest malondialdehyde (MDA) content and the highest total thiol content ($P < 0.05$), effectively inhibiting oxidative damage to lipids and proteins in the fish paste. In summary, BPG-type NADES is a highly promising natural cryoprotectant for freeze-thawed fish paste.

Key words: Natural deep eutectic solvents; *Golden pompano* surimi; Freeze-thaw cycles; *Ice recrystallization*; Oxidative stability

壳聚糖表面改性对复合凝胶球再生性能的强化及海藻浓缩汁品质保护效应研究

杨作苗[1]，启航[2*]

1. 北部湾大学食品工程学院，广西钦州市，535011；2. 大连工业大学食品学院，辽宁省大连市，116034

摘要：【目的】为改善多糖凝胶在不同海藻浓缩汁脱除 Pb^{2+}过程中的结构稳定性、吸附选择性与循环再生能力，对羧甲基纤维素钠-海藻酸钠-藻蓝蛋白、羧甲基纤维素钠-海藻酸钠-鱼皮胶原蛋白、羧甲基纤维素钠-海藻酸钠-玉米醇溶蛋白三元复合凝胶球进行壳聚糖表面改性。【方法】开展壳聚糖表面改性制备，结合多尺度微观结构表征、静态吸附、循环再生实验，评价凝胶在海藻浓缩汁实际体系中的应用效果。【结果】壳聚糖在凝胶表面构筑防护层，重构交联网络，提升热稳定与耐酸碱性能；氨基位点提升铅离子吸附能力，减弱基质干扰，处理后海藻浓缩汁铅含量符合国标，材料循环使用性能改善。【结论】壳聚糖改性优化多糖凝胶性能，为海藻制品绿色脱铅提供技术支撑。

关键词：壳聚糖改性；复合凝胶球；铅离子；海藻浓缩汁；吸附

基金项目：“十四五”国家重点研发计划项目（2023YFD2100600）

第一作者简介：杨作苗，男，博士，讲师，主要从事多糖凝胶功能材料、海洋食品安全加工研究；手机：13737774119；E-mail：yangzuomiao@bbgu.edu.cn

Chitosan-mediated surface reconstruction of composite gel beads: Enhanced regeneration performance and quality preservation of seaweed juice concentrates

Zuomiao Yang[1], Hang Qi[2*]

1. School of Food Engineering, Beibu Gulf University, Qinzhou 535011, Guangxi, China; 2. School of Food Science and Technology, Dalian Polytechnic University, Dalian 116034, Liaoning, China

Abstract: **[Objective]** To improve the structural stability, adsorption selectivity, and cyclic regeneration performance of polysaccharide composite gel beads during Pb^{2+} removal from different

seaweed concentrates, chitosan surface modification was performed on three ternary composite gel bead systems: sodium carboxymethyl cellulose–sodium alginate–phycocyanin, carboxymethyl cellulose–sodium alginate–fish skin collagen, and sodium carboxymethyl cellulose–sodium alginate–zein. **[Methods]** Chitosan-based surface modification was carried out and systematically evaluated through multi-scale microstructural characterization, static adsorption experiments, and cyclic regeneration tests, with the application performance assessed in real seaweed concentrate systems. **[Results]** Chitosan constructed a protective layer on the gel surface and reconstructed the crosslinked network, enhancing thermal stability and acid–alkali resistance. The introduced amino groups improved Pb^{2+} adsorption capacity and mitigated matrix interference. After treatment, the lead content of the seaweed concentrates met the national food safety standard, and the cyclic reuse performance of the materials was significantly improved. **[Conclusion]** Chitosan surface modification effectively optimized the performance of polysaccharide-based composite gels, providing technical support for the green removal of lead from seaweed-based products.

Key words: chitosan modification; composite gel beads; Pb(II); seaweed juice concentrate; adsorption

壳聚糖-芳香醛席夫碱的合成、表征及其在磁场辅助金鲳鱼冷藏保鲜中的应用

林洪萍[1] 刘中原[2*]

海南大学食品科学与工程学院 海南海口 570228

摘要：本研究以壳聚糖(CS)为基材，分别与香草醛(VA)、丁香醛(SY)、5-羟基香草醛(HV)发生席夫碱反应，制备三种芳香醛改性壳聚糖衍生物(CS-g-VA，CS-g-SY，CS-g-HV)。FTIR、^{1}H NMR、紫外及荧光光谱表征证实芳香醛成功共价接枝至壳聚糖分子链。体外抗氧化与抑菌试验表明，改性产物具有良好的抗氧化能力和抑菌性能，并且具有浓度依赖性；其中 CS-g-HV 综合性能最优，1.0 mg/mL 时 DPPH、ABTS 自由基清除率分别为 95.14% 和 89.65%。将 CS-g-HV 改性涂膜用于金鲳鱼冷藏保鲜，可抑制 pH 升高、挥发性盐基氮累积与腐败菌增殖，维持鱼肉的质构与水分稳定性等；另外发现 3 mT 静磁场与该涂膜存在显著协同保鲜作用。本研究可为水产品绿色保鲜材料的研发提供理论依据与技术支撑。

关键词：壳聚糖；芳香醛；席夫碱反应；金鲳鱼；保鲜

资助项目：国家自然基金（32402196）

通讯作者：刘中原，男，副教授，热带水产品加工与贮藏，15714114602，liuzhongyuan999@126.com

Chitosan-aromatic aldehyde Schiff base: synthesis, characterization and application in magnetic-field-assisted refrigerated preservation of golden pompano (Trachinotus ovatus)

Lin Hongping[1]，Liu Zhongyuan[2*]

College of Food Science and Engineering, Hainan University, Haikou, China, 570228

Abstract: In this work, chitosan (CS) was reacted with vanillin (VA), syringaldehyde (SY) and 5-hydroxyvanillin (HV) via Schiff-base reaction to prepare three aromatic aldehyde-modified chitosan derivatives (CS-g-VA, CS-g-SY, CS-g-HV). Fourier transform infrared spectroscopy, ^{1}H nuclear magnetic resonance spectroscopy, ultraviolet

spectroscopy, and fluorescence spectroscopy confirmed that aromatic aldehydes were successfully covalently grafted onto chitosan molecular chains. In vitro antioxidant and antibacterial tests showed that the modified derivatives possessed favorable antioxidant and antibacterial activities in a concentration-dependent manner. Among them, CS-g-HV emerged as the optimal candidate, with DPPH and ABTS radical scavenging rates of 95.14% and 89.65%, respectively, at 1.0 mg/mL. The CS-g-HV modified coating was applied in the refrigerated preservation of golden pompano. It could inhibit pH value rise, spoilage bacteria growth and total volatile basic nitrogen accumulation, and well maintain the texture properties and water stability of fish fillets. Furthermore, the combined treatment with 3 mT static magnetic field exerted a synergistic preservation effect on fillet quality. This work provides theoretical basis and technical support for the research and development of green preservation materials for aquatic products.

Keywords: Chitosan; Aromatic aldehydes; Schiff base reaction; Golden pompano; Preservation

Funding: National Natural Science Foundation of China (Grant No. 32402196)

Corresponding author: Liu Zhongyuan, Male, Associate Professor, research focus: processing and storage of tropical aquatic products. Tel: +86-15714114602; E-mail: liuzhongyuan999@126.com

壳聚糖-聚乙烯亚胺功能材料对碘离子的高效吸附：作用机制及其在海藻浓缩汁中的应用

刘宇，启航*

大连工业大学食品学院，辽宁省大连市，116000

摘要：采用戊二醛（GA）介导壳聚糖（CS）与聚乙烯亚胺（PEI）交联，制备了一种轻质、可压缩的氨基功能化多孔吸附材料（CS-PEI-GA），用于高效去除碘离子（I^-）。通过优化制备参数，提高了材料的结构稳定性和吸附性能。采用傅里叶变换红外光谱、X 射线衍射、热重分析和扫描电子显微镜对吸附材料的结构、热学性质及微观形貌进行了表征。结果表明，CS-PEI-GA 对 I^-的最大吸附容量达到 1.12 ± 0.01 mmol·g^{-1}。吸附动力学和吸附平衡数据分别与准二级动力学模型和 Freundlich 等温吸附模型具有较好的拟合效果。热力学分析结合红外光谱和 X 射线光电子能谱结果表明，吸附过程主要涉及质子化氨基与 I^-之间的静电吸引，同时氢键作用也具有一定贡献。将该吸附材料应用于浓缩海藻汁处理时，I^-去除率达到 21.52 ± 0.74%～45.77 ± 2.73%，且对海藻汁色泽影响较小。吸附后表征结果显示，材料表面形貌发生一定变化，并伴有少量矿物组分的共吸附。研究结果表明，CS-PEI-GA 多孔材料在海藻加工体系碘离子去除方面具有良好的应用潜力。

关键词：氨基功能化吸附材料；壳聚糖-聚乙烯亚胺；多孔材料；碘离子吸附；吸附机制

Efficient iodide adsorption by chitosan–polyethyleneimine functional materials: Mechanisms and applications in concentrated seaweed juices

Yu Liu[1], Hang Qi[1,*]

1. College of Food Science and Technology, Dalian Polytechnic University, Dalian, 116034, Liaoning.

Abstract: A lightweight, compressible amino-functionalized porous adsorbent, prepared through glutaraldehyde (GA)-mediated crosslinking of chitosan (CS) and polyethyleneimine (PEI), was denoted as CS-PEI-GA for efficient iodide removal. The preparation parameters were optimized to improve structural stability and adsorption

performance. The structural, thermal, and morphological characteristics of the adsorbent were characterized by Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (XRD), thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). The adsorbent exhibited a maximum adsorption capacity of 1.12 ± 0.01 mmol g-1. The adsorption kinetics and equilibrium isotherms were best described by the pseudo-second-order and Freundlich models, respectively. Thermodynamic analysis, together with FT-IR and X-ray photoelectron spectroscopy (XPS) results, suggested that iodide adsorption involved electrostatic attraction between protonated amino groups and iodide ions, with additional contributions from hydrogen bonding. Application of the adsorbent for treating concentrated seaweed juices achieved 21.52 ± 0.74%–45.77 ± 2.73% iodide removal, with minimal impact on color. Post-adsorption characterization revealed changes in surface morphology and minor co-adsorption of mineral components. These findings highlight the potential of the CS-PEI-GA porous material as an efficient adsorbent for iodide removal.

Key words: Amino-functionalized adsorbent; Chitosan-polyethyleneimine; porous material; Iodide adsorption; Adsorption mechanism

该研究得到了辽宁省“兴辽英才计划”领军人才项目（XLYC2202029）、“十四五”国家重点研发计划项目（2023YFD2100601）、辽宁省教育厅基本科研项目（LJ212510152047）的资助。

*启航，男，博士，大连工业大学食品学院教授、博士生导师，现任大连工业大学食品学院食品科学与工程系主任，兼任第三届辽宁省食品科学技术学会执行秘书长，全国食品工业标准化技术委员会第五届罐头分技术委员会委员，中国食品科学技术学会休闲食品加工技术分会第二届理事会理事。入选教育部“人才奖励计划”青年学者；辽宁省“兴辽英才计划”领军人才；辽宁省“百千万人才工程”百层次，辽宁省“兴辽英才计划”青年拔尖人才，大连市杰出青年科技人才，大连市政府特殊津贴。主要从事水产品加工贮藏技术；藻类资源综合开发利用的教学和科研工作，主持国家自然科学基金项目、国家重点研发计划项目等科研项目 10 余项。获辽宁省科技进步一等奖 2 项；以第一发明人申请国家专利 35 项，授权 18 项；以第一或通讯作者发表 SCI 论文 70 余篇。电话：13804082670，E-mail：qihang@dlpu.edu.cn。

壳聚糖-酪蛋白 Pickering 乳液的构建及稳定机制

林思浩[1,2]，魏涯[2]，潘创[2]，赵永强[2]

(1. 上海海洋大学，食品学院，上海，201306，

2. 中国水产科学研究院南海水产研究所，加工与质量安全研究室，广东 广州 510300)

摘要：为了开发一种复合生物大分子乳化剂，本文探究了四种脱乙酰度壳聚糖与三种蛋白质的复合作用机制，对二者的相互作用及稳定 Pickering 乳液的机理展开研究。结果表明，壳聚糖可改变蛋白质结构，二者主要通过静电相互作用与氢键复合。复合比例为 1:1 时，70%脱乙酰度壳聚糖-酪蛋白复合物 β-折叠占比最大，二级结构有序度最高，微观呈疏松多孔形貌；该配比制备的乳液乳化指数为0.89，60%油相下离心稳定系数为0.78，稳定性最高。以该复合物构建 Pickering 乳液，虾青素包埋率为95.42%，优于单一壳聚糖与单一酪蛋白，在不同贮藏条件下可保护虾青素。综上，本研究构建出负载虾青素的 70%脱乙酰度壳聚糖-酪蛋白 Pickering 乳液，为生物大分子复合乳化剂开发及虾青素包埋保护提供理论依据与实验参考。

关键词：壳聚糖；蛋白质；Pickering 乳液；虾青素

Study on the structural evolution of chitosan-casein complexes and the stabilization of Pickering emulsions

Lin Sihao[1,2]，Wei Ya[2]，Pan Chuang[2]，Zhao Yongqiang[2]

(1.College of Food Science, Shanghai Ocean University, Shanghai 201306, China

2. South China Fisheries Research Institute, Guangzhou 510300, China)

Abstract: To develop a stable composite biomacromolecular emulsifier, this study investigated the complexation mechanisms of four chitosan samples with varying degrees of deacetylation and three proteins. The 70% deacetylated chitosan-casein combination was identified as the optimal pair. The interaction of this combination was studied, the mechanism by which it stabilizes Pickering emulsions was explored, and the astaxanthin encapsulation efficiency of the 70% deacetylated chitosan-casein Pickering emulsion was determined under different conditions. Zeta potential, particle size, Fourier transform infrared spectroscopy, emulsion storage stability, and scanning electron microscopy results indicated that chitosan altered the protein molecular structure and combined with the protein through electrostatic interactions and hydrogen bonds. Among them, the emulsion formed by 70% deacetylated chito

san-casein was the most stable, with an emulsification index of 0.89. At a complex ratio of 1:1, the proportion of β-sheet structure was 25.4%, representing the highest order in secondary structure, and the microstructure exhibited a loose, porous, and continuous morphology, identifying it as the optimal complex ratio. Centrifugal stability results showed that the emulsion prepared with 70% deacetylated chitosan-casein under 60% oil phase conditions was the most stable one, with a centrifugal stability coefficient of 0.78. Astaxanthin encapsulation results showed that the encapsulation efficiency of the 70% deacetylated chitosan-casein Pickering emulsion was 95.42%±2.2%, which was higher than that of single chitosan or single casein. The study indicates that the 70% deacetylated chitosan-casein complex is an excellent solid emulsifier for Pickering emulsions. The degree of deacetylation and the polysaccharide-protein ratio can modulate intermolecular interactions and protein secondary structure to enhance emulsion stability. This system demonstrates high astaxanthin encapsulation efficiency and strong stability, providing theoretical and experimental references for the development of green biomacromolecular delivery vehicles for lipophilic active substances.

Keyword: chitosan; deacetylation; protein; Pickering emulsion

可食用微载体机械信号介导鱼类细胞快速扩增和分化效应研究

郑洪伟[1,2*]，周旋[1]，薛长湖[1,2]

1. 中国海洋大学食品科学与工程学院，海洋食品加工与安全控制全国重点实验室，山东青岛 266404

2. 青岛海洋食品营养与健康创新研究院，山东青岛 266109

摘要：细胞命运的定向调控是细胞培养鱼肉高效制造与品质形成的关键。首先采用 RGD 修饰的海藻酸钠水凝胶基底，解析大黄鱼肌肉干细胞的力学感知。骨架收缩干预表明，细胞骨架参与细胞铺展的刚度响应；整合素相关黏附信号与 YAP 核定位随刚度改变，提示机械刺激可由黏附界面向细胞核传递。为考察细胞在三维力学微环境中的功能响应，构建刚度与孔径独立可调的可食用微载体，研究细胞扩增、分化与营养沉积。微载体刚度升高促进细胞骨架重塑与 YAP 核转位，细胞分化方向及营养组成呈刚度依赖性。高刚度促进成肌分化及必需氨基酸和 ω-3 脂肪酸富集，低刚度促进成脂分化与脂质积累。孔隙结构可改善低刚度下的细胞黏附，大孔结构在高刚度下促进细胞扩增与肌管成熟，为微组织形成提供适宜的生长空间。利用可食用大孔微载体实现 5 L 生物反应器中肌肉与脂肪细胞连续逐级放大，所获成熟微组织用于三维打印培养鱼排。研究揭示了微载体机械性能调控细胞命运与营养沉积的规律，为培养鱼肉组织高效构建与品质调控提供材料设计依据。

关键词：可食用微载体；力学微环境；细胞命运；营养沉积；细胞培养鱼肉

资助项目：山东省泰山学者工程（tsqn202408079）；国家自然科学基金青年科学基金项目（32202151）；国家重点研发计划（2023YFD2401504）；山东省重点研发计划（重大科技创新工程）（2023CXGC010710）。

通讯作者简介：郑洪伟，工学博士，副教授，主要从事细胞培养鱼肉工程及海洋生物介质功能调控与生物利用研究。E-mail：zhenghongwei@ouc.edu.cn。性别：男；联系电话：17685503385。

Mechanical Cues from Edible Microcarriers Regulate the Rapid Expansion and Differentiation of Fish Cells

Hongwei Zheng[1,2*], Xuan Zhou[1], Changhu Xue[1,2]

1. State Key Laboratory of Marine Food Processing and Safety Control, College of Food Science and Engineering, Ocean University of China, Qingdao 266404, China

2. Qingdao Institute of Marine Bioresources for Nutrition & Health Innovation, Qingdao 266109, China

Abstract: Directed control of cell fate is essential for efficient cultured fish meat production and quality development. RGD-modified sodium alginate hydrogel substrates were first used to investigate mechanosensing in muscle stem cells from large yellow croaker (*Larimichthys crocea*). Inhibition of cytoskeletal contractility showed that the cytoskeleton contributes to stiffness-dependent cell spreading. Stiffness-dependent changes in integrin-associated adhesion signaling and YAP nuclear localization suggested transmission of mechanical stimuli from cell-substrate interfaces to the nucleus. To examine cellular responses in three-dimensional mechanical microenvironments, edible microcarriers with independently tunable stiffness and pore size were fabricated to evaluate cell expansion, differentiation, and nutrient deposition. Increasing microcarrier stiffness promoted cytoskeletal remodeling and YAP nuclear translocation, with stiffness-dependent shifts in differentiation and nutrient composition. High stiffness promoted myogenic differentiation and enrichment of essential amino acids and omega-3 fatty acids, whereas low stiffness promoted adipogenic differentiation and lipid accumulation. Porous structures improved cell adhesion under low-stiffness conditions, while large pores promoted cell expansion and myotube maturation at high stiffness, providing space for microtissue development. Edible macroporous microcarriers supported continuous, stepwise expansion of muscle and adipose-derived cells up to a 5-L bioreactor. The resulting mature microtissues were used for three-dimensional printing of cultured fish fillets. These findings identify microcarrier mechanics as a regulator of cell fate and nutrient deposition and provide design principles for efficient tissue construction and quality control in cultured fish meat.

Keywords: Edible microcarriers; Mechanical microenvironment; Cell fate; Nutrient deposition; Cultured fish meat

*** Corresponding author:** Hongwei Zheng. E-mail: zhenghongwei@ouc.edu.cn.

克氏原螯虾头降尿酸肽的挖掘与功效机制研究

李骏 1，彭进明 1，段邓乐 1，杨文华 1，徐玉娟 1，肖更生 1

1 仲恺农业工程学院 轻工食品学院/农业农村部岭南特色食品绿色加工与智能制造重点实验室/广东省岭南特色食品科学与技术重点实验室，广东 广州 510225

摘要：小龙虾虾头经超声-微波辅助碱性蛋白酶水解制备 XOD 抑制肽，超滤获得高活性组分 F3，从中鉴定出 WSPDAPF、SGGPWRPL、WTPDAPF 和 DWSPPYPT 四条新型肽，IC_{50}为 2.00~2.33 mmol/L。分子对接显示肽段通过氢键和疏水作用与 XOD 活性口袋关键残基（Leu257、Ile353、Val345）稳定结合，色氨酸残基对活性至关重要。在高尿酸 HK-2 细胞中，四条肽（0.1~2 mM）可显著降低胞内尿酸且无细胞毒性，WTPDAPF 效果最优（降幅 63.54%，接近别嘌醇）；同时下调 GLUT9、上调 HPRT1 和 OAT1 表达以减少重吸收并促排泄，并减轻炎症因子（IL-1β、IL-6、TNF-α、MCP-1）和活性氧水平。斑马鱼实验证实 WTPDAPF（30~60 μg/mL）能有效降低尿酸和 XOD 活性，改善 MDA、SOD 等氧化应激指标，并一致调控上述转运蛋白。本研究揭示虾头肽的多靶点降尿酸机制，为其高值化利用和功能食品开发提供科学依据。

关键词：克氏原螯虾；肽；黄嘌呤氧化酶；降尿酸；机制研究

基金项目：国家重点研发计划 (2024YFD2402102).

第一作者简介：李骏，男，副教授，博士，研究方向为水产品绿色加工与营养健康。E-mail: lijun@zhku.edu.cn

Exploration and mechanism study of uric acid lowering peptides in the head of Procambarus clarkii

Li Jun[1], Peng Jinming[1], Duan Dengle[1], Yang Wenhua[1], Xu Yujuan[1], Xiao Gengsheng[1]

1. College of Light Industry and Food, Zhongkai University of Agriculture and Engineering/Key Laboratory of Green Processing and Intelligent Manufacturing of Lingnan Specialty Food, Ministry of Agriculture and Rural Affairs/Guangdong Provincial Key Laboratory of Lingnan Specialty Food Science and Technology, Guangzhou

510225, China

Abstract Crayfish heads, a processing by-product, were used to prepare xanthine oxidase (XOD)-inhibitory peptides via ultrasound-microwave-assisted alkaline protease hydrolysis. After ultrafiltration, a high-activity fraction (F3) was obtained, from which four novel peptides—WSPDAPF, SGGPWRPL, WTPDAPF, and DWSPPYPT—were identified, with IC_{50} values of 2.00–2.33 mmol/L. Molecular docking revealed that the peptides stably bind to the XOD active pocket through hydrogen bonds and hydrophobic interactions with key residues (Leu257, Ile353, Val345), with tryptophan residues playing a critical role in activity. In hyperuricemic HK-2 cells, all four peptides (0.1–2 mM) significantly reduced intracellular uric acid without cytotoxicity; WTPDAPF showed the best efficacy (63.54% reduction), comparable to allopurinol. Mechanistically, the peptides downregulated GLUT9 and upregulated HPRT1 and OAT1 expression to reduce reabsorption and promote excretion, while also attenuating inflammatory cytokines (IL-1β, IL-6, TNF-α, MCP-1) and reactive oxygen species levels. Zebrafish experiments further confirmed that WTPDAPF (30–60 μg/mL) effectively decreased uric acid and XOD activity, improved oxidative stress markers (MDA, SOD), and consistently modulated the above transporters. This study elucidates the multi-target uric acid-lowering mechanism of crayfish head-derived peptides, providing a scientific basis for their high-value utilization and functional food development.

Key words: *Procambarus clarkii*; Peptide; Xanthine oxidase; Reduce uric acid; mechanism research

空间电场辅助制冷减轻鲍鱼肌肉质量恶化：微生物演替和代谢重塑的多维视角

王善宇[1,2]，郑美丽[1,2]，孙永[2]，刘淇[2]，薛勇[1]，曹荣[2]*

1.中国海洋大学食品科学与工程学院，青岛，266003，山东；2.中国水产科学院黄海水产研究所食品工程与营养研究室，青岛，266071，山东.

摘要:【目的】鲍鱼冷藏易品质劣变。评估空间电场（SEF）延缓 4℃贮藏 12 d 鲍鱼肌肉品质损失的效果。【方法】采用感官、理化、微生物、挥发性及非靶向代谢组学联合分析。【结果】常规冷藏引发序贯劣变：早期蛋白水解、膜磷脂降解，后期 TCA 循环受阻伴氧化应激，支原体增殖并取代嗜冷杆菌。SEF 将感官货架期由 9 d 延长至 12 d。其保护作用并非改变代谢物或菌种，而是减缓劣变：蛋白水解与膜脂降解延迟，TVB-N、TBARS 和 α-酮戊二酸积累减少，鲜味氨基酸与多不饱和脂肪酸更好保留，并维持嗜冷杆菌优势、抑制支原体。Mantel 分析显示劣变因子耦合减弱，表明微生物生态与代谢稳定性协同调控。【结论】SEF 辅助冷藏是高档贝类有前景的清洁标签策略。

关键词：空间电场；鲍鱼；冷藏；微生物群落；非靶向代谢组学

资助项目：国家重点研发计划项目（2024YFD2401901）。

*通讯作者：曹荣，男，研究员，博士，研究方向为水产品保鲜与加工。E-mail: caorong@ysfri.ac.cn

Space electric field-assisted refrigeration attenuates quality deterioration in abalonemuscle: a multi-dimensional insight into microbial succession and metabolic remodeling

Shanyu Wang[1, 2], Meili Zheng[1, 2], Yong Sun[2], Qi Liu[2], Yong Xue[1], Rong Cao[2]*

1. College of Food Science and Engineering, Ocean University of China, Qingdao, 266003, Shandong; 2. Department of Food Engineering and Nutrition, Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao, 266071, Shandong.

Abstract: [Objective] Abalone is a premium shellfish that is highly susceptible to quality deterioration during refrigerated storage. This study evaluated whether space electric field (SEF) technology could delay quality loss in abalone muscle stored at 4 ℃ for 12 days. [Methods] A combined sensory, physicochemical, microbial, volatile, and untargeted metabolomic analysis was conducted. [Results] Conventional cold storage induced a sequential deterioration cascade encompassing early protein hydrolysis, subsequent membrane phospholipid degradation, and late-stage tricarboxylic acid (TCA) cycle blockage accompanied by oxidative stress, along with the proliferation of *Mycoplasma* that displaced the inherent *Psychrobacter*. In contrast, SEF extended the sensory shelf life from 9 to 12 days. This protective effect was not attributed to alterations in metabolite classes or microbial species identity, but rather to a deceleration of deteriorative processes: protein hydrolysis and membrane lipid degradation were delayed, the accumulation of TVB-N, TBARS, and α-ketoglutarate was reduced, and umami amino acids and polyunsaturated fatty acids (PUFAs) were better retained. SEF also maintained the inherent dominance of *Psychrobacter* while suppressing the proliferation of *Mycoplasma*. Mantel analysis further revealed weakened coupling among deteriorative factors under SEF, indicating coordinated regulation of microbial ecology and metabolic stability. [Conclusion] These findings position SEF-assisted refrigeration as a promising clean-label strategy for premium shellfish products.

Key words: Space electric field; Abalone; Refrigerated storage; Microbial community; Untargeted metabolomics

快速发酵无盐虾头副产物的品质分析与风味变化

宋婉瑜[1]，相欢[2,3*]，郝淑贤[2,3]，于刚[2,3]，赵永强[2,3]，潘创[2,3]

（1.上海海洋大学食品学院，上海 201306； 2.中国水产科学研究院南海水产研究所/农业农村部水产品加工重点实验室/国家水产品加工技术研发中心，广东广州 510300 3.三亚热带水产研究院，海南三亚 572018）

摘 要：目的：探究南美白对虾和克氏原螯虾虾头副产物的无盐快速发酵工艺及其风味形成特征，为虾类副产物高值化利用提供技术支撑。方法： 对发酵过程中样品的基础理化指标、游离氨基酸、有机酸和核苷酸等滋味指标，以及挥发性物质等气味指标进行分析。结果：发酵过程中两组样品 pH 和总糖含量均显著下降，氨基酸态氮总体呈累积趋势；南美白对虾组可溶性蛋白持续升高，72 h 达 21.88 mg/mL，而克氏原螯虾组于 24 h 达到峰值 18.49 mg/mL 后下降。南美白对虾组初始游离氨基酸含量（6810.09 mg/100 mL）约为克氏原螯虾组（2351.34 mg/100 mL）的 3 倍，且鲜味氨基酸占比较高，谷氨酸、缬氨酸、丙氨酸及精氨酸为两组共有的主要呈味氨基酸。发酵促进有机酸积累，乳酸和琥珀酸为主要共有有机酸；同时优化核苷酸组成，提高鲜味核苷酸占比并降低苦味核苷酸。挥发性物质方面，发酵降低己醛、蘑菇醇等异味物质，并促进 2-甲基丁醛、3-甲硫基丙醛、苯乙醛及吡嗪类等香气物质形成，使两组样品风味趋于一致。结论： 风味蛋白酶酶解结合植物乳杆菌发酵可有效改善虾头副产物的滋味和香气特征，植物乳杆菌适用于虾头发酵调味料的风味修饰，为南美白对虾和克氏原螯虾虾头副产物的高值化利用提供了技术支撑。

关键词：虾头副产物；无盐；发酵；品质；挥发性风味物质

Quality Analysis and Flavor Changes in Rapid Fermentation of Salt-Free Shrimp Head Byproduct Seasoning

Song Wanyu [1], Xiang Huan[2], Hao Shuxian[2], Yu Gang[2], Zhao Yongqiang[2], Pan Chuang[2]

基金项目：国家重点研发计划项目（2024YFD2402104），“尖锋”行动计划（广西重大专项计划）（桂科JF2503980035）

*通信作者简介：相欢（1994-） （ORCID: 0000-0002-3231-2143），女，副研究员，博士研究生，研究方向为水产品加工及风味活性肽。E-mail: skyxianghuan@163.com.

(1. College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China;
2. South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural, National Aquatic Product Processing Technology Research and Development Center, Guangzhou 510300, China;
3. Sanya Tropical Fisheries Research Institute, Sanya 572018, China)

Abstract: [Objective]: To investigate the rapid salt-free fermentation process and flavor formation characteristics of shrimp head by-products from Litopenaeus vannamei and Procambarus clarkii, and to provide a technical basis for their high-value utilization. [Methods]: Basic physicochemical properties, taste-related indicators including free amino acids, organic acids, and nucleotides, and aroma-related indicators including volatile compounds were analyzed during fermentation. [Results]: The pH and total sugar contents of both groups decreased significantly during fermentation, whereas amino nitrogen generally accumulated. Soluble protein in the L. vannamei group continuously increased, reaching 21.88 mg/mL at 72 h, whereas that in the P. clarkii group peaked at 18.49 mg/mL at 24 h and subsequently decreased. The initial free amino acid content of the L. vannamei group (6810.09 mg/100 mL) was approximately three times that of the P. clarkii group (2351.34 mg/100 mL), with a higher proportion of umami amino acids. Glutamic acid, valine, alanine, and arginine were the major taste-contributing amino acids shared by both groups. Fermentation promoted organic acid accumulation, with lactic acid and succinic acid being the major common organic acids. It also improved the nucleotide profile by increasing the proportion of umami-related nucleotides and decreasing that of bitter-tasting nucleotides. Fermentation reduced off-flavor compounds such as hexanal and 1-octen-3-ol, while promoting the formation of aroma compounds including 2-methylbutanal, 3-(methylthio)propanal, phenylacetaldehyde, and pyrazines, resulting in more similar flavor profiles between the two groups.[Conclusion]: Hydrolysis with a flavor protease preparation followed by Lactiplantibacillus plantarum fermentation effectively improved the taste and aroma characteristics of shrimp head by-products. L. plantarum is therefore suitable for flavor modification of fermented shrimp head seasonings, providing a technical basis for the high-value utilization of shrimp head by-products from L. vannamei and P. clarkii.

Keywords: shrimp head by-products; salt-free; fermentation; quality; volatile flavor compounds

来源于 *Flammeovirga yaeyamensis* 的新型 PL24 家族石莼多糖裂解酶 Uly24Fy 的克隆表达与性质表征

何梅，申晶晶*，王永娜，王绣梓，徐子仪

宁波大学食品科学与工程学院，浙江宁波，315832

摘要：石莼多糖（Ulvan）是绿藻门石莼属（Ulva）细胞壁的核心组分，是一种极具高值化开发潜力的天然硫酸化杂多糖。然而，目前石莼多糖的高效降解工具仍较为匮乏。本研究从海洋细菌 *Flammeovirga yaeyamensis* 基因组中克隆并表征了一种新型多糖裂解酶家族 24（PL24）成员，其编码蛋白命名为 Uly24Fy，其与已知 PL24 家族蛋白的最高序列一致性仅为 41.82%。重组 Uly24Fy 的最适反应条件为 35℃，pH7.5，以内切方式降解石莼多糖，主要终产物为不饱和二糖。分子对接和分子动力学模拟进一步揭示了 Uly24Fy 与底物二糖的关键互作模式。该新型酶的获得将为石莼多糖及其寡糖在食品与生物医药等领域的开发利用提供重要的工具酶资源。

关键词：石莼多糖裂解酶；PL24；Uly24Fy；产物分析；动力学模拟

通讯作者：申晶晶，工学博士学位；电子邮箱：shenjingjing1@nbu.edu.cn；研究方向为：1. 海洋多糖降解酶的基因挖掘及作用方式研究；2. 酶在水产品加工及保鲜中的应用。

资助项目：浙江省自然科学基金（LQN26C200006）；国家重点研发计划：（2024YFD2401601）。

A novel cold-adapted ulvan lyase in polysaccharide lyase family 24 enables enzymatic production of ulvan oligosaccharides

Mei He, Jingjing Shen*,Yongna Wang, Xiuzi Wang,Ziyi Xu

College of Food Science and Engineering, Ningbo University , Ningbo, 315832, Zhejiang

Abstract :Ulvan is a sulfated polysaccharide with considerable potential for high-value utilization, whereas its enzymatic conversion is limited by the scarcity of well-characterized ulvan lyases, particularly those in the PL24 family. Herein, a novel PL24 ulvan lyase, Uly24Fy, was identified

and biochemically characterized. Uly24Fy shared only 41.82% sequence identity with known PL24 enzymes and formed a distinct phylogenetic clade. The optimal activity of the recombinant purified enzyme was observed at 35 °C and pH 7.5 while retaining high activity at low temperatures, indicating a cold-adapted catalytic characteristic. Product analysis demonstrated that Uly24Fy acts in an endolytic manner and mainly generates ulvan disaccharides and tetrasaccharides. Molecular docking and molecular dynamics simulations suggested that substrate binding and catalysis involve a series of basic and polar residues. This study expands the functional diversity of the PL24 family and provides a promising enzymatic tool for the production of ulvan oligosaccharides.

Key words: Ulvan lyase; PL24; Uly24Fy; product analysis; molecular dynamics simulation

Corresponding author: Shen Jingjing, Doctor of Engineering. E-mail address: shenjingjing1@nbu.edu.cn. Research directions: 1. Gene mining and action mode research of marine polysaccharide-degrading enzymes; 2. Application of enzymes in aquatic product processing and preservation.

Funding: This work was supported by the Zhejiang Provincial Natural Science Foundation of China under Grant No. LQN26C200006 and National Key Research and Development Program of China under Grant No. 2024YFD2401601.

冷等离子体沉淀肌浆蛋白的高值化改性：羧甲基纤维素改性纤维在碱性贮藏过程中的结构与功能变化

李强[1,2]，陆剑锋[1,2,*]，蔡志成[1,2]，宋媛[1,2]，叶韬[3]，林琳[1,2,*]

1. 合肥工业大学食品与生物工程学院，安徽合肥，230601；2. 安徽省农产品现代加工重点实验室，安徽合肥，230601；3. 淮南师范学院，安徽淮南，232038

摘要：【目的】本研究旨在解决冷等离子体沉淀肌浆蛋白纤维（CSPF）的 pH 介导不稳定性，提高其碱性适应性与贮藏稳定性。【方法】制备 CSPF，采用不同取代度（DS 0.7、0.9、1.2）的羧甲基纤维素（CMC）进行修饰，系统考察修饰前后及贮藏后的理化与结构性质。【结果】pH 8 时，CMC 修饰提高了 ζ-电位，降低了浊度和粒径；CMC 物理屏障减轻了硫黄素 T 荧光及极性环境中色氨酸荧光下降；DS 0.9 促进贮藏中连续长链结构形成，使弹性模量恢复、凝胶网络重建，而 DS 0.7 保护不足，DS 1.2 因强静电斥力导致过度解聚和收缩；所有复合物对 Caco-2 细胞无细胞毒性。【结论】CMC 修饰可克服淀粉样纤维 pH 依赖的应用限制，并为冷等离子体回收蛋白的高值化利用提供理论依据和改性策略。

关键词：冷等离子体；肌浆蛋白原纤维；羧甲基纤维素；取代度；碱性稳定性

资助项目：安徽现代农业产业技术体系项目（AARS-08）；财政部和农业农村部: 国家现代农业产业技术体系项目（CARS-47）；国家重点研发计划（2023YFD2401500）
通讯作者：陆剑锋，男，博士，教授，研究方向为水产品加工及综合利用，Tel: +86-13349207505，E-mail: lujf@sibs.ac.cn

冷等离子体辅助蟹壳甲壳质资源转化及分子调控

蔡志成[1]，林琳[1,2,3*]，陆剑锋[1,2,3*]

1.合肥工业大学食品与生物工程学院，合肥 230601；2.农产品现代加工安徽省重点实验室，合肥 230601；3.农产品生物化工教育部工程研究中心，合肥 230601

摘要：【目的】构建蟹壳甲壳素提取—壳聚糖制备—低分子化的等离子体辅助加工链。【方法】采用大气压等离子体射流协同酸碱法提取甲壳素并强化脱乙酰，进一步以预制等离子体活化水（PAW）/Fe^{2+}体系氧化解聚，结合 XRD、NMR、GPC-MALS 和 MALDI-TOF-MS 表征。【结果】无需化学脱色即可获得结晶度 64.58%、Mw 为 6.89×10^5 g/mol 的高纯甲壳素；壳聚糖 DD 最高 74%、结晶度 31.18%；PAW/Fe^{2+}将 Mw 降至 5.13×10^3 g/mol、PDI 1.67，并形成 DP2–DP7 低聚产物。【结论】该策略实现了甲壳素提取、壳聚糖制备与分子量调控的连续强化，为甲壳类副产物高值利用提供绿色路径。

关键词：冷等离子体；等离子体活化水；甲壳素；壳聚糖；氧化解聚[1]

[1] 资助项目：国家重点研发计划（2023YFD2401500）；国家虾蟹产业技术体系（CARS-47）；安徽水产产业技术体系（AARS-08）
通讯作者：陆剑锋，男，博士，教授，研究方向为水产品加工与贮藏工程。 E-mail: lujf@sibs.ac.cn

冷冻方式与预处理对花青素降解动力学的影响及水产品锁鲜应用

燕嘉[1]，马有川[1],胡亚芹[1]*

1. 海南热带海洋学院，海南三亚 572022

摘要：目的：本研究以富含花青素的紫甘蓝为模式体系，系统探究冷冻方式、护色预处理及冻融循环对-18℃冻藏 180 天期间花青素降解动力学与色泽稳定性的影响，为天然色素保护及水产品加工冷链品质调控提供理论支撑。方法：以富含矢车菊素-3-O-葡萄糖苷（C3G）的紫甘蓝为模式食品体系，比较四种冷冻方式（-20℃、-40℃、-80℃及液氮速冻）和三种冻融循环次数（1、3、5 次），采用一级动力学模型量化降解参数。结果：液氮速冻（-196℃）通过形成细小均匀冰晶维持细胞区室化，花青素保留率达 75%~85%（180 天后），降解速率常数 $k=1.6\times10^{-3}$ day^{-1}，半衰期 $t_{1/2}$=433 天，显著优于-20℃常规冷冻组（保留率 28%~40%，$k=8.5\times10^{-3}$ day^{-1}）；反复冻融通过冰晶重结晶（奥斯特瓦尔德熟化）加速降解，5 次冻融后 k 值增大 6.8 倍；柠檬酸预处理表现出最佳综合护色效果。结论：冷冻速率是决定花青素冻藏稳定性的关键参数，冷链温度恒定至关重要；本研究建立的冷冻降解动力学模型和锁鲜策略可推广至水产品加工领域，为富含虾青素的甲壳类、肌红蛋白保护的鱼类等水产品的精准锁鲜、全链质控和智慧冷链提供理论依据。

关键词：冷冻锁鲜；花青素；降解动力学；护色预处理；水产品加工

基金项目：国家自然科学基金（32603375）；海南热带海洋学院高层次人才项目（RHDRC202117）；海南热带海洋学院青年人才项目（RHDRCZK202624).

通讯作者：胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，15868109010，1004346262@qq.com.

Effects of Freezing Methods and Pretreatments on Anthocyanin Degradation Kinetics and Their Application in Aquatic Products Quality Preservation

Yan Jia[1],Ma Youchuan[1], Hu Yaqin[1]*

1. Hainan Tropical Ocean University, Sanya, Hainan 572022, China

Abstract: [Objective] To investigate the effects of freezing methods, color-preserving pretreatments, and freeze-thaw cycles on the degradation kinetics, color stability, and antioxidant activity of anthocyanins during frozen storage at -18°C for 180 days, and to provide theoretical support for natural pigment preservation and cold chain quality control in aquatic product processing. [Methods] Purple cabbage, rich in cyanidin-3-O-glucoside (C3G), was used as a model food system. Four freezing methods (-20°C, -40°C, -80°C, and liquid nitrogen freezing) and three freeze-thaw cycles (1, 3, 5 times) were compared. A first-order kinetic model was applied to quantify degradation parameters. [Results] Liquid nitrogen freezing (-196°C) maintained cell compartmentalization by forming fine and uniform ice crystals, achieving the highest anthocyanin retention (75%-85% after 180 days), the lowest degradation rate constant ($k = 1.6\times10^{-3}$ day^{-1}), and the longest half-life ($t_{1/2}$ = 433 days), significantly outperforming conventional -20°C freezing (28%-40% retention, $k=8.5\times10^{-3}$ day^{-1}). Repeated freeze-thaw cycles accelerated degradation via ice crystal recrystallization (Ostwald ripening), with k increasing by 6.8 folds after 5 cycles. Citric acid pretreatment showed the best comprehensive color-preserving effect. [Conclusion] Freezing rate is the critical parameter determining anthocyanin frozen stability, and constant cold chain temperature is essential. The established degradation kinetics model and color-preserving strategy can be extended to aquatic product processing, providing methodological reference for precision freezing preservation and cold chain quality control of aquatic products rich in astaxanthin (crustaceans) or myoglobin (fish).

Key words: freezing preservation; anthocyanin; degradation kinetics; color-preserving pretreatment; aquatic product processing

*通讯作者：胡亚芹，女，博士，教授，研究方向：果蔬冷冻贮藏与品质调控。

作者简介：燕嘉，女，硕士研究生，研究方向：食品冷冻加工与天然色素稳定性。

冷冻干燥与喷雾干燥对皱肋文蛤酶解粉风味特性的影响

蒋　溶[1,2]，王禹鸥[1,2]，欧作銮[1,2]，高加龙[1,2,3]，陈忠琴[1,2,3]，谭明堂[1,2,3]，曹文红[1,2,3,*]

(1.广东海洋大学深圳研究院，广东 深圳 518120；2.广东海洋大学食品科技学院，广东 湛江 524088；3.广东省水产品加工与安全重点实验室，广东 湛江 524088)

摘要:【目的】探究干燥方式对皱肋文蛤（*Meretrix lyrata*）酶解粉品质特性的影响，为贝类酶解粉的高值化加工与风味优化提供理论支撑。【方法】以冷冻干燥（FD）和喷雾干燥（SD）制备皱肋文蛤酶解粉，对比其理化特性、非挥发性呈味物质与挥发性风味特征。【结果】SD 粉粒径更小、质地致密，高温诱导美拉德反应导致色泽显著加深；FD 粉结构疏松多孔。以干基计，FD 组总游离氨基酸（269.00 mg/g）、鲜味氨基酸（38.03 mg/g）及呈味核苷酸（118.25 μg/g）质量分数显著高于 SD 组，SD 组琥珀酸、甜菜碱及 Na^+、K^+等无机离子富集。FD 电子舌显示在鲜味、丰富度及涩味维度的响应值显著高于喷雾干燥组。电子鼻、气相离子迁移谱（GC-IMS）以及气相色谱-质谱联用（GC-MS）技术分析表明，FD 中醇类、酯类、含硫化合物等原生海鲜香气更突出；而 SD 通过热反应产生吡嗪类、醛类物质，烘烤香更突出。【结论】冷冻干燥在保留天然呈味与风味物质方面更具优势，适用于对风味品质要求较高的高端海鲜呈味基料与功能性食品；喷雾干燥在生产效率与热加工风味形成方面表现突出，更适合调味品、方便食品及肉制品等工业化应用场景。

关键词：皱肋文蛤；酶解粉；冷冻干燥；喷雾干燥；呈味物质；风味

基金项目：国家重点研发计划课题（2024YFD2401902）；国家现代农业产业技术体系（CARS-49）；深圳市科研计划（JCYJ20230807120316033）；

***通讯作者**：曹文红（1977-），男，博士，教授，博士生导师，研究方向为海洋生物资源利用。E-mail: cchunlin@163.com

Effects of Freeze Drying and Spray Drying on Flavor Characteristics of Enzymatic Hydrolysate Powder from Meretrix lyrata

JIANG Rong[1,2], WANG Yuou[1,2], OU Zuoluan[1,2], GAO Jialong[1,2,3], CHEN Zhongqin[1,2,3], TAN Mingtang[1,2,3], CAO Wenhong[1,2,3,*]

(1. Shenzhen Research Institute, Guangdong Ocean University, Shenzhen 518120, China; 2. College of Food Science and Technology, Guangdong Ocean University, Zhanjiang 524088, China; 3. Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Zhanjiang 524088, China)

Abstract:【Objective】To investigate the effects of drying methods on the quality characteristics of *Meretrix lyrata* hydrolysate powder. This study provides theoretical support for high-value-added processing and flavor optimization of shellfish hydrolysate powder. 【Methods】Hydrolysate powders of *Meretrix lyrata* were prepared by freeze-drying (FD) and spray-drying (SD). Their physicochemical properties, non-volatile taste-active substances and volatile flavor characteristics were compared.【Results】SD powder showed a smaller particle size ((257.10 ± 4.60) nm) and compact texture. High-temperature-induced Maillard reaction significantly deepened its color. FD powder presented a loose and porous structure. On a dry-weight basis, the contents of total free amino acids (269.00 mg/g), umami amino acids (38.03 mg/g) and taste-active nucleotides (118.25 μg/g) in FD group were significantly higher than those in SD group. Succinic acid, betaine, Na^+, K^+ and other inorganic ions were enriched in SD group. Electronic-tongue analysis recorded significantly higher response values of FD group in umami, richness and astringency. Electronic nose, gas chromatography-ion mobility spectrometry (GC-IMS) and gas chromatography-mass spectrometry (GC-MS) detected more prominent native seafood aroma (alcohols, esters, sulfur-containing compounds) in FD powder. Thermal reactions in SD powder produced pyrazines and aldehydes with strong roasted flavor.【Conclusion】Freeze-drying exhibited advantages in retaining natural taste-active and flavor substances. It is suitable for high-end seafood flavor-base materials and functional foods with strict flavor requirements. Spray-drying delivers high production efficiency and favorable thermal-processed flavor. It fits industrial production of condiments, instant

foods and meat products.

Key words: *Meretrix lyrata*; enzymatic hydrolysate powder; freeze drying; spray drying; taste substances; flavor

Funding: National Key R&D Program Project (2024YFD2401902); National Modern Agricultural Industry Technology System (CARS-49); Shenzhen Municipal Science and Technology Research Program (JCYJ20230807120316033)

** Correspondence author: Wenhong Cao (1977-), Ph.D., Professor, College of Food Science and Technology, Guangdong Ocean University, Zhanjiang, China. Research interest: utilization of marine biological resources. E-mail: cchunlin@163.com*

笼目海带酚糖复合物提取、结构解析及抗衰老活性研究

胡鸽[1,2,3]，赵武文韬[1,2,3]，刘舒[1,2,3]，张晗[1,2,3]，马艺超[1,2,3]，任丹丹[1,2,3]，汪秋宽[1,2,3]，何云海[1,2,3*]

1.大连海洋大学 食品科学与工程学院，辽宁 大连 116023；2.国家海藻加工技术研发分中心，辽宁 大连 116023；3.辽宁省水产品加工及综合利用重点实验室，辽宁 大连 116023

摘要：本研究以旅顺地区栽培的笼目海带为原料，采用碱提-分级醇沉法提取酚糖复合物（KC-PPC），通过响应面法优化提取工艺，确定最优条件：碱液浓度2.5%、料液比1:55(g/mL)、65 ℃提取320 min。利用DEAE阴离子交换层析分离得到F1、F2、F3三个纯化组分。借助UV-Vis、FT-IR、HPGPC、NMR、SEM等手段表征结构，结果表明各组分均以多糖骨架为主，但单糖构型、硫酸化修饰存在差异。体外抗氧化实验证实KC-PPC及其纯化组分均具有自由基清除能力，F2抗氧化活性最优。

本研究构建D-半乳糖诱导衰老小鼠模型，开展酚糖复合物纯化组分抗衰老活性评价。结果显示，样品可缓解衰老小鼠体重与脏器指数下降，降低血清炎症因子水平，减轻肝脏氧化损伤，改善肝组织病理变化，并调节衰老紊乱的肠道菌群。其中F2、F3干预效果更突出。综上，笼目海带酚糖复合物不同纯化组分结构各异，F2、F3表现出优异抗衰老活性，其活性与多酚含量、硫酸化水平及多糖骨架密切相关，可为抗衰老功能食品开发提供理论支撑。

关键词：笼目海带；酚糖复合物；提取；结构表征；抗衰老

Extraction, Structural Characterization and Anti-Aging Activity of Phenolic-Polysaccharide Complex from Kjellmaniella crassifolia

Hu Ge[1,2,3], Zhao Wuwentao[1,2,3], Liu Shu[1,2,3], Zhang Han[1,2,3], Ma Yichao[1,2,3], Ren Dandan[1,2,3], Wang Qiukuan[1,2,3], He Yunhai[1,2,3]*

1. College of Food Science and Engineering；2. National R&D Branch Center For Seaweed Processing；3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian Ocean University , Dalian 116023, China

Abstract: In this study, phenolic-polysaccharide complex (KC-PPC) was extracted from cultivated *Kjellmaniella crassifolia* collected in Lvshun area via alkali-assisted extraction combined with fractional ethanol precipitation. Response surface methodology was adopted to optimize the extraction process, and the optimal conditions were determined as follows: alkali concentration of 2.5%, solid-liquid ratio of 1:55 (g/mL), extraction temperature of 65 °C and extraction time of 320 min. Three purified fractions (F1, F2 and F3) were obtained by DEAE anion-exchange chromatography. Structural characterization was performed using UV-Vis, FT-IR, HPGPC, NMR and SEM. The results showed that all fractions were dominated by polysaccharide backbones, with differences in monosaccharide configuration and sulfation modification. In-vitro antioxidant assays demonstrated that KC-PPC and its purified fractions possessed free-radical-scavenging capacity, and F2 exhibited the strongest antioxidant activity.

A D-galactose-induced aging mouse model was established to evaluate the anti-aging activity of the purified phenolic-polysaccharide fractions. The results indicated that the samples could alleviate the decline in body weight and organ index of aging mice, reduce serum inflammatory factor levels, relieve hepatic oxidative damage, improve hepatic pathological lesions, and regulate age-related gut microbiota dysbiosis. Fractions F2 and F3 showed more prominent intervention effects. In conclusion, the purified fractions of *Kjellmaniella crassifolia* phenolic-polysaccharide complex possessed diverse structures. F2 and F3 displayed favorable anti-aging activity, which was closely related to polyphenol content, sulfation level and polysaccharide backbone. This study provides theoretical support for the development of anti-aging functional foods.

Key words: *Kjellmaniella crassifolia*; phenolic-polysaccharide complex; abstract;structural characterization;anti-aging;

项目：国家重点研发计划项目（2025YFD2400200），国家藻类产业技术体系岗位科学家项目（CARS-50）

通讯作者：何云海，男，教授，藻类加工及资源利用，13840847973，hyh@dlou.edu.cn

卵形鲳鲹低温暂养的保活工艺及生理代谢特征

张懿 1,2，岑剑伟 1,魏涯 1，郝淑贤 1，黄卉 1，吴燕燕 1，杨少玲 1

1. 中国水产科学研究院南海水产研究所　农业农村部水产品加工重点实验室　国家水产品加工技术研发中心，广东 广州 510300

2. 上海海洋大学食品学院，上海 201306

摘要：为降低活鱼流通损耗，探究适温暂养延缓死亡及最终保活失效的生理代谢基础，通过盐度筛选、梯度降温和肝脏非靶向代谢组学，分析卵形鲳鲹存活及生理代谢响应。结果表明，26‰、21 ℃为适宜暂养条件，21 ℃组全过程平均存活维持时间较 29 ℃延长 19.33 h。暂养 24 h 时，21 ℃组较 25 ℃组呈部分不饱和脂肪酸相对较高、磷脂相关代谢物相对较低的趋势，提示脂质调整可能参与低温保活。21 ℃组濒死阶段较 24 h 时，部分不饱和脂肪酸及肌苷显著降低、蛋氨酸亚砜显著升高，提示脂质、核苷及氧化相关代谢改变与生理失稳有关。研究解析了低温保活与最终失效机制，为暂养管理及活鲜流通减损提供依据。

关键词：卵形鲳鲹；低温暂养；保活效应；濒死状态；代谢组学

资助项目：广东省科技计划项目（2025B1111140001）；广州市科技计划项目重点研发计划项目（2024B03J1346）；广东省现代农业产业技术体系创新团队建设项目（2024CXTD27）；中国水产科学研究院南海水产研究所中央级公益性科研院所基本科研业务费专项资金项目（2026LH06）；中国水产科学研究院中央级公益性科研院所基本科研业务费专项资金项目（2023TD78）。

第一作者简介：张懿（2001—），女，上海海洋大学硕士研究生，研究方向为水产品加工与质量安全、水产品保鲜保活。

第一作者联系方式：19200256864、19819297553；E-mail：zhyi3789@163.com。

通讯地址：广东省广州市海珠区新港西路 231 号，510300。

通讯作者：岑剑伟，研究员；E-mail：genvex@163.com。

Low-temperature live-holding technology and physiological metabolic responses of Trachinotus ovatus

Yi Zhang[1,2], Jianwei Cen[1], Ya Wei[1], Shuxian Hao[1], Hui Huang[1], Yanyan Wu[1], Shaoling Yang[1]

1. South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences; Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs; National Aquatic Product Processing Technology Research and Development Center, Guangzhou 510300, Guangdong, China

2. College of Food Sciences and Technology, Shanghai Ocean University, Shanghai 201306, China

Abstract: To reduce losses during live-fish distribution, this study investigated the physiological and metabolic basis of delayed mortality under suitable holding conditions and the eventual failure to sustain survival in golden pompano (Trachinotus ovatus). Salinity screening, progressive cooling and untargeted liver metabolomics were combined to evaluate survival and physiological and metabolic responses. A salinity of 26‰ and a temperature of 21 °C were identified as suitable holding conditions within the tested range. Whole-process mean survival maintenance time at 21 °C was 19.33 h longer than at 29 °C. After 24 h of holding, the 21 °C group showed trends towards higher relative abundances of selected unsaturated fatty acids and lower abundances of phospholipid-related metabolites than the 25 °C group, suggesting that lipid adjustments may contribute to low-temperature live holding. At 21 °C, moribund fish had significantly lower relative abundances of selected unsaturated fatty acids and inosine and higher methionine sulfoxide than fish sampled after 24 h, indicating that changes in lipid, nucleoside and oxidation-related metabolism accompany physiological destabilization. These findings provide clues for investigating the mechanisms underlying low-temperature survival maintenance and its eventual failure, and inform holding management and loss reduction during live-fish distribution.

Keywords: Trachinotus ovatus; low-temperature holding; survival maintenance; moribund state; metabolomics

罗非鱼品种差异对营养品质及蛋白质结构功能特性差异的影响

作者 李雨航[1]，作者 张子越[2]

海南大学食品科学与工程学院，中国海口，570228

摘要：以海水红罗非鱼（SRT）、淡水红罗非鱼（FRT）、普通黑罗非鱼（FBT）、脆罗非鱼（FCT）为对象，探究品种差异对原料特性、蛋白质结构功能的影响。结果：SRT 粗蛋白、维生素 E、EPA 和 DHA 功能性脂肪酸及钙、钠等矿物质含量高；FCT 鲜味氨基酸含量较高，蛋白结构完整性好。FRT 粗脂肪、维生素 A 及铁、硒含量高。FBT 水分含量最高，蛋白结构稳定性最差。FBT 肌原纤维蛋白溶解度最高（75%）；FCT 最低（35%），但总巯基/活性巯基（73 μmol/g /32 μmol/g）含量最高；SRT 总巯基/活性巯基含量最低（42μmol/g /16 μmol/g）；FRT 各项加工特性处于中间水平。综上所述：品种差异决定原料基础营养品质与结构特性。蛋白功能特性与品种结构特征密切相关。研究结果为罗非鱼品种品质评价及定向加工利用提供理论依据。

关键词：罗非鱼；品种差异；营养品质；肌原纤维蛋白；加工利用；

通讯作者：李川，男，博士，教授，热带海洋食品科学与营养工程，17733163410，lichuan@hainanu.edu.cn;

Effects of Tilapia Variety Differences on Nutritional Quality and Protein Structural and Functional Property Differences

Yuhang Li[1], Ziyue Zhang[2]

1. School of Food Science and Engineering, Hainan University , Haikou, 570228, China

Abstract :In this study, fresh sea red tilapia (Oreochromis spp, SRT), fresh water red tilapia (Oreochromis spp, FRT), common black tilapia (Oreochromis niloticus, FBT) and crisp tilapia (Oreochromis niloticus, FCT) were used to investigate the effects of variety differences on raw material characteristics and protein structure and function. The results showed that SRT had high contents of crude protein, vitamin E, functional fatty acids such as EPA and DHA, and minerals such as calcium and sodium; FCT had relatively high umami amino acid content and good protein structural integrity. FRT was rich in crude fat, vitamin A, iron, and selenium. FBT had the highest moisture content

and the poorest protein structural stability. FBT showed the highest myofibrillar protein solubility (75%), whereas FCT had the lowest myofibrillar protein solubility (35%) but the highest total and active sulfhydryl contents (73 μmol/g/32 μmol/g); SRT had the lowest total and active sulfhydryl contents (42 μmol/g/16 μmol/g); and FRT exhibited intermediate levels in various processing properties. In conclusion, variety differences determine the basic nutritional quality and structural characteristics of raw materials, and protein functional properties are closely related to variety-specific structural characteristics. These findings provide a theoretical basis for the quality evaluation and targeted processing utilization of tilapia varieties.

Key words: Tilapia; Variety differences; Nutritional quality;Protein structure;Functional properties;Processing characteristics

毛鳞鱼鱼籽磷脂重塑高脂膳食小鼠脂肪酸谱并缓解肝脏氧化应激与脂质沉积

李浩 [1,2], 尹明雨 [1,2]*, 王锡昌 [1,2]*

[1] 上海海洋大学食品学院，上海 201306；

[2] 上海水产品加工及贮藏工程技术研究中心，上海 201306

摘要：目的：探究毛鳞鱼鱼籽磷脂（CPL）改善高脂膳食（HFD）诱导小鼠脂代谢紊乱与肝损伤的作用。方法：小鼠分为对照、模型、1.0%和 2.0% CPL 及蛋黄、大豆磷脂组，测定表型、糖耐量、血脂与肝氧化应激，并结合脂肪酸谱与转录组。结果：2.0% CPL 显著降低体重增量、腰围、BMI、血脂及肝脂，改善糖耐量，提高肝 SOD、GSH-Px、CAT 活性、降低 MDA，减轻肝脂肪变性与脂细胞肥大；其降低 MUFA、提高 n-3 多不饱和脂肪酸，上调 Gpx3、Gpx8、下调 Scd 等脂质合成基因，效果优于同剂量蛋黄、大豆磷脂。结论：CPL 通过抑制脂质合成、增强抗氧化防御和重塑脂肪酸组成改善 HFD 代谢紊乱。

关键词：毛鳞鱼鱼籽磷脂；高脂膳食；脂代谢紊乱；氧化应激；脂肪酸重塑

资助项目：国家重点研发计划项目（2023YFD2401503）

第一作者：尹明雨，男，博士，讲师，研究方向为海洋活性脂质与脂质组学、水产品脂质及营养品质；电话：17849012574；E-mail：xcwang@shou.edu.cn

Capelin Roe Phospholipids Reshape Fatty Acid Profiles and Alleviate Hepatic Oxidative Stress and Lipid Deposition in High-Fat Diet-Fed Mice

Hao Li [1,2], Mingyu Yin [1,2]*, Xichang Wang [1,2]*

[1] College of Food Science and Technology, Shanghai Ocean University, Shanghai 201306, China;

[2] Shanghai Engineering Research Center of Aquatic-Product Processing and Preservation, Shanghai 201306, China

Abstract: [Objective] To clarify the mechanisms by which capelin roe phospholipids (CPL) ameliorate high-fat diet (HFD)-induced lipid metabolic disorders and hepatic injury in mice. [Methods] C57BL/6 mice were assigned to control, model, 1.0% and 2.0% CPL, 2.0% egg yolk and

2.0% soybean phospholipid groups; phenotypes, glucose tolerance, serum lipids, hepatic oxidative stress and histopathology were determined and integrated with fatty acid profiling and hepatic transcriptomics. [Results] 2.0% CPL markedly reduced body weight gain, waist circumference, BMI, serum and hepatic lipids, improved glucose tolerance, elevated hepatic SOD, GSH-Px and CAT activities while lowering MDA, and alleviated hepatic steatosis and adipocyte hypertrophy. CPL decreased monounsaturated fatty acids and increased n-3 polyunsaturated fatty acids, up-regulated Gpx3 and Gpx8 and down-regulated Scd and other lipogenic genes, outperforming egg yolk and soybean phospholipids at the same dose. [Conclusion] CPL improves HFD-induced metabolic disorders by suppressing lipogenesis, enhancing antioxidant defence and remodelling fatty acid composition, and is a promising marine-derived functional food ingredient.

Key words: Capelin roe phospholipids; High-fat diet; Lipid metabolism disorder; Oxidative stress; Fatty acid remodeling

Funding: National Key Research and Development Program of China (Grant No. 2023YFD2401503)

First author: Yin Mingyu, male, PhD, Lecturer. Research interests: marine bioactive lipids and lipidomics, lipids and nutritional quality of aquatic products. Tel: 17849012574; E-mail: xcwang@shou.edu.cn

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

窦雨梦[1]，高沛[1,*]，姜启兴[1]，杨淑涵[1]，张晓靖[1]，于沛沛[1]，杨方[1]，刘少全[2,3]，夏文水[1]

[1]江南大学食品科学与资源国家重点实验室，食品安全与质量控制协同创新中心　江苏无锡　214122

[2]新加坡国立大学食品科学与技术系　新加坡　117546

[3]新加坡国立大学(苏州)研究院　江苏苏州　215123

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

资助项目：国家自然科学基金(31801575)、江苏省农业产业技术体系专项基金(JATS [2023] 464)、中国农业研究体系(CARS-45)

通讯作者：姓名：高沛；性别：男；学位：博士；职称：副研究员；研究方向：食品科学、食品生物加工技术、水产品加工；电话：18206188719；E-mail：g_pei1988@163.com

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

Yumeng Dou[1], Pei Gao[1,*], Qixing Jiang[1], Shuhan Yang[1], Xiaojing Zhang[1], Peipei Yu[1], Fang Yang[1], Shaoquan Liu[2,3], Wenshui Xia[1]

1. State Key Laboratory of Food Science and Resources, Collaborative Innovation Center of Food Safety and Quality Control, Jiangnan University, Wuxi, 214122, Jiangsu; 2. Department of Food Science and Technology, National University of Singapore, Singapore, 117546, Singapore; 3. National University of Singapore (Suzhou) Research Institute, Suzhou, 215123, Jiangsu

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

木聚糖链长与化学取代对六方冰晶面生长抑制的分子动力学研究

马有川，燕嘉，张恒颐，胡亚芹*

1.海南热带海洋学院食品科学与工程学院，572022，海南，三亚

摘要：目的：冰晶生长是决定水产品冷冻过程品质劣变的关键因素，半纤维素类多糖具有显著抑制冰晶生长效果，其抗冻行为与其在六方冰不同晶面上的相互作用密切相关，但木聚糖链长与化学取代如何调控晶面依赖的冰生长仍缺乏分子层面的认识。本研究旨在从分子尺度揭示木聚糖链长与化学取代对六方冰晶面生长的抑制机制。方法：采用全原子分子动力学模拟（CHARMM36/CGenFF 力场，TIP4P-ice 水模型，253 K，70 ns），对九种木聚糖类半纤维素（不同聚合度 DP 4、8、12，阿拉伯糖取代及 O-乙酰化 3/6/9）在冰 Ih 的(100)、(110)、(111)三个晶面（分别对应基面、一次棱柱面、二次棱柱面）上的吸附行为进行系统研究，并通过局部有序参数（q6）及氢键/能量分析解析溶质-水相互作用与冰生长动力学的耦合关系。结果：晶面各向异性为主导因素，九种结构均满足(110)＞(111)＞(100)的生长速率与平衡冰量排序，二次棱柱面(110)对结构差异最为敏感；九种结构中，3-O-乙酰化十二聚木糖（Ac3Xylo12）抗冻活性最强，在(110)快面冰生长速率最低（13.6 mol/ns），平衡冰量最低（5120 个水分子中仅约 606 个成冰），Ac9Xylo12 次之，Xylo8 再次之，而 Xylo4、Xylo12 及阿拉伯糖基木聚糖抗冻活性最弱；构效关系可概括为：链长（聚合度）提供吸附容量，糖-水氢键数随聚合度近线性增长，O-乙酰化使每残基静电相互作用随乙酰度单调增强（静电相互作用能由-19.6 增至-27.6 kJ/mol·res），但抑制呈非单调趋势（3/9 乙酰强抑制、6 乙酰回弹），提示疏水甲基与羰基偶极的竞争；阿拉伯糖侧链稀释界面极性、弱化冰面匹配，抗冻活性较弱。结论：本研究为冷冻食品体系中乙酰化木聚糖冰晶调控剂的设计提供了明确的构效关系依据，为水产品冷冻保鲜技术提供基础支撑。

关键词：

分子动力学模拟；冰晶生长；抗冻

基金项目：国家自然科学基金（32603375）；海南热带海洋学院高层次人才项目（RHDRC202117）；海南热带海洋学院青年人才项目（No. RHDRCZK202624).

*通讯作者：胡亚芹，女，博士，教授，研究方向：水产品冷冻保鲜；果蔬冷冻贮藏与品质调控。

作者简介：马有川，男，讲师，研究方向：水产品冷冻保鲜，冷冻干燥技术。

Molecular Dynamics Study on the Inhibition of Ice Growth on Hexagonal Ice Facets by Xylan Chain Length and Chemical Substitution

Youchuan Ma, Jia Yan, Hengyi Zhang, Yaqin Hu*

1. Hainan Tropical Ocean University, Sanya, Hainan 572022, China

Abstract: [Objective] The growth of ice crystals is a critical determinant of quality deterioration in frozen food, where the cryoprotective behavior of hemicellulosic polysaccharides depends on their interaction with distinct facets of hexagonal ice. However, a molecular-level understanding of how xylan chain length and chemical substitution modulate facet-dependent ice growth remains incomplete. This study aims to elucidate the molecular mechanisms by which xylan chain length and chemical substitution inhibit ice growth on hexagonal ice facets. [Methods] All-atom molecular dynamics simulations (CHARMM36/CGenFF, TIP4P-ice, 253 K, 70 ns) were performed for nine xylan-type hemicelluloses—varying in degree of polymerization (DP 4, 8, 12), arabinosyl substitution, and O-acetylation (3/6/9 acetyl groups)—adsorbed at the (100), (110), and (111) faces of ice Ih, corresponding to the basal, primary-prism, and secondary-prism growth planes. Local order parameters (q6) and hydrogen-bond/energy analyses over a 10–70 ns equilibrated window resolved the coupling between solute–water interactions and ice growth kinetics. [Results] Facet anisotropy dominates: growth rate and equilibrium ice fraction follow (110) > (111) > (100) across all nine structures, with the fast secondary-prism face amplifying structural differences. Among the nine structures, Ac3Xylo12 (3-O-acetylated DP12 xylan) exhibits the strongest antifreeze activity, with the lowest growth rate (13.6 mol/ns on the (110) face) and the lowest equilibrium ice fraction, followed by Ac9Xylo12 and Xylo8, whereas Xylo4, Xylo12, and the arabinosylated xylans are least effective. A structure–activity relationship emerges: chain length provides the adsorption capacity, solute–water hydrogen bonds scaling near-linearly with DP, while O-acetylation monotonically strengthens per-residue electrostatic coupling (from -19.6 to -27.6 kJ/mol·res) and acts as the dominant chemical switch for inhibition, yet suppression is non-monotonic on the (110) face (Ac3/Ac9 strong, Ac6 weak), implicating competition between hydrophobic methyl groups and carbonyl dipoles; arabinosyl side chains dilute interfacial polarity and weaken ice-face matching, yielding weak activity. [Conclusion] These findings provide a structure–activity framework for designing acetylated xylan cryoprotectants in frozen food systems and offer fundamental support for aquatic product freezing preservation technology.

Key words: molecular dynamic simulation, ice crystal growth, antifreeze

牡蛎抗疲劳肽的酶法制备及其体内外活性评价研究

陈文，胡晓*

上海海洋大学食品学院，上海，200100；中国水产科学研究院南海水产研究所/农业农村部水产品加工重点实验室，广州，510000

摘要：本研究以缓解运动性疲劳为切入点，以香港牡蛎为原料制备牡蛎抗疲劳肽。在单因素试验基础上，采用响应面法对牡蛎肽酶解工艺进行优化，以 ABTs 清除率为评价指标，建立二次回归模型，确定最佳酶解工艺参数。评估经不同改性方式及其顺序对牡蛎肽体外活性的影响，并开展理化性质分析。采用红外光谱、紫外光谱等手段对牡蛎肽进行结构表征，推测其分子结构的关键结构。通过小鼠负重游泳实验，评价牡蛎肽的体内抗疲劳活性，检测相关生化指标，揭示其抗疲劳作用潜力。本研究可为牡蛎源抗疲劳活性肽的开发与应用提供理论依据与实验支撑。

关键词：抗疲劳；响应面；体内活性；体外活性

资助项目：国家重点研发计划项目（2024YFD2401903）、广东省现代农业产业共性关键技术研发创新团队建设项目（加工与保鲜共性关键技术）（2024CXTD16）、中国水产科学研究院中央级公益性科研院所基本科研业务费专项资金资助（2023TD74）

*通讯作者：胡晓，男，博士，研究员，研究方向为水产品加工与质量安全、食品生物技术，13570526936，E-mail:hnhuxiao@163.com。

Enzymatic Preparation of Oyster Anti-Fatigue Peptides and Its In Vivo and In Vitro Activities Evaluation

Chen Wen, Hu Xiao*

College of Food Science and Technology, Shanghai Ocean University，Shanghai，200100；College of Food Science and Technology, Shanghai Ocean University，Guangzhou，510000

Abstract: This study takes the alleviation of exercise-induced fatigue as the starting point, and prepares anti-fatigue oyster peptides using *Crassostrea hongkongensis* (Hong Kong oyster) as raw material. On the basis of single-factor experiments, response surface methodology (RSM) was adopted to optimize the enzymatic hydrolysis process of oyster peptides. With ABTs scavenging rate as the evaluation index, a quadratic regression model was established to

determine the optimal enzymatic hydrolysis parameters. The effects of different modification methods and their sequences on the *in-vitro* activity of oyster peptides were evaluated, and physicochemical property analysis was carried out. Fourier transform infrared spectroscopy, ultraviolet spectroscopy and other techniques were used for structural characterization of oyster peptides to deduce the key molecular structural features. A weight-loaded swimming test in mice was performed to assess the *in-vivo* anti-fatigue activity of oyster peptides. Relevant biochemical indicators were determined to reveal its anti-fatigue potential. This study can provide theoretical basis and experimental support for the development and application of oyster-derived anti-fatigue active peptides.

Key words: anti-fatigue; response surface methodology; in vivo activity; in vitro activity

牡蛎源多肽和糖肽缓解脂质积累及结构表征

黄倩倩 [1,2]，陈忠琴 [1,2]，谭明堂 [1,2]，郑惠娜 [1,2]，林海生 [1,2]， 高加龙 [1,2]，秦小明 [1,2]，曹文红 [1,2*]

1.广东海洋大学食品科技学院，广东省水产品加工与安全重点实验室，广东湛江，524088；2.国家贝类加工技术研发分中心，广东湛江，524088

摘要：目的：挖掘牡蛎酶解产物中的天然活性肽及糖肽，探究其降血脂活性及结构特征。方法：以酶抑制活性为追踪指标，采用超滤与离子交换柱层析从牡蛎酶解物中分离获得活性组分 UF3-2，从酶分子、细胞与动物水平评价 UF3-2 的降血脂活性，并采用 UPLC-MS/MS 鉴定结构特征。结果：UF3-2 可显著抑制胰脂肪酶和胆固醇酯酶的活性，IC_{50} 分别为 0.5779 mg/mL 和 1.335 mg/mL。在游离脂肪酸诱导的 HepG2 细胞中，50 μg/mL UF3-2 可分别降低细胞内总胆固醇和甘油三酯水平 24.3%和 41.8%（$p<0.05$）。qPCR 结果显示，UF3-2 可下调 SREBP-1c, FASN, ACC, PPAR-γ, SREBP-2 和 HMGCR mRNA 的表达，上调 PPAR-α 和 CPT1A 的表达。动物实验表明，UF3-2 可缓解高脂饮食诱导的小鼠体内脂肪过度蓄积，改善血脂异常。LC-MS/MS 表征鉴定 UF3-2 为同时含有多肽和 N-连接及 O-连接糖肽的复合组分。结论：综上，UF3-2 可通过缓解脂质代谢异常发挥降血脂作用，具有作为功能性食品配料的开发潜力。

关键词：牡蛎；活性肽；糖肽；降血脂活性；结构表征

基金项目：国家现代农业产业技术体系 （CARS-49）；广东海洋大学研究生教育创新计划资助项目（202626）；广东省现代农业产业技术体系贝类藻类产业创新团队项目（2024CXTD23）

***通讯作者**：曹文红（1977-），男，博士，教授，博士生导师，研究方向为海洋生物资源利用。E-mail: cwenhong@gdou.edu.cn

Oyster-derived peptides and glycopeptides alleviate lipid accumulation and structural characterization

Qianqian Huang [1, 2], Zhongqin Chen[1, 2], Mingtang Tan [1, 2], Huina Zheng [1, 2], Haisheng Lin [1, 2], Jialong Gao [1, 2], Xiaoming Qin [1, 2], Wenhong Cao [1, 2, *]

1.College of Food Science and Technology, Guangdong Ocean University, Zhanjiang 524088, China; 2.National Research and Development Branch Center for Shellfish Processing, Zhanjiang 524088, China.

Abstract: Objective: To explore the natural active peptides and glycopeptides from oyster enzymatic hydrolysates, and to investigate their hypolipidemic activity and structural characteristics. Methods: Using enzyme inhibitory activity as a tracking indicator, the active fraction UF3-2 was isolated from oyster hydrolysates via ultrafiltration and ion-exchange column chromatography. The hypolipidemic activity of UF3-2 was evaluated at the enzymatic, cellular, and animal levels, and its structural characteristics were identified using UPLC-MS/MS. Results: UF3-2 significantly inhibited pancreatic lipase and cholesterol esterase activities, with IC_{50} values of 0.5779 mg/mL and 1.335 mg/mL, respectively. In free fatty acid (FFA)-induced HepG2 cells, 50 μg/mL UF3-2 reduced intracellular total cholesterol and triglyceride levels by 24.3% and 41.8% ($p < 0.05$), respectively. qPCR results showed that UF3-2 downregulated the mRNA expression of SREBP-1c, FASN, ACC, PPAR-γ, SREBP-2, and HMGCR, while upregulating the expression of PPAR-α and CPT1A. Animal experiments demonstrated that UF3-2 alleviated excessive fat accumulation induced by a high-fat diet and ameliorated dyslipidemia. UPLC-MS/MS identified UF3-2 as a complex fraction containing both peptides and N-linked and O-linked glycopeptides. Conclusion: UF3-2 exerts a hypolipidemic effect that is associated with the alleviation of abnormal lipid metabolism, exhibiting potential for development as a functional food ingredient.

Keywords: Oyster; Active peptides; Glycopeptides; Hypolipidemic activity; Structural characterization

Funding: This work was supported by the earmarked fund for China Agriculture Research System (CARS-49), the Postgraduate Education Innovation Project of Guangdong Ocean University (202626) and the Shellfish & Algae Industry Innovation Team of Guangdong Modern Agricultural Technology System (No. 2024CXTD23).

* *Correspondence author: Wenhong Cao, College of Food Science and Technology, Guangdong Ocean University, Zhanjiang, China. Email: cwenhong@gdou.edu.cn*

纳米颗粒稳定的精油皮克林乳液/壳聚糖膜对虾的保鲜效果研究

夏文[1]，林雁芸[1]，刘书成[1*]

1. 广东海洋大学 食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研发中心，广东省海洋生物制品工程重点实验室，水产品深加工广东普通高校重点实验室，广东 湛江 524088

摘要:【目的】针对虾类易腐败、石油基保鲜膜难降解且抗菌不足，开发绿色可降解活性包装。【方法】通过 DHPM“一步法”制备木薯淀粉-杨梅素复合纳米颗粒（MY/HMTS），稳定肉桂精油/椰子油 Pickering 乳液，流延法制备壳聚糖基复合膜（CH-PC），用于对虾冷藏保鲜。【结果】MY/HMTS 包埋率 93%~96%；CH-10%PC 膜疏水性较壳聚糖膜提升 31.13%，DPPH 清除率 86%，抑菌显著。贮藏第 8 天，该膜组 MDA 13.8 nmol/mg、pH 7.28，菌落总数<6 log CFU/g，色泽、持水力与质构均优于 PE 膜和纯壳聚糖膜。【结论】该膜可延缓对虾品质劣变，为高效环保活性包装提供新思路。

关键词：纳米淀粉；杨梅素；壳聚糖；虾；保鲜

资助项目：国家虾蟹产业技术体系“虾加工与保鲜”（项目编号：CARS-48）专项和广东省重点研发计划项目“深远海养殖产品绿色加工关键技术研发及示范应用”（项目编号：2025B1111140001）

第一作者：夏文，男，博士，副教授，主要从事食品纳米技术的生物可降解材料的构建及应用。

电话：13414878093；E-mail: xiawensg@163.com

南海特色海参脂质改善高尿酸血症小鼠肾损伤的比较研究

李庚轩，王玉明*，史豪豪*

中国海洋大学，海南大学，食品科学与工程学院，海口，571101

摘要：高尿酸血症是慢性肾脏病发生发展的重要危险因素。黑玉参和黄玉参是南海特色海参资源，富含多种脂溶性活性成分，具有潜在的降尿酸及肾脏保护作用。本研究以黑玉参和黄玉参为原料提取粗脂，采用高酵母饮食联合氧嗪酸钾和腺嘌呤灌胃构建高尿酸血症小鼠肾损伤模型，系统评价两种海参粗脂对高尿酸血症及其相关肾损伤的改善作用，并比较其干预效果差异。结果表明，该造模方式可显著升高小鼠血清尿酸水平，并伴随肾功能异常、肾组织病理损伤及炎症反应增强。与模型组相比，黑玉参粗脂和黄玉参粗脂干预均可显著降低血清尿酸水平，改善肾功能指标，减轻肾组织病理损伤并抑制炎症反应。其中，黑玉参粗脂在降低血清尿酸、改善肾功能及缓解肾组织损伤方面表现出更为显著的作用。综上，南海特色海参脂质对高尿酸血症相关肾损伤具有良好的改善潜力，且不同海参来源脂质的作用效果存在一定差异。本研究为南海特色海参脂质活性成分的深入开发及海参资源高值化利用提供了实验依据。

关键词：海参；功能性脂质；高尿酸血症；肾损伤；尿酸代谢

资助项目：海南省国际科技合作研发项目（GHYF2026045）

通讯作者：史豪豪，男，博士研究生，副教授，食品化学与营养，17864272928，shihaohao@hainanu.edu.cn

Improvement Effects and Comparative Study of Lipids from South China Sea Characteristic Sea Cucumbers on Kidney Injury in Hyperuricemic Mice

Gengxuan Li, Yuming Wang*, Haohao Shi*

College of Food Science and Engineering, Ocean University of China, Hainan University, Haikou, 571101, Hainan

Abstract: Hyperuricemia is an important risk factor for the development and progression of chronic kidney disease. *Holothuria atra* and *Stichopus hermanni* are characteristic sea cucumber resources from the South China Sea and are rich in various bioactive lipid-soluble components, suggesting their potential hypouricemic and renoprotective effects. In this study, crude lipids were extracted from *Holothuria atra* and *Stichopus hermanni*. A mouse model of hyperuricemia-associated renal injury was established using a high-yeast diet combined with potassium oxonate and adenine gavage. The protective effects of the two sea cucumber crude lipids against hyperuricemia and related renal injury were systematically evaluated, and their differential effects were compared. The results showed that the modeling procedure significantly increased serum uric acid levels in mice, accompanied by impaired renal function, renal histopathological damage, and enhanced inflammatory responses. Compared with the model group, intervention with both *Holothuria atra* crude lipid and *Stichopus hermanni* crude lipid significantly reduced serum uric acid levels, improved renal function, alleviated renal histopathological damage, and suppressed inflammatory responses. Notably, *Holothuria atra* crude lipid exerted more pronounced effects than *Stichopus hermanni* crude lipid in reducing serum uric acid levels, improving renal function, and alleviating renal tissue injury. Collectively, lipids from characteristic sea cucumbers of the South China Sea showed promising protective effects against hyperuricemia-associated renal injury, with differences in efficacy between lipids derived from different sea cucumber species. These findings provide experimental evidence for the further development of bioactive lipid components from characteristic sea cucumber resources of the South China Sea and their high-value utilization.

Keywords: sea cucumber; functional lipids; hyperuricemia; renal injury; uric acid metabolism

南极磷虾可溶性蛋白抗冻组分的分离筛选及其对保加利亚乳杆菌的冷冻保护作用

唐世英[1]，刘海泉[1]，赵勇[1*]，王敬敬[2*]

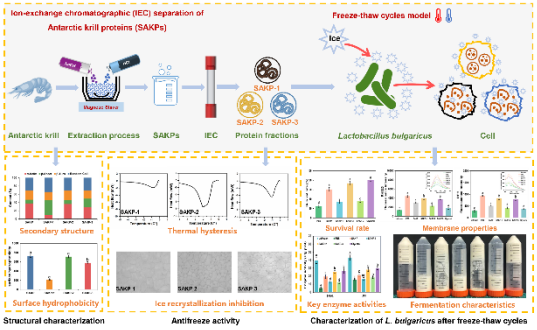
[1]上海海洋大学食品学院，中国上海，201306

[2]佛山大学食品科学系，中国佛山，528225

摘要：本研究从南极磷虾（*Euphausia superba*）可溶性蛋白中分离蛋白组分，并评价其抗冻活性及对保加利亚乳杆菌的冷冻保护作用。通过离子交换层析获得三个组分（SAKP-1、SAKP-2、SAKP-3），各组分表现出不同的结构特征。SAKP-1 的特点为脯氨酸含量高、α-螺旋含量低（9.77%）。相比之下，SAKP-2 具有较高的 α-螺旋含量（36.11%）和较强的表面疏水性。SAKP-3 的 α-螺旋含量适中（27.90%），疏水性居中。相应地，SAKP-2 在三个组分中表现出最高的热滞活性（0.45 °C）和冰重结晶抑制活性。在冷冻保护试验中，SAKP-2 提高了保加利亚乳杆菌经冻融循环后的存活率，达到 73.86%，与 10%甘油的效果相当。此外，SAKP-2 处理保持了菌体细胞膜完整性，维持了代谢活性，并改善了菌体的发酵性能。这些发现表明 SAKP-2 是一种有前景的天然冷冻保护剂，并为南极磷虾的高值化利用提供了策略。

关键词：南极磷虾；抗冻蛋白；结构表征；冷冻保护；天然冷冻保护剂

图形摘要：



资助项目：国家重点研发计划（2024YFD2402204）、广东省智能食品制造重点实验室（2022B1212010015）。

通讯作者：

王敬敬，男，博士，副教授，研究方向为新型光动力杀菌技术的开发、水产品贮藏保鲜及品质控制、食品功能蛋白构效关系与食品副产物高质化利用。电话 15918056890，邮箱 w_j2010@126.com

赵勇，男，博士，教授，研究方向为食品微生物分子生态学、食品质量安全风险评估以及食品质量安全与系统生物学研究。电话 15692165928，邮箱 yzhao@shou.edu.cn

南极磷虾蒸煮分离液中水溶性蛋白的回收及理化特性分析

魏努亚[1,2]，马田田[2]，刘远昊[2]，欧阳杰[2,*]，王晓辉[2]

（1.上海海洋大学食品学院，上海 201306；2.中国水产科学研究院渔业机械仪器研究所，上海 200092）

摘要：南极磷虾粉加工产生的蒸煮分离液回收率低，常被废弃。本研究评估其回收利用潜力：该分离液干基蛋白质含量达 56.45%，蒸煮分离过程中约 21.03%的蛋白质流失其中。分别从初始磷虾、蒸煮分离后虾体及蒸煮分离液中盐析提取水溶性蛋白（O-WP、C-WP、L-WP），比较其氨基酸组成、分子量分布、结构及功能特性。结果显示，L-WP 总氨基酸含量、亲水/疏水氨基酸比值及必需氨基酸指数最高，营养品质良好；以<55 kDa 小分子蛋白为主，二级结构高度有序（β-折叠+α-螺旋占比 76.22%）；溶解度达 454.27±10.02 μg/mL，起泡能力 36.02%，泡沫稳定性、乳化性及持水持油性与 O-WP、C-WP 多无显著差异，主成分分析显示三者性能高度重叠。综上，L-WP 安全、营养高、具小分子结构和优良功能特性，回收价值良好，为南极磷虾加工废弃物高值化利用提供了科学依据。

关键词：南极磷虾；水溶性蛋白质；回收；氨基酸组成；功能特性

作者简介：魏努亚（2001-），女，硕士研究生，研究方向：水产加工副产物高值化利用。Tel: 15608016206; Email: 2350096960@qq.com。

*通讯作者简介：欧阳杰（1983-），男，研究员，研究方向：水产品加工技术与装备研究。Tel: 13564403710; Email: ouyangjie@fmiri.ac.cn。

基金项目：国家重点研发计划《食品级南极磷虾粉船载加工技术与自动化成套装备研发》（2023YFD2401204）。

泥蚶铁蛋白-抗坏血酸纳米颗粒的构建及其铁吸收机制研究

毛志城[1]，朱育涟[1]，黄涛[2]，杨文鸽[2*]，孙博伦[1*]

1 温州医科大学护理学院，浙江温州，325035

2 宁波大学食品科学与工程学院，浙江宁波，315211

摘要：

目的： 构建泥蚶铁蛋白-抗坏血酸纳米颗粒（Ferritin-Ascorbic Acid Nanoparticles，FANs），评价其体外铁生物可及性、细胞吸收特性及体内改善缺铁性贫血（IDA）的效果，为开发新型海洋源补铁剂提供理论依据。**方法：** 采用 pH 驱动法制备不同配比 FANs，利用粒径、Zeta 电位、荧光光谱、FTIR、CD、SEM 等技术对其结构进行表征；结合模拟胃肠消化、Caco-2 细胞模型及细胞摄取抑制实验评价铁释放行为、生物利用率及吸收机制；建立 IDA 大鼠模型，检测血液学指标、铁代谢相关指标及肠道铁转运蛋白表达，评价其补铁效果及安全性。**结果：**FANs 形成后蛋白构象发生重排，铁结合位点增加，并表现出持续稳定的铁释放特性。其中 FANs（10:1）具有最佳铁生物利用率，可显著促进 Caco-2 细胞铁吸收，主要通过受体介导的内吞途径进入细胞。动物实验表明，FANs 能够显著改善 IDA 大鼠血液学和生化指标，恢复组织铁稳态，上调 DMT1、Dcytb 和 FPN 等铁转运相关蛋白表达，其补铁效果优于 $FeSO_4$，并具有良好的生物安全性。**结论：** 抗坏血酸可有效调控泥蚶铁蛋白纳米结构，提高铁释放效率及生物利用率。FANs 具有优异的补铁性能和良好的安全性，在海洋源功能性补铁剂开发及海洋生物资源高值化利用方面具有良好的应用前景。

关键词：泥蚶铁蛋白；抗坏血酸；纳米颗粒；缺铁性贫血；铁生物利用率

国家重点研发计划（项目编号：2024YFD2401601）；温州市护理学会科研项目（项目编号：WHQN202507）。**通讯作者：**孙博伦，男，博士，校聘副研究员，硕士生导师，主要从事食品营养与人体健康、微量营养素与缺铁性贫血、海洋功能性食品开发及海洋生物资源高值化利用研究。Tel：**19858812202**；E-mail：**sunbolun@wmu.edu.cn**

Ferritin-Ascorbic Acid Nanoparticles from Tegillarca granosa Enhance Iron Bioavailability and Alleviate Iron-Deficiency Anemia

Zhicheng Mao[1], Yulian Zhu[1], Tao Huang[2], Wenge Yang[2]*, Bolun Sun[1]*

[1] **School of Nursing, Wenzhou Medical University, Wenzhou 325035, Zhejiang, China**

[2] **School of Food Science and Engineering, Ningbo University, Ningbo 315211, Zhejiang, China**

Abstract: **Objective:** To construct ferritin–ascorbic acid nanoparticles (FANs) derived from *Tegillarca granosa* ferritin and evaluate their in vitro iron bioaccessibility, cellular iron uptake, and therapeutic efficacy against iron-deficiency anemia (IDA), thereby providing a theoretical basis for the development of novel marine-derived iron supplements. **Methods:** FANs with different ferritin-to-ascorbic acid ratios were prepared using a pH-driven method. Their physicochemical properties were characterized by particle size analysis, zeta potential measurement, fluorescence spectroscopy, Fourier transform infrared spectroscopy (FTIR), circular dichroism (CD), and scanning electron microscopy (SEM). Simulated gastrointestinal digestion, Caco-2 cell models, and uptake inhibition assays were employed to investigate iron release behavior, bioavailability, and cellular uptake mechanisms. An IDA rat model was established to evaluate the anti-anemia efficacy and biosafety of FANs through hematological, biochemical, and iron metabolism-related analyses. **Results:** The formation of FANs induced conformational rearrangement of ferritin, increased iron-binding sites, and exhibited sustained iron release during simulated gastrointestinal digestion. Among the formulations, FANs (10:1) showed the highest iron bioavailability and significantly enhanced iron uptake by Caco-2 cells, primarily through receptor-mediated endocytosis. In vivo, FANs markedly improved hematological and biochemical parameters, restored systemic iron homeostasis, upregulated the expression of intestinal iron transport proteins including DMT1, Dcytb, and FPN, and demonstrated superior anti-anemia efficacy compared with $FeSO_4$ while maintaining excellent biosafety. **Conclusion:** Ascorbic acid effectively regulates the nanostructure of *Tegillarca granosa* ferritin, thereby enhancing iron release efficiency and bioavailability. FANs exhibit excellent iron supplementation efficacy and biosafety, highlighting their promising potential as marine-derived functional iron supplements and providing a new strategy for the high-value utilization of marine biological resources.

Key words: *Tegillarca granosa* ferritin; Ascorbic acid; Ferritin–ascorbic acid nanoparticles; Iron-deficiency anemia; Iron bioavailability

烹饪方式对卤制中华鳖食用品质的影响

潘长乐[1]，陈怀远[1],黄涛[1*]

1. 宁波大学食品科学与工程学院，浙江宁波，315800

摘要：本研究探究了焯水、传统烹饪（TC）、真空烹饪（VC）与高压烹饪（HPC）对卤制中华鳖食用品质的影响。结果表明，三种热处理方式会造成样品色泽呈现差异化变化：裙边颜色加深并偏绿，鳖腿肉色泽变浅且发黄。高压烹饪（HPC）样品质地最为柔嫩；真空烹饪（VC）则能最好地保留鳖腿肉的持水性与整体感官可接受度。体外消化实验结果显示，真空烹饪提升了裙边蛋白的消化率，而焯水与传统烹饪更利于提高鳖腿肉的消化率。电子舌、电子鼻结合主成分分析（PCA）表明，真空烹饪组的整体滋味与气味轮廓最为均衡。采用顶空固相微萃取 - 气相色谱 - 质谱联用技术（HS-SPME-GC-MS）共鉴定出 130 种挥发性物质；其中高压烹饪组的挥发性物质种类最为丰富。通过正交偏最小二乘判别分析（OPLS-DA）与气味活性值（OAV）筛选得到关键风味标志物及核心香气活性物质。分子对接模拟结果进一步证实，5 种关键香气物质（OAV＞10：辛醛、庚醛、壬醛、1 - 辛烯 - 3 - 醇、癸醛）可与人嗅觉受体 OR1A1 的活性位点有效结合。综上，真空烹饪可实现食用品质的综合最优平衡；高压烹饪更适合开发质地极柔嫩、风味浓郁的产品。该研究结果可为中华鳖加工工艺优化及加工制品品质提升提供理论依据。

关键词：中华鳖；烹饪方式；食用品质；蛋白消化率；风味物质；分子对接

作者简介：潘长乐（2002-），男，硕士研究生，研究方向：水产品资源高值化综合利用，

通讯作者：黄涛（1987-），男，博士，研究员，研究方向：水产品资源高值化综合利用

工作单位：宁波大学食品科学与工程学院

邮政编码：315800

联系电话：+86-13586713769

样刊邮递地址：浙江省宁波市北仑区梅山街道七星南路169号宁波大学梅山校区

电子邮箱：19818518260@163.com

基金项目：国家重点研发计划（2024YFD2401602）、浙江省“三农九方”科技合作项目（2025SNJF092SNJF2026015）、宁波大学高层次科技项目培育专项（GJPY2025031）

Effect of cooking methods on the edible quality of marinated Chinese soft-shelled turtle (Pelodiscus sinensis)

Pan Changle[1], Chen Huaiyuan[1]， Huang Tao[1*]

1. School of Food Science and Engineering, Ningbo University , Ningbo, 315832, Zhejiang

Abstract: This study investigated the effects of blanching, traditional cooking (TC), vacuum cooking (VC), and high-pressure cooking (HPC) on the edible quality of marinated Chinese soft-shelled turtle. It showed that the three thermal processing induced distinct color changes, with calipash darkening and greening and leg meat lightening and yellowing. HPC produced the tenderest texture, whereas VC best retained water-holding capacity and overall sensory acceptability of leg meat. The in vitro digestion analysis showed that VC improved the calipash protein digestibility, while blanching and TC optimized leg meat digestibility. E-tongue and e-nose combined with PCA showed that VC presented the most balanced overall taste and odor profile. HS-SPME-GC-MS characterized 130 volatile compounds, among which HPC generated the most abundant volatile composition. OPLS-DA and odor activity value (OAV) analysis identified key flavor biomarkers and core aroma-active compounds. Furthermore, molecular docking simulations revealed that five key aroma molecules (OAV > 10: octanal, heptanal, nonanal, 1-octen-3-ol, and decanal) could effectively bind to the active site of human olfactory receptor OR1A1, Collectively, VC provided the best balance of edible quality, while HPC favored the development of highly tender, strongly flavored products. These results offer a theoretical basis for optimizing processing techniques and improving the quality of processed Chinese soft-shelled turtle products.

Key words: Chinese soft-shelled turtle; cooking methods; edible quality; protein digestibility; flavor substance; molecular docking

热带水果果皮多酚-壳聚糖复合膜的构建及对石斑鱼保鲜效果的研究

周依诺，谢玫珍，云永欢，陈李品*

（海南大学食品科学与工程学院，海口，570228）

摘要：多酚类物质作为天然且安全的活性成分，在食品保鲜中发挥着关键作用，热带水果是潜在的多酚类物质资源宝库，因此，本研究选用海南热带水果为原料，对果皮与果肉中的多酚类物质进行靶向定量，研究发现菠萝蜜果皮多酚有潜在的抗菌和抗氧化能力，并结合分子对接对其活性机制进行阐明。此外，将菠萝蜜果皮多酚与壳聚糖接枝并制成保鲜薄膜应用于石斑鱼的保鲜。研究发现，随着果皮多酚含量的升高的添加，薄膜的溶胀度、含水量等物理性质得到了改善，在冷藏石斑鱼保鲜过程中试验组的保鲜期延长了 4 天，改性膜的菌落总数指标呈现出较优异的效果，鱼肉的 TBA 和 TVBN 的积累随着多酚含量的升高而下降。该研究为水果副产品的利用以及石斑鱼贮藏保鲜技术提供了理论基础。

关键词：热带水果多酚；薄膜保鲜；石斑鱼

热加工方式调控海带强化牦牛肉体系消化行为及活性肽释放机制研究

王玉娇，启航*

大连工业大学食品学院，辽宁省大连市，116000

摘要：本研究探究不同热加工方式对海带（*Laminaria japonica*）强化牦牛肉复合体系结构特性、营养释放及消化衍生活性肽形成的影响，为海洋藻类资源高值化利用及功能肉制品开发提供理论依据。以海带-牦牛肉复合肉饼为研究对象，采用湿热和干热两种加工方式制备样品，结合 INFOGEST 体外胃肠消化模型，通过蛋白消化率、氨基酸释放、糖类、酚类及钙释放分析，结合粒径、微观结构表征及 LC-MS/MS 肽组学技术，系统解析热加工-结构变化-消化释放之间的关联机制。结果表明，湿热处理促进蛋白质展开及水合作用，形成酶易接近的疏松结构，提高蛋白消化率，并促进酚类、糖类及钙等营养成分释放；干热处理则诱导蛋白氧化交联和聚集，形成致密结构，限制酶解过程及营养释放。肽组学分析表明，湿热加工体系产生更多具有潜在抗氧化和钙结合能力的短链活性肽，而干热体系释放肽段生物可及性较低。总之，两种热加工方式通过调控海藻多糖-肌肉蛋白互作网络及消化微环境，决定海带强化牦牛肉体系的营养利用效率和活性肽生成特征。本研究为海洋藻类功能食品及高营养复合肉制品精准加工提供理论基础。

关键词：海藻牦牛肉复合体系；体外模拟消化；营养释放；结构演变；肽组学

Thermal Processing Regulates Digestion Behavior and Bioactive Peptide Release of Laminaria-Fortified Yak Meat Systems

Yujiao Wang, Hang Qi*

School of Food Science and Technology, Dalian Polytechnic University, , Dalian, 116034, Liaoning.

Abstract: This study investigated the effects of different thermal processing methods on structural characteristics, nutrient release, and digestion-derived bioactive peptide formation in *Laminaria japonica*-fortified yak meat composite systems, providing insights into the high-value utilization of marine algae resources and functional food development. Seaweed-yak meat patties were prepared using moist-heat and dry-heat treatments and evaluated using the INFOGEST in vitro gastrointestinal digestion model. Protein digestibility, nutrient release, microstructural changes, and peptide profiles were characterized through biochemical analyses, particle size measurement,

microscopic observation, and LC-MS/MS-based peptidomics. The results showed that moist-heat treatment promoted protein unfolding and hydration, generating an enzyme-accessible matrix with enhanced digestibility and increased release of phenolics, carbohydrates, and calcium. In contrast, dry-heat treatment induced protein oxidation, cross-linking, and aggregation, forming compact structures that inhibited enzymatic hydrolysis and nutrient release. Peptidomic analysis revealed that moist-heat processing promoted the generation of short-chain peptides with potential antioxidant and calcium-binding activities, whereas dry-heat processing resulted in lower peptide bioaccessibility. Overall, thermal processing regulated the digestion behavior and functional properties of *Laminaria japonica*-fortified yak meat systems by modulating seaweed polysaccharide-protein interactions and matrix structures. These findings provide a theoretical basis for the precise processing and development of marine algae-enriched functional meat products.

Key words: seaweed-yak meat composite system; in vitro simulated digestion; nutrient release; structural evolution; peptidomics

该研究得到了辽宁省“兴辽英才计划”领军人才项目（XLYC2202029）、“十四五”国家重点研发计划项目（2023YFD2100601）、辽宁省应用基础研究计划（2022JH2/101300138）、辽宁省教育厅基本科研项目重点攻关项目（LJKZZ20220065）的资助。

*启航，男，博士，大连工业大学食品学院教授、博士生导师，现任大连工业大学食品学院食品科学与工程系主任，兼任第三届辽宁省食品科学技术学会执行秘书长，全国食品工业标准化技术委员会第五届罐头分技术委员会委员，中国食品科学技术学会休闲食品加工技术分会第二届理事会理事。入选教育部“人才奖励计划”青年学者；辽宁省“兴辽英才计划”领军人才；辽宁省“百千万人才工程”百层次，辽宁省“兴辽英才计划”青年拔尖人才，大连市杰出青年科技人才，大连市政府特殊津贴。主要从事水产品加工贮藏技术；藻类资源综合开发利用的教学和科研工作，主持国家自然科学基金项目、国家重点研发计划项目等科研项目 10 余项。获辽宁省科技进步一等奖 2 项；以第一发明人申请国家专利 35 项，授权 18 项；以第一或通讯作者发表 SCI 论文 70 余篇。电话：13804082670，E-mail：qihang@dlpu.edu.cn。

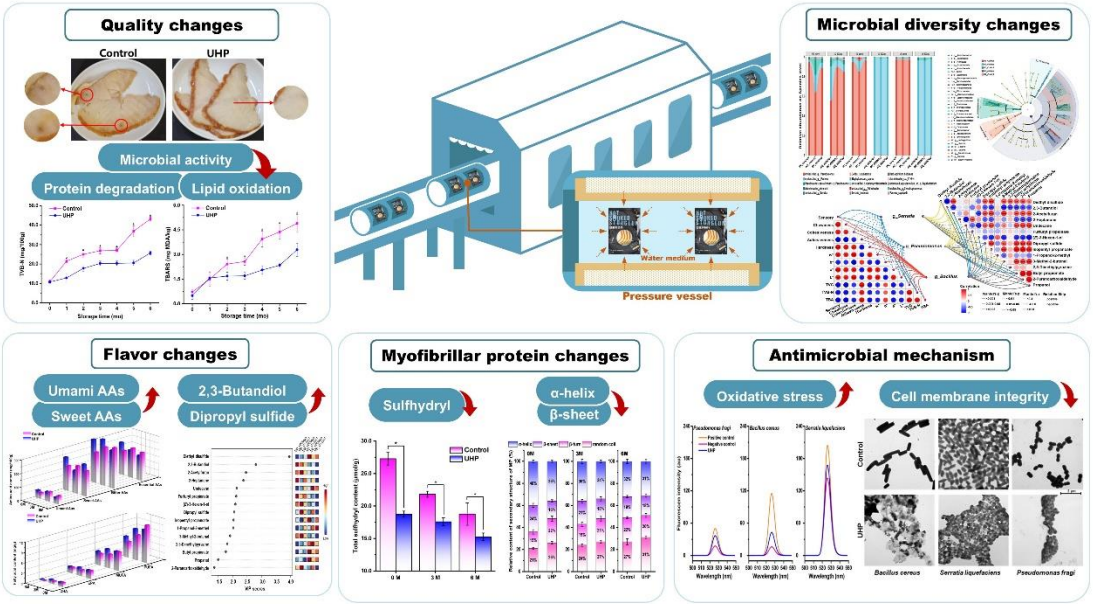
热熏鲟鱼片品质变化的机制解析：超高压条件下腐败菌群动态研究

李珂 1，徐新星 1，赵元晖 1*

1 中国海洋大学食品科学与工程学院，山东青岛，266000

摘要：热熏鲟鱼片风味独特，但真空包装下货架期较短，限制其经济价值。本研究探究超高压（UHP）处理对真空包装热熏鲟鱼片的品质影响机制。结果显示，600 MPa 超高压处理可将产品货架期由 3 个月延长至 6 个月。贮藏 6 个月后，样品挥发性盐基氮为 25.67 mg/100g，硫代巴比妥酸反应物达 3.28 mg MDA/kg，肌原纤维蛋白高级结构发生改变。该处理可较好保留酚类、二丙硫醚等特征风味，抑制庚醛、丁酸等不良风味物质生成。微生物组分析表明，*Serratia liquefaciens* S1, *Pseudomonas fragi* P1, *and Bacillus cereus* B1 是介导挥发性组分与品质劣变的关键腐败微生物。超高压通过破坏菌体细胞膜、诱发氧化应激，实现对腐败菌的抑制。本研究从腐败菌群动态角度证明，UHP 可作为提升鲟鱼制品附加值的有效非热加工技术。

关键词：热熏鲟鱼片；超高压；肌原纤维蛋白；贮藏品质；抑菌机制



溶菌酶-壳聚糖复合颗粒的构建及其对典型水产腐败菌的协同抑菌机理

金宁[1,2]，张俊[1,2*]，刘书成[1,2*]

1.广东海洋大学食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋生物制品工程实验室，广东省海洋食品工程技术研究中心，广东省水产预制食品加工与品质控制工程技术研究中心，广东湛江，524088；

2.海洋食品精深加工关键技术省部共建协同创新中心，大连工业大学，辽宁大连，116034

摘要：针对游离溶菌酶（Lysozyme, LYZ）环境稳定性不足及对革兰氏阴性菌抑菌作用有限的问题，本研究以壳聚糖（Chitosan, CS）为基体，引入植酸（phytic acid, PA）和乙二胺四乙酸（ethylenediaminetetraacetic acid, EDTA）功能基团，通过醛基化及席夫碱共价交联构建 CS-PA-LYZ 和 CS-EDTA-LYZ 固定化溶菌酶复合颗粒。经响应面优化，两种复合颗粒的比酶活分别达到 53.12 和 55.76 U·mg^{-1}。固定化后，LYZ 最适温度和最适 pH 分别提高至 40 ℃和 5.0，并在 pH 4.0-8.0、高盐及 4 ℃储藏条件下表现出更好的活性保持能力和稳定性。结构表征表明，LYZ 与功能化壳聚糖形成稳定共价结合，固定化过程中蛋白构象仅发生有限调整，有利于维持其催化活性。所得复合颗粒平均粒径约 7-8 μm，三相接触角为 70°-85°，兼具良好的界面润湿性和颗粒稳定特征。多尺度结构表征分析，PA 和 EDTA 可通过螯合外膜稳定离子、削弱革兰氏阴性菌外膜屏障，提高 LYZ 对细胞壁肽聚糖的作用可及性，与 LYZ 的酶促水解作用形成协同抑菌效应。CS-PA-LYZ 和 CS-EDTA-LYZ 均对金黄色葡萄球菌、大肠杆菌、假单胞菌和希瓦氏菌表现出较好的抑菌活性，并在 4 ℃条件下保持稳定的抗菌效果。本研究构建了集溶菌酶稳定化、革兰氏阴性菌增敏及界面功能于一体的复合抗菌颗粒，为天然抗菌材料在水产食品保鲜及活性包装中的应用提供了新的材料设计思路。

关键词：溶菌酶；壳聚糖；植酸；乙二胺四乙酸；固定化酶；协同抑菌

通讯作者：张俊，zhangjun@gdou.edu.cn; 刘书成，liusc@gdou.edu.cn

基金项目：广东省重点研发领域研发计划项目(2025B1111140001)；国家虾蟹产业技术体系（CARS-47）；广东省普通高校青年创新人才项目（2023KQNCX025）

Lysozyme-Chitosan Composite Particles: Construction and Synergistic Antibacterial Mechanisms against Typical Aquatic Spoilage Bacteria

Ning Jin[1, 2]，Jun Zhang[1, 2*]，Shucheng Liu[1, 2*]

1College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Guangdong Province Engineering Laboratory for Marine Biological Products, Guangdong Provincial Engineering Technology Research Center of Seafood, Guangdong Provincial Engineering Technology Research Center of Prefabricated Seafood Processing and Quality Control, Zhanjiang 524088, China

2Collaborative Innovation Center of Seafood Deep Processing, Dalian Polytechnic University，Dalian, 116034

Abstract：To improve the stability of free lysozyme (LYZ) and its limited activity against Gram-negative bacteria, chitosan (CS)-based immobilized LYZ particles were prepared using phytic acid (PA) or EDTA through aldehyde functionalization and Schiff-base crosslinking. After optimization, the specific activities of CS-PA-LYZ and CS-EDTA-LYZ reached 53.12 and 55.76 $U \cdot mg^{-1}$, respectively. Immobilization increased the optimum temperature and pH to 40 °C and 5.0, and enhanced LYZ stability under pH 4.0-8.0, high-salt, and 4℃ storage conditions. The particles showed sizes of approximately 7-8 μm and contact angles of 70°-85°, indicating favorable interfacial wettability. PA and EDTA weakened the outer membrane barrier of Gram-negative bacteria through ion chelation, improving LYZ accessibility to peptidoglycan and producing synergistic antibacterial effects. Both particles exhibited effective antibacterial activity against **Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas* spp., and *Shewanella* spp*. This study provides a multifunctional antibacterial system with improved enzyme stability, Gram-negative bacterial sensitization, and interfacial functionality for aquatic food preservation and active packaging.

Keywords：Lysozyme；Chitosan；EDTA；Phytic acid；Immobilized enzyme；Synergistic antibacterial

Corresponding authors: Zhang Jun, zhangjun@gdou.edu.cn; Liu Shucheng, liusc@gdou.edu.cn

Funding: Guangdong Provincial Key R&D Program (2025B1111140001); National Shrimp and Crab Industry Technology System (CARS-47); Guangdong Province Young Innovative Talent Project for General Universities (2023KQNCX025)

山苍子精油包埋产物的比较及其复合膜对石斑鱼的保鲜应用

云显婷，谢玫珍，云永欢，陈李品*

（中国，570228，海口，海南大学食品科学与工程学院）

摘要：山苍子精油抑菌及抗氧化性能优异，在食品保鲜中潜力显著，但气味强烈、易挥发，可通过包埋进行风味掩蔽和缓释。针对石斑鱼易腐败、亟需新型保鲜手段的现状，本研究对比了山苍子精油乳液、脂质体和微胶囊三种包埋产物的释放行为、环境稳定性、风味掩盖效果及其对石斑鱼的保鲜作用。通过综合比较，进一步选取包埋产物——脂质体，制作成山苍子精油脂质体+壳聚糖+木薯淀粉+玉米醇溶蛋白活性复合膜。在 4℃贮藏条件下，壳聚糖+木薯淀粉+玉米醇溶蛋白+5%山苍子精油脂质体活性复合膜可将石斑鱼货架期延长至 10 天，有效抑制菌落总数增长、挥发性盐基氮积累和脂肪氧化。该技术作为一种天然、绿色的保鲜方法，符合当前食品行业对环保和健康的发展趋势，为开发绿色水产品保鲜技术提供理论基础。

关键词：山苍子精油；包埋；风味掩盖效果；石斑鱼；保鲜

资助项目：海南大学科研基金项目（XJ2400012944）、海南省研究生创新科研课题（Hys2025-182）

通讯作者：陈李品、女、博士、副研究员、水产品加工与智能化分析研究、86-13045020086、chenlipin@hainanu.edu.cn

山苍子精油复合膜的制备及其对点篮子鱼的保鲜性能研究

刘广聿[1]，胡之恒[2]，胡亚芹[1]*

1. 海南热带海洋学院 食品科学与工程学院，海南三亚 572022

2. 岩手大学 联合农学研究科，日本岩手 020-8550

摘要：

[目的] 以酶辅助水蒸气蒸馏法提取山苍子精油（LCEO），以聚乙烯醇（PVA）、岩藻多糖（FCD）和纤维素纳米晶（CNC）为成膜基材，制备 PVA-FCD-LCEO 复合膜，系统评价其力学性能和阻隔性能，并以点篮子鱼为对象，探究该复合膜在 4℃冷藏条件下的保鲜效果。[方法] 采用流延法制备复合膜，通过测定膜的机械强度、水蒸气透过率、氧气透过率等指标评估其包装性能；以菌落总数（TVC）、K 值、挥发性盐基氮（TVB-N）和硫代巴比妥酸反应物（TBARS）为品质指标，对比分析复合膜处理组与对照组在冷藏期间鱼肉新鲜度的变化。[结果] 结果表明，PVA-FCD-LCEO 复合膜具有良好的力学和阻隔性能。与对照组相比，复合膜处理可显著抑制微生物生长，延缓感官品质劣变，并有效减缓 K 值、TVB-N 和 TBARS 的上升速率。对照组在第 6 天时 TVC 达 6.996±0.167log CFU/g，接近腐败阈值，货架期终止；而复合膜处理组货架期延长至第 12 天，TVC 为 6.949±0.085log CFU/g，且 TVB-N、K 值和 TBARS 均显著低于对照组（*p*< 0.05）。[结论] PVA-FCD-LCEO 复合膜可有效延缓点篮子鱼冷藏期间品质劣变，与对照组相比货架期延长约 6 天，在水产品活性包装领域具有良好的应用潜力。

关键词：山苍子精油；点篮子鱼；活性包装；水产品保鲜

基金项目：国家自然科学基金（32603375）；海南热带海洋学院高层次人才项目（RHDRC202117）；海南热带海洋学院青年人才项目（RHDRCZK202624).

通讯作者：胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，15868109010，1004346262@qq.com.

Preparation of Litsea cubeba essential oil composite film and its preservation performance for Siganus guttatus

Liu guangyu[1], Hu zhiheng[2], Hu yaqin[1*]

1. College of Food Science and Engineering, Hainan Tropical Ocean University , Sanya, 572022, Hainan;

2. United Graduate School of Agricultural Sciences, Iwate University, Morioka, Iwate, 020-8550, Japan.

Abstract: [Objective]*Litsea cubeba* essential oil (LCEO) was extracted using an enzyme-assisted steam distillation method. Polyvinyl alcohol (PVA), fucoidan (FCD), and cellulose nanocrystals (CNC) were used as film-forming materials to prepare PVA-FCD-LCEO composite films, and their mechanical and barrier properties were systematically evaluated. The preservation efficacy of the composite films was investigated using *Siganus guttatus* as a fish model during refrigerated storage at 4°C. [Methods] The composite films were prepared by the casting method. Packaging performance was assessed by measuring mechanical strength, water vapor transmission rate, and oxygen transmission rate. The freshness changes of fish during refrigeration were compared between the composite film-treated group and the control group using total viable count (TVC), K value, total volatile basic nitrogen (TVB-N), and thiobarbituric acid reactive substances (TBARS) as quality indicators. [Results] The results showed that PVA-FCD-LCEO composite films exhibited favorable mechanical and barrier properties. Compared with the control group, treatment with the composite films significantly inhibited microbial growth, delayed sensory deterioration, and effectively slowed the increases in K value, TVB-N, and TBARS during storage. The control group reached the end of its shelf life on day 6, with a TVC of 6.996±0.167log CFU/g, which was close to the spoilage threshold. In contrast, the composite film-treated group extended the shelf life to day 12, with a TVC of 6.949±0.085log CFU/g, and the TVB-N, K value, and TBARS remained significantly lower than those of the control group ($p<0.05$). [Conclusion] PVA-FCD-LCEO composite films effectively delayed the quality deterioration of *Siganus guttatus* during refrigerated storage and extended its shelf life by approximately 6 days compared with the control group, demonstrating good application potential in the field of active packaging for aquatic products.

Key words: *Litsea cubeba* essential oil; *Siganus guttatus*; Active packaging; Aquatic product preservation

生、熟鲍鱼内脏酱油的发酵工艺及品质的比较研究

李伟涵 1，孙乐常*

集美大学海洋食品与生物工程学院，福建 厦门 361021

摘要：【目的】本研究旨在探究生、熟鲍鱼内脏对鲍鱼酱油发酵过程中理化指标、蛋白质降解及风味形成的影响，以期为鲍鱼加工副产物的高值化利用及海鲜酱油开发提供理论依据。【方法】以大豆、小麦为原料，经米曲霉制曲后分别添加生鲍鱼内脏和熟鲍鱼内脏，在盐水条件下进行半固态发酵。测定曲料蛋白酶活力、pH、总酸、色率、非盐固形物、还原糖、TCA-可溶性肽、TBARS 值、挥发性盐基氮及氨基酸态氮等指标，并结合 Tricine SDS-PAGE、游离氨基酸分析、电子鼻及感官评定，比较生、熟鲍鱼内脏对酱油发酵品质及风味的影响。【结果】随着发酵时间延长，两组样品的 pH 均持续下降，总酸、色率、非盐固形物、TCA-可溶性肽、TBARS 值、挥发性盐基氮及氨基酸态氮总体呈上升趋势，其中生鲍鱼内脏组 pH 低于熟鲍鱼内脏组，总酸、色率、TCA-可溶性肽、TBARS 值及氨基酸态氮含量均较高；熟鲍鱼内脏组非盐固形物含量在发酵至 75 天后较高。游离氨基酸分析表明，生鲍鱼内脏组总游离氨基酸及鲜味氨基酸含量更高，而熟鲍鱼内脏组部分苦味氨基酸含量更高。Tricine SDS-PAGE 显示两组样品在发酵过程中均出现明显的低分子量蛋白/肽组分，生鲍鱼内脏组在 66.2 kDa 条带且 18.4 kDa 条带更明显，熟鲍鱼内脏组无 66.2 kDa 条带而 25 kDa 条带渐深。电子鼻分析表明，两组样品均以含氮及含硫挥发性物质响应较为突出，生鲍鱼内脏组在发酵中后期响应更强。感官评定显示，生鲍鱼内脏组在色泽、气味、滋味和质地上的整体接受度均优于熟鲍鱼内脏组。【结论】生鲍鱼内脏更有利于鲍鱼酱油的发酵品质和风味提升。

关键词：鲍鱼内脏；酱油发酵；米曲霉；游离氨基酸；风味

作者简介：李伟涵（2001-），男，硕士研究生，研究方向：水产品加工与贮藏，E-mail：420141872@qq.com。

*通信作者：孙乐常（1985-），男，博士，教授，研究方向：水产品加工与贮藏，E-mail：sunlechang@163.com。

Comparative analysis of Fermentation Process and Quality of Sauce with Raw and Cooked Abalone Viscera

LI WEIHAN1 , SUN LECHANG* CHEN DANDAN1, LIN ZHAOMING2, SUN LECHANG*

College of Ocean Food and Biological Engineering, Jimei University, Xiamen, Fujian 361021, China

Abstract: [Objective] This study aimed to investigate the effects of raw and cooked abalone viscera on the physicochemical indices, protein degradation, and flavor formation during abalone sauce fermentation, in order to provide a theoretical basis for the high-value utilization of abalone processing by-products and the development of seafood sauce.[Methods] Soybean and wheat were used as raw materials. After koji-making with *Aspergillus oryzae*, raw abalone viscera and cooked abalone viscera were added separately, followed by semi-solid fermentation under saline conditions. The protease activity of koji, pH, total acid, color intensity, non-salt solid content, reducing sugar, TCA-soluble peptides, TBARS value, volatile basic nitrogen, and amino acid nitrogen were measured. Combined with Tricine SDS-PAGE, free amino acid analysis, electronic nose, and sensory evaluation, the effects of raw and cooked abalone viscera on sauce fermentation quality and flavor were compared.[Results] With prolonged fermentation, the pH of both groups continued to decrease, while total acid, color intensity, non-salt solid content, TCA-soluble peptides, TBARS value, volatile basic nitrogen, and amino acid nitrogen generally increased. The raw abalone viscera group had lower pH and higher total acid, color intensity, TCA-soluble peptides, TBARS value, and amino acid nitrogen than the cooked abalone viscera group; the cooked abalone viscera group had higher non-salt solid content after 75 days of fermentation. Free amino acid analysis showed that the raw abalone viscera group had higher contents of total free amino acids and umami amino acids, whereas the cooked abalone viscera group had increased contents of some bitter amino acids. Tricine SDS-PAGE showed that both groups exhibited obvious low-molecular-weight protein/peptide fractions during fermentation. The raw abalone viscera group had a 66.2 kDa band and a more prominent 18.4 kDa band, whereas the cooked abalone viscera group lacked the 66.2 kDa band and showed a gradually deepening 25 kDa band. Electronic nose analysis indicated that both groups showed prominent responses to nitrogen- and sulfur-containing volatile compounds,

and the raw abalone viscera group showed stronger responses in the middle and late fermentation stages. Sensory evaluation showed that the raw abalone viscera group had better overall acceptability in color, odor, taste, and texture than the cooked abalone viscera group.[Conclusion] Raw abalone viscera are more beneficial to improving the fermentation quality and flavor of abalone sauce.

Keywords: Abalone viscera; Sauce fermentation; Aspergillus oryzae; Free amino acids; Flavor

食用昆虫在水产食品加工与饲料领域的功能特性研究进展

胡亚芹

海南热带海洋学院，海南省三亚市育才路 1 号，572022

摘要：目的：全球水产养殖业面临鱼粉资源紧缺与加工副产物利用率低的双重压力，食用昆虫作为新型可持续蛋白源，在水产饲料与食品加工领域展现出巨大潜力。方法：基于多组 Meta 分析与国内外权威试验数据，系统梳理食用昆虫（黄粉虫、黑水虻、家蟋蟀等）在水产相关场景中的研究进展。结果：昆虫蛋白粗蛋白含量达 26.53%~91%，其中黑水虻幼虫稳定在 43.7%，经脱脂及超声辅助提取后蛋白得率可提升 10%~18%，其体外消化率最高达 92.53%，是替代鱼粉的优质候选；通过日粮添加微藻或鱼内脏废渣饲喂昆虫，可定向富集 DHA 与 ω-3 脂肪酸，家蚕蛹 ω-3 占总脂 13.7%，为水产油脂功能强化提供新路径；昆虫源几丁质（含量 1.6%~10.7%）脱乙酰所得壳聚糖（15~76 kDa），对水产常见致病菌最低抑菌浓度低至 0.03%~0.06%，且浓度 0.5%时对轮纹病菌抑制率超 90%，可开发为水产食品天然保鲜膜及抗氧化涂层；昆虫酶解小分子肽（如柞蚕蛹 ACE 抑制肽及抗氧化肽）兼具清除自由基、抑制脂质氧化及抗炎活性，可延缓水产品贮藏过程中的品质劣变。结论：食用昆虫在替代水产饲料蛋白、富集功能性油脂、开发壳聚糖基可食膜及抗氧化肽类保鲜剂方面具有明确的应用前景，但需解决标准化定量、人体/养殖临床验证及全组分联产等瓶颈，为昆虫基水产功能原料产业化提供参考。

关键词：食用昆虫；水产食品；蛋白质替代；几丁质；脂肪酸调控；生物活性肽

Research Progress on Functional Properties of Edible Insects in Aquatic Food Processing and Feed

Yaqin Hu

College of Food Science and Engineering, Hainan Tropical Ocean University, Sanya, 572022

Abstract: [Objective] Global aquaculture faces dual pressures from fishmeal shortage and low utilization of processing by-products. Edible insects, as novel sustainable protein sources, show great potential in aquatic feed and food processing. [Methods] Based on multiple meta-analyses and authoritative experimental data, this review systematically summarizes research progress of edible insects (*Tenebrio molitor, Hermetia illucens, Acheta domesticus*, etc.) in aquaculture-related scenarios. [Results] Insect crude protein ranges 26.53%~91% (43.7% in

Hermetia illucens larvae), with digestibility up to 92.53%, making it a high-quality fishmeal alternative. Dietary supplementation with microalgae or fish viscera enables directional enrichment of DHA and ω-3 fatty acids (up to 13.7% in silkworm pupae). Insect-derived chitosan (15-76 kDa) exhibits minimum inhibitory concentrations as low as 0.03%~0.06% against aquatic pathogens and >90% inhibition against ring rot pathogens at 0.5%, suitable for biodegradable preservative films. Enzymatic hydrolysates (e.g., antioxidant and ACE-inhibitory peptides from tussah pupae) show free radical scavenging, lipid oxidation inhibition, and anti-inflammatory activities, delaying quality deterioration in stored aquatic products. [Conclusion] Edible insects have clear application prospects in replacing fishmeal protein, enriching functional lipids, developing chitosan-based edible films, and producing antioxidant peptides, though bottlenecks such as standardized quantification, clinical/feeding validation, and integrated co-production need to be addressed.

Key words: Edible insects; Aquatic food; Protein replacement; Chitin; Fatty acid regulation; Bioactive peptides

双频超声辅助腌制对烤制鲴鱼肉品质的影响

朱贝贝，周楠楠，高瑞昌*

江苏大学食品科学与工程学院，江苏 镇江，212013

摘要 目的：探究多频超声腌制对鲴鱼腌制效率及烤制品质的影响。方法：以传统腌制为对照，优化筛选超声腌制参数，考察腌制鱼肉品质及烤制过程中理化特性、挥发性风味、滋味与体外消化率。结果：最佳参数为双频（20+60 kHz），腌制时间由 40 min 缩短至 20 min，NaCl 分布更均匀，持水性、白度显著提高，蛋白质氧化降低、脂质氧化升高。烤制后，超声组美拉德反应增强、持水力更优，挥发性化合物增多，壬醛、1 - 辛烯 - 3 - 醇含量降低、鱼腥味减轻，游离氨基酸与有机酸积累增加，等效鲜味浓度显著提升，胃肠总消化率提高。结论：双频超声腌制可显著缩短腌制时间、改善烤制鲴鱼品质与风味，为低盐快速腌制提供新途径。

关键词 双频超声腌制；鲴鱼；烤制；风味；体外消化

资助项目：国家特色淡水鱼产业技术体系岗位科学家（CARS-45）

通讯作者：高瑞昌，男，博士，教授，研究方向：水产品加工与综合利用，15905288317，xiyuan2008@ujs.edu.cn.

Effect of dual-frequency ultrasound-assisted curing on the quality of roasted catfish meat

Zhu Beibei, Zhou Nannan, Gao Ruichang Gao

1. School of Food Science and Engineering, Jiangsu University, Zhenjiang 212013, Jiangsu

Abstract: Objective: To investigate the effects of multi-frequency ultrasonic-assisted brining on the brining efficiency and roasting quality of channel catfish. Methods: Using traditional brining as the control, the ultrasonic brining parameters were optimized and screened, and the quality of brined fish muscle, as well as the physicochemical properties, volatile flavor compounds, taste, and in vitro digestibility during roasting, were evaluated. Results: The optimal parameters were dual-frequency ultrasound (20 + 60 kHz), which shortened the brining time from 40 min to 20 min. The distribution of NaCl in the fish muscle became more uniform, and water-

holding capacity and whiteness were significantly improved, while protein oxidation decreased and lipid oxidation increased. After roasting, the ultrasound-treated group exhibited a stronger Maillard reaction and better water-holding capacity, with more volatile compounds, reduced contents of nonanal and 1-octen-3-ol, and alleviated fishy odor. The accumulation of free amino acids and organic acids increased, the equivalent umami concentration (EUC) was significantly elevated, and the total gastrointestinal digestibility was improved. Conclusion: Dual-frequency ultrasonic brining can significantly shorten the brining time and improve the quality and flavor of roasted catfish, providing a novel approach for low-salt rapid brining.

Key words: channel catfish; dual-frequency ultrasound curing; roasting; flavor; in vitro digestion

双氧水处理对鲣鱼鱼糜凝胶脱腥的作用机理研究

王琳[1]，周敬轩[1]，张宏英[1]，李川[1,2]，夏光华[1]，张小栓[3]，Mai Thi Tuyet Nga[4]，何燕富[1,2,*]

1. 海南大学食品科学与工程学院，海南省海口市美兰区人民大道 58 号，邮编 570228；2. 海南热带水产品资源创新利用国际联合研究中心，海南省海口市，邮编 570228；3.中国农业大学工程学院，北京食品质量与安全实验室，北京市，邮编 100083；4. 芽庄大学食品技术学院，越南芽庄市阮定初街 02 号。

摘要：鲣鱼低脂肪、高蛋白，但强烈的鱼腥味限制了其应用。过氧化氢 (H_2O_2) 是一种高效且环保的氧化剂，可用于食品加工。适度氧化可削弱鱼腥味并提升鱼糜凝胶产品的品质。然而，H_2O_2 处理后肌原纤维蛋白的构象变化以及其与腥味物质之间相互作用的动态机制尚不明确。因此，本文研究了 H_2O_2 处理对鲣鱼鱼糜凝胶品质和鱼腥味的影响，并进一步探讨了脱腥机制。结果表明，在鱼糜凝胶制备的漂洗阶段，使用 80 mM H_2O_2 作为溶剂漂洗鱼肉可显著降低鱼糜凝胶的鱼腥味，同时改善其质地和色泽。分子动力学模拟结果显示，80 mM H_2O_2 处理能削弱蛋白质分子与腥味小分子（如己醛和 1-辛烯-3-醇）之间的结合能力，从而在鱼糜凝胶制备过程中促进鱼腥味分子释放，达到脱腥的目的。

关键词：鲣鱼鱼糜；过氧化氢；脱腥；肌球蛋白；分子动力学模拟

资助项目：海南省重点研发项目[ZDYF2024XDNY258]、海南省科技专项基金[GHYF2024022]、三亚崖州湾科技城建设项目[SKJC -2023-01-001]

通讯作者：何燕富，女，博士，副教授，博士生导师，海南省自由贸易港 D 类人才。国家对虾加工技术研发分中心副主任，海南省营养学会烹饪与营养专业委员会委员。主持国家自然科学基金、海南省重点研发、海南省国际科技合作研发等科研项目 10 余项。研究方向为水产品保活保鲜与精深加工、水产品副产物综合利用。获海南省科技进步二等奖 1 项，以第一作者/通讯作者在 Carbohydrate Polymers、Trends in Food Science & Technology、Food Chemistry 等期刊上发表论文 20 余篇，入选 ESI 高被引论文 1 篇。联系电话：13719193709；邮箱：heyanfu819@163.com。

水产品组胺降解菌的筛选鉴定及酶学性质研究

王永娜，胡雨薇，申晶晶*，欧昌荣*

宁波大学食品科学与工程学院 浙江宁波 315832

摘要：水产品及其制品在加工和贮藏过程中易积累组胺，过量组胺会引发食品安全问题，而传统控制方法难以有效去除已形成的组胺。本研究采用双层膜体系从水产品及其制品中筛选组胺降解菌，结合菌株鉴定、降解特性分析、全基因组测序及酶学性质测定，评价其组胺降解能力。结果表明，共筛选获得 11 株组胺降解菌，其中 4 株菌的组胺降解率超过 80%。菌株 D-Z-14 表现出最强的组胺降解能力，培养 16 h 后组胺降解率达到 100%。经 16S rRNA 基因序列分析鉴定为假单胞菌属（*Pseudomonas*）。该菌株在 30 ℃、初始 pH 6.0-8.0 及 0-5% NaCl 条件下具有较高的组胺降解能力。全基因组测序结果显示，D-Z-14 基因组大小为 5.5 Mb，共编码 5723 个基因，功能注释发现了二胺氧化酶基因、组胺 N-甲基转移酶基因等组胺代谢相关候选基因。进一步研究发现，该菌株的组胺降解酶定位于细胞膜，适宜反应温度为 30 ℃，pH 为 6.0-7.0，NaCl 浓度为 0-5%；Ca^{2+}和 Mg^{2+}对酶活性具有促进作用，而 Fe^{2+}和 Cu^{2+}表现出抑制作用。本研究获得了具有较高组胺降解能力的菌株及其相关酶学信息，为水产品及其制品中组胺的生物控制提供了潜在的微生物和酶资源。

关键词：筛选；组胺；降解；酶学性质

资助项目：浙江省自然科学基金（LQN26C200006）

通讯作者：申晶晶，博士，讲师，主要研究方向为：1. 海洋多糖降解酶的基因挖掘及作用方式研究；2. 酶在水产品加工及保鲜中的应用。E-mail：shenjingjing1@nbu.edu.cn

欧昌荣，男，教授，博士，博导，主要研究方向为水产品加工贮藏新技术应用、食品风味化学、水产化学、食品安全与质量控制、水产生物活性物质开发等。E-mail：Ouchangrong@nbu.edu.cn

Screening, Identification and Enzymatic Properties of Histamine-Degrading Bacteria from Aquatic Products

Yongna Wang, Yuwei Hu, Jingjing Shen, Changrong Ou*

College of Food Science and Engineering, Ningbo University; Ningbo 315832; China

Abstract: Histamine tends to accumulate in aquatic products and their derivatives during processing and storage. Excessive histamine poses food safety hazards, whereas conventional control strategies cannot efficiently remove pre-formed histamine. In this study, a double-layer membrane system was used to screen histamine-degrading bacteria from aquatic products and their products. Strain identification, degradation characteristic analysis, whole-genome sequencing, and enzymatic property assays were combined to evaluate their histamine-degrading capacity. The results showed that 11 histamine-degrading bacterial strains were isolated, among which four strains achieved a histamine degradation rate of over 80%. Strain D-Z-14 exhibited the strongest histamine-degrading ability, with a 100% histamine degradation rate after 16 h of incubation. Based on 16S rRNA gene sequence analysis, it was identified as Pseudomonas. This strain maintained high histamine-degrading activity at 30 °C, initial pH of 6.0–8.0, and NaCl concentrations of 0-5%. Whole-genome sequencing revealed that the genome of D-Z-14 was 5.5 Mb in size, encoding a total of 5723 genes. Functional annotation identified candidate genes associated with histamine metabolism, including diamine oxidase and histamine N-methyltransferase genes. Further investigation demonstrated that the histamine-degrading enzyme of this strain was localized on the cell membrane. The optimal reaction conditions for the enzyme were 30 °C, pH 6.0–7.0, and 0–5% NaCl. Ca^{2+} and Mg^{2+} promoted enzyme activity, while Fe^{2+} and Cu^{2+} exerted inhibitory effects. This study obtained bacterial strains with high histamine-degrading capacity and relevant enzymatic information, providing potential microbial and enzyme resources for the biological control of histamine in aquatic products and their derivatives.

Keywords: Screening; Histamine; Degradation; Enzymatic properties

四种鱼鳔酸溶性胶原蛋白理化性质及结构特点的比较研究

王晓燕[1,2] 张泓麟[1,2] 陈婉婷[1,2] 陈奕欣[1,2] 孟庆丞[1,2,3] 苏永昌[1,*] 刘智禹[1,2,*]

[1]福建农林大学食品科学学院，福建福州（350002）

[2]福建水产研究所，国家海水鱼类加工技术研发分中心（厦门），福建省海洋生物增养殖与高值化利用重点实验室，福建厦门 361013）

[3] 中国海洋大学食品科学与工程学院，青岛 266404，中国

摘要 目的：鱼源胶原蛋白具有良好的生物相容性和资源可持续性，是陆生动物源胶原蛋白的重要替代材料，但不同鱼类鱼鳔来源对其结构与功能特性的影响尚不明确。方法：本研究以中国大黄鱼、新西兰大黄鱼、巴沙鱼和鲢鱼鱼鳔为原料，低温酸溶法提取I型胶原蛋白并比较。结果：中国大黄鱼胶原蛋白得率最高（23.0%），甘氨酸含量为 20.48%；巴沙鱼胶原蛋白变性温度最高（47.12 ℃）；鲢鱼胶原蛋白 ζ 电位绝对值为 32.3 mV、粒径最小（465.2 nm）；新西兰大黄鱼胶原蛋白具有 150～200 μm 开放孔结构，5 mg/mL 时羟基自由基清除率达 53.2%。不同鱼源胶原蛋白表现出明显的结构与功能差异，可为其定向筛选及生物材料开发提供依据。

关键词： 酸溶性胶原蛋白；鱼鳔；结构表征

基金项目： 福建省海洋与渔业综合服务专项资金项目（FYZF-KTYJ-2025-12）；福建省自然科学基金项目（2023J011326）

通信作者：苏永昌，男，副研究员，博士，研究方向为海洋活性物质开发。E-mail: suyongchang5@126.com

刘智禹，男，教授级高级工程师，博士，研究方向为水产品加工与综合利用。E-mail: 13906008638@163.com

A comparative study on the physicochemical properties and structural conformation of acid-soluble collagens from four swim bladders

Xiaoyan Wang[1,2], Honglin Zhang[1,2], Wanting Chen[1,2], Yixin Chen[1,2], Qingcheng Men[2,3], Yongchang Su[2,*], Zhiyu Liu[1,2,*]

[1] College of Food Science, Fujian Agriculture and Forestry University, Fuzhou 350002, China

[2] Key Laboratory of Cultivation and High-value Utilization of Marine Organisms in Fujian Province, Fisheries Research Institute of Fujian, National Research and Development Center for Marine Fish Processing (Xiamen), Xiamen 361013, China

[3] College of Food Science and Engineering, Ocean University of China, Qingdao 266404, China

Abstract Objective: Fish-derived collagen has good biocompatibility and sustainable availability, making it a promising alternative to terrestrial animal-derived collagen. However, the effects of different fish swim bladder sources on the structural and functional properties of collagen remain unclear.Methods:Type I collagen was extracted from the swim bladders of Chinese large yellow croaker, New Zealand large yellow croaker, basa fish, and silver carp using a low-temperature acid-soluble extraction method, and their physicochemical, structural, and functional properties were comparatively evaluated.Results: Collagen from Chinese large yellow croaker showed the highest yield (23.0%) and a glycine content of 20.48%. Basa fish collagen exhibited the highest denaturation temperature (47.12 °C). Silver carp collagen showed an absolute ζ-potential of 32.3 mV and the smallest particle size (465.2 nm). New Zealand large yellow croaker collagen exhibited an open porous structure with pore sizes of 150–200 μm and achieved a hydroxyl radical scavenging rate of 53.2% at 5 mg/mL.Conclusion:Collagens derived from different fish swim bladders exhibited distinct structural and functional characteristics, providing a basis for their targeted selection and potential application in biomaterial development.

Keywords: acid-soluble collagen; swim bladder; structural characterization

酸预处理与碱消化工艺对巨藻 LF 和泡叶藻褐藻胶提取率及品质的差异化调控

曾飞艳[1]，孟媛[1]，武帅兵[1]，彭晨辰[1]，马艺超[1,2,3]，刘舒[1,2,3]，周慧[1,2,3]，何云海[1,2,3]，任丹丹[1,2,3]*

1. 大连海洋大学食品科学与工程学院，大连，116023

2. 辽宁省水产品加工与综合利用重点实验室，大连，116023

3. 国家海藻加工技术研发分中心，大连，116023

摘要 ：以巨藻 LF（*Lessonia flavicans*）和泡叶藻（*Ascophyllum nodosum*）为原料，系统优化酸预处理与碱消化工艺参数，建立基于原料特性的差异化提取策略。通过单因素实验筛选酸种类、浓度及浸泡时间，测定褐藻胶提取率、黏度、分子量及 M/G 比值。采用 $L_9(3^3)$正交试验优化 Na_2CO_3 浓度、温度和消化时间，测定褐藻胶提取率。结果表明：巨藻 LF 的最适酸预处理条件为 0.10 mol/L HCl 处理 1 h，提取率为 30.78%，泡叶藻为 0.20 mol/L HCl 处理 2 h，提取率为 30.58%。碱消化正交试验确定巨藻 LF 最优组合为 3.5% Na_2CO_3、65℃、4 h，提取率 38.90%），泡叶藻为 2.5% Na_2CO_3、65℃、3.5 h，提取率为 34.80%）。极差分析揭示巨藻 LF 以温度为首要因素（R=4.47），泡叶藻以 Na_2CO_3 浓度为首要因素（R=1.84），反映两种原料细胞壁结构和褐藻胶溶出限速步骤的根本差异。巨藻 LF 为高 G 型褐藻胶（M/G=0.53~0.55），黏度 523.6 mPa·s，分子量 604.3 kDa，适用于高强度凝胶产品；泡叶藻为高 M 型（M/G=1.37~1.82），黏度和分子量均较低。提取率与黏度无显著相关（r=0.08），可独立优化。

关键词：褐藻胶；褐藻原料；酸预处理；碱消化；工艺优化

坛紫菜纯化多糖的结构解析及其对冻藏凡纳滨对虾虾仁的品质维持

姚东圻[1,2]，马静蓉[2,4]，魏涯[2,3]，戚勃[2,3]，龙晓珊[2,3]，任幸[5]，赵永强[2,3]，刘书成[1*]，潘创[2,3*]

1（广东海洋大学 食品科技学院，广东 湛江，524088）

2（中国水产科学研究院南海水产研究所，农业农村部水产品加工重点实验室，国家水产品加工技术研发中心，广东 广州，510300）

3（三亚热带水产研究院，海南省深远海渔业资源高效利用与加工重点实验室，海南 三亚，572018）

4（肇庆学院食品与制药工程学院，广东 肇庆 526061）

5（广西北部湾海洋资源环境与可持续发展重点实验室，广西 北海 536015）

摘要：【目的】探究坛紫菜纯化多糖PHP9的结构特征及其对冻藏凡纳滨对虾虾仁品质和肌原纤维蛋白结构稳定性的影响，评估其作为无磷冷冻保护剂的潜力。【方法】以琼胶降解物和复合磷酸盐为对照，比较各处理虾仁在−18 °C冻藏30 d期间色差、pH、质构及肌原纤维蛋白表面疏水性、Zeta电位和二、三级结构变化，并采用高效凝胶渗透色谱、离子色谱、甲基化分析和红外光谱表征PHP9结构。【结果】PHP9可减缓色差增加、pH波动及硬度和弹性下降，维持肌原纤维蛋白结构稳定；其重均分子量为1077.05 kDa，半乳糖含量为99.17%，主要由4-Gal(p)和t-Gal(p)残基构成，整体效果优于琼胶降解物，部分指标接近复合磷酸盐。【结论】PHP9具有较好的冻藏虾仁品质维持作用和作为无磷冷冻保护剂的应用潜力。

关键词：坛紫菜纯化多糖；琼胶降解物；凡纳滨对虾；冻藏；品质维持

资助项目：“尖峰”行动计划（广西重大专项计划）（桂科JF2503980035）；广东省现代农业产业技术体系创新团队建设项目（2026CXTD27）；科技支撑“百千万工程”专项资金项目：水产品加工产业研究开发及水产品加工技术开发推广（2025D032）；国家藻类产业技术体系（CARS-49）；广西北部湾海洋资源环境与可持续发展重点实验室开放基金项目（MRESD-2025-B06）；中国水产科学研究院中央级公益性科研院所基本科研业务费专项资金（2023TD78）。

通讯作者简介：潘创，男，副研究员，E-mail：silverpfoxc@hotmail.com；刘书成，男，教授，E-mail：lsc771017@163.com。

糖基化鱼明胶乳液凝胶对带鱼鱼糜凝胶品质及结构的影响

Huaiyuan Chen，Jiaqi Huang，Xinxin Fan，Ru Jia，Changrong Ou，Huamao Wei，Tao Huang*

（宁波大学食品科学与工程学院，浙江—马来西亚农产品加工与营养联合实验室，宁波，315211）

摘要：目的：探究糖基化鱼明胶乳液凝胶对带鱼鱼糜凝胶品质与结构的影响。方法：以葡萄糖或 β-环糊精修饰鱼明胶，制备乳液凝胶，按 5%、10%、15%添加至鱼糜，测定凝胶强度、质构、白度、汁液损失、水分分布及蛋白结构。结果：适量添加可改善凝胶品质，β-环糊精组总体效果更佳；其 15%添加组凝胶强度为 14.33 N，高于对照组的 9.02 N，不易流动水比例达 96.30%。葡萄糖组添加量升至 15%时凝胶强度下降。结构分析表明，适量添加促进蛋白二级结构有序化，疏水作用与非特异性结合参与网络强化。结论：糖基化鱼明胶乳液凝胶可改善鱼糜凝胶品质，其效果取决于糖修饰类型及添加量。

关键词：糖基化鱼明胶；乳液凝胶；带鱼鱼糜；凝胶品质；水分分布

资助项目：国家自然科学基金（32572608）；宁波大学高水平科技项目培育计划（GJPY2025031）；国家淡水鱼加工技术研发中心开放课题（NC2FP-KF-202301）；浙江省教育厅一般项目（Y202248913）；浙江省“尖兵”项目（2024C04050）。

通讯作者简介：Tao Huang；男、博士、特聘研究员、研究方向：水产品资源高值化综合利用；E-mail：huangtao@nbu.edu.cn。

原文出处：Chen H, et al. Impact of Glycosylated Fish Gelatin Emulsion Gels on the Gel Properties and Structural Characteristics of Surimi Gels. Foods, 2026, 15: 1434. DOI: 10.3390/foods15081434.

溏心干鲍品质评价方法的初步构建与应用

向慧敏，项雷文*

【福建技术师范学院食品与生物工程学院，福建福清，350300】

摘要：

目的：初步构建溏心干鲍品质评价方法，比较五组市售样品的综合品质。

方法：测定营养组成、复水特性、蛋白相关指标、质构、色泽和感官特性，对 21 项指标标准化后进行主成分分析，按方差贡献率计算综合得分；电子鼻用于辅助比较气味。

结果：前三个主成分累计解释 84.815%的变异；综合得分依次为 ME（1.663）、JP（0.517）、ZA（0.122）、CN（−0.907）和 AU（−1.904）。ME 组复水率为 129.74%，AU 组复热后硬度为 30.54 N。

结论：21 项指标可用于本批样品的初步综合评价；复水率、肌原纤维蛋白浓度、羟脯氨酸含量和弹性为简化评价的候选指标，尚需独立批次验证。

关键词：溏心干鲍；品质评价；主成分分析；指标筛选；感官评价

基金项目：【No. 2025N5015； No. 2024J01161】

通讯作者：【项雷文，男，博士，教授，主要从事水产品精深加工、谷物精深加工等方面研究，电话:13960738979，E-mail: xiangleiwen@163.com】

同轴电喷雾法制备二十碳五烯酸乙酯核壳微胶囊

张小菁[1,2]，竺桢孚[1,3]，苏永昌[1]，刘淑集[1]，陈慧斌[2]，潘南[1,*]，刘智禹[1,*]

1. 福建省水产研究所，国家海水鱼类加工技术研发分中心 福建厦门，361013；2. 福建师范大学生命科学学院，福建福州，350117；3 福建农林大学食品科学学院，福建福州，350007

摘要：药用级二十碳五烯酸乙酯（EPA）可有效降低心血管风险，但因高度不饱和而极易氧化变质，限制了其应用。研究采用同轴电喷雾技术，以 EPA（纯度≥90%）为芯材，以海藻酸钠（SA）与 Ca^{2+}交联形成初级核壳，壳寡糖/海藻糖（COS/Tre）复合中层，Eudragit L-100（L-100）肠溶包衣外层，构建逐层封装核壳微胶囊 EPA@SA-COS/Tre-L 100。结果表明：在电压 12 kV、1.5% SA（M:G = 1:2， M_w 140-150 kDa）、芯壁流速比 1:3、4% Ca^{2+} 固化液、固化时间 25 min、0.5% COS/Tre（1:1, m:m）、0.2% Eudragit L-100 的最优条件下，微胶囊包埋率、载药量分别达 95.59%、53.91%。ATR-FTIR 显示 EPA 被完全包裹，其与壁材依靠氢键相互作用结合，无新共价键生成；XPS 证实多层壁材可形成逐层包覆结构；TG 结果表明微胶囊可明显改善 EPA 的热稳定性；体外模拟胃肠消化实验证实微胶囊在酸性胃液中维持结构完整，进入肠液环境后实现 EPA 的靶向释放。综上，研究基于同轴电喷雾技术构建 SA-COS/Tre-L 100 逐层封装 EPA 的核壳型微胶囊，实现 EPA 的氧化保护与肠道靶向释放，为药用级 EPA 的稳态化利用提供了新方法和理论依据。

关键词：二十碳五烯酸乙酯；核壳型微胶囊；同轴电喷雾；海藻酸钠；模拟胃肠消化

资助项目：福建省海洋与渔业综合服务专项资金项目(FYZF-KTYJ-2025-18)；厦门市自然科学基金项目(3502Z202573301)

通讯作者：
潘南，博士，助理研究员，水产品加工与综合利用，pannancn@163.com
刘智禹，博士，教授级高级工程师，水产品加工与综合利用研究，13906008638@163.com

微刻蚀与虫胶涂层联用构建活性PVA/CMC/海藻酸钠复合膜及其在水产品保鲜中的应用

Abubakr Sallam，胡亚芹*

海南热带海洋学院食品科学与工程学院，海南三亚，572022

摘要：目的：为寻求可持续包装替代石油化工塑料，开发可生物降解的天然活性薄膜一直是食品包装领域关注的热点问题。然而，基于 PVA、海藻酸钠和 CMC 的亲水性生物聚合物薄膜因其较差的水蒸气阻隔性能而受到严重制约。本研究旨在通过表面微刻蚀与天然疏水涂层联用的策略，构建一种全生物降解、高阻隔的活性薄膜，以作为石油化工塑料的替代品。方法：以 PVA、海藻酸钠和 CMC 为基材，添加 2.5%丁香油和 2%γ-谷维素制备亲水性活性薄膜。为克服水阻隔瓶颈，采用辊式微刻蚀工具在薄膜表面构建物理锚定位点，随后喷涂天然虫胶涂层。系统比较有无微刻蚀处理、单层及双层虫胶涂层的组合效果。通过 XPS、FTIR、SEM 和 DSC 阐明了界面结合机制，并在 45 天内评价了薄膜的土壤可生物降解性。在应用方面，采用最优复合膜（微刻蚀+双层虫胶）将罗非鱼片在 4°C 下贮藏 12 天，以聚乙烯（PE）膜和未改性单层膜作为对照。结果：表征结果表明，微刻蚀处理构建了有效的物理锚定结构，显著增强了虫胶层的界面附着力。在该物理-疏水协同机制驱动下，复合膜的水蒸气透过系数从未改性单层膜的 5.34g·mm/(m²·h·kPa)显著降低至 0g·mm/(m²·h·kPa)，实现优越的防水性能。此外，微刻蚀双层虫胶复合膜的抗拉强度显著提高至 6.34 MPa，而未经改性的单层膜仅为 3.62 MPa，确保了其在实际包装应用中的机械完整性。生物降解测试表明，45 天后薄膜重量损失达 60%，证实了其生态可回归性。在罗非鱼贮藏研究中，微刻蚀双层虫胶复合膜表现出优异的保鲜效果，12 天后，其菌落总数仅为 5.36 Log CFU/g，过氧化值为 1.29 meqO_2/kg，而 PE 对照组分别达到 12.91 Log CFU/g 和 15.23 meqO_2/kg。这种对过氧化物生成的显著抑制主要归因于 γ-谷维素的添加，其作为一种强效抗氧化剂，在整个贮藏期内有效延缓了鱼样品的脂质氧化。结论：微刻蚀与双层虫胶涂层的协同策略成功克服了天然亲水性薄膜固有的水阻隔缺陷。该复合膜不仅在保鲜效果上优于传统石油化工塑料，而且具有优异的可生物降解性，为水产品包装提供了一种极具实用性和可持续性的替代方案。

关键词：可生物降解活性薄膜；石油化工替代；表面微刻蚀；虫胶涂层；罗非鱼保鲜

通讯作者：胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，15868109010，yqhu@zju.edu.cn

A Novel Micro-Blading and Shellac Coating Technique for Active PVA/CMC/Sodium Alginate Films Integrated with Clove Oil and Gamma Oryzanol for Aquatic Products Preservation

Abubakr Sallam, Hu Yaqin*

College of Food Science and Engineering, Hainan Tropical Ocean University, Sanya 572022, China

Abstract: [Objective] In the quest to replace petrochemical packaging with sustainable alternatives, developing biodegradable natural active films with high barrier properties is an urgent need, yet hydrophilic biopolymer films are severely limited by their poor water vapor barrier performance. [Methods] A hydrophilic active film was formulated using PVA, sodium alginate, and CMC, incorporated with 2.5% clove oil and 2% gamma oryzanol. A roller microblading tool was utilized to create physical anchoring sites on the film surface, followed by spraying of natural shellac. Treatments with and without microblading, combined with single or double shellac layers, were systematically compared. Interfacial binding mechanisms were elucidated via XPS, FTIR, SEM, and DSC, and soil biodegradability was evaluated over 45 days. For application, tilapia fillets were stored at 4°C for 12 days using the optimal composite film (micro-bladed + double shellac), with polyethylene (PE) film and unmodified single-layer film as controls. [Results] Microblading established effective physical anchoring structures, significantly enhancing interfacial adhesion of the shellac layer. The water vapor permeability (WVP) of the composite film remarkably dropped from 5.34g·mm/(m²·h·kPa) for the unmodified film to 0g·mm/(m²·h·kPa), achieving absolute water resistance. Tensile strength increased from 3.62 MPa to 6.34 MPa. Biodegradation tests indicated 60% weight loss after 45 days. In the tilapia storage study, after 12 days, the total viable count (TVC) of the composite film group was only 5.36 Log CFU/g and peroxide value (PV) was 1.29 meqO_2/kg, whereas the PE control reached 12.91 Log CFU/g and 15.23 meqO_2/kg, respectively. [Conclusion] The synergistic strategy of microblading and double shellac coating successfully overcame the inherent water barrier defect of natural hydrophilic films. This composite film outperforms traditional PE plastics in preservation efficacy and possesses excellent biodegradability, offering a practical and sustainable alternative for aquatic product packaging.

Key words: Biodegradable active film; Petrochemical replacement; Surface microblading; Shellac coating; Tilapia preservation

微拟球藻 ACE 抑制肽的定向制备、结构特征及其活性评价

李志棋 1,2,3，王迪 3，张怡 1,2，郭泽镔 1,2，戚勃 3，胡晓 3,*，陈胜军 3,*

(1.闽台特色海洋食品加工及营养健康教育部工程研究中心，福建，福州，350002；

(2.福建农林大学食品科学学院，福建，福州，350002；

(3.中国水产科学研究院南海水产研究所，农业农村部水产品加工重点实验室，国家水产品加工技术研发中心，广东，广州，510300）

摘要：为提高微拟球藻（*Nannochloropsis gaditana*）的开发与应用，研究以微拟球藻蛋白为原料，基于计算机虚拟酶解获取 ACE 抑制肽最佳蛋白酶种类，利用单因素试验与响应面优化试验确定微拟球藻 ACE 抑制肽的最佳酶解工艺。通过超滤对不同组分进行分离、测定以获得活性最高的组分，基于以上优化条件鉴定氨基酸序列结合生物信息学工具预测与筛选，最后进行分子对接阐明了肽与 ACE 的分子结合模式。结果表明，使用菠萝蛋白酶时微拟球藻中产生 ACE 抑制肽效率最高（$\Sigma A_{\text{ACE 抑制}}$=0.69），最佳酶解工艺为 pH 7.5、酶底比 2060 U/g、时间 3.20 h、温度 53 ℃，其中低分子量组分 III（＜3 kDa ）ACE 抑制率（92.76 ± 0.26%），表现出显著的 ACE 抑制活性。经高分辨液质联用（UPCL）鉴定获得 1970 条肽段，筛选获得四条新肽段 DAGYF、FDPW、WRDNF、WDPI，它们与 ACE 活性中心形成疏水相互作用、氢键、范德华力以及 π-阳离子相互作用，能够与 ACE 有效结合。固相合成 DAGYF、FDPW、WRDNF、WDPI 进行体外 ACE 抑制活性验证，其中 FDPW、WDPI 的 IC_{50} 分别为 0.303 ± 0.03、0.585 ± 0.01 mg/ml，具有较强的 ACE 抑制活性。本研究结果表明微拟球藻在 ACE 抑制肽的制备方面具有较高的潜力，为微藻来源 ACE 抑制肽的定向制备及其在降压功能食品中的应用提供了理论依据和技术支撑。

关键词：微拟球藻；虚拟酶解；工艺优化；血管紧张素转换酶（ACE）抑制肽；分子对接

基金项目：国家重点研发计划（2025YFD2400200）；国家藻类产业技术体系（CARS-49）；海南省自然科学基金面上项目（326MS0353）；中国水产科学研究院基本科研业务费（2023TD78，2023TD74）；广东省现代农业产业共性关键技术研发创新团队建设项目（2026CXTD16）

共同第一作者简介：李志棋，男，硕士研究生，研究方向为水产品加工与质量安全。E-mail: 15986972679@163.com；王迪，女，副研究员，博士，研究方向为水产品品质调控与质量安

全。E-mail：wangdi1991624@hotmail.com

*通信作者简介：胡晓，男，研究员，博士，研究方向为水产品加工与质量安全、食品生物技术。E-mail: hnhuxiao@163.com；陈胜军，男，研究员，博士，研究方向为水产品高值化精深加工与质量安全控制。E-mail：chenshengjun@scsfri.ac.cn

Directed Synthesis, Structural Characterization and Activity Evaluation of ACE-inhibitory Peptides from Nannochloropsis gaditana

LI Zhiqi[1,2], WANG Di[3], ZHANG Yi[1,2], GUO Zebin[1,2], QI Bo[3], HU Xiao[1,*], CHENG Shengjun[1,*]

1. Engineering Research Center of Fujian–Taiwan Special Marine Food Processing and Nutrition, Ministry of Education, Fuzhou 350002,Fujian;

2. College of Food Science, Fujian Agriculture and Forestry University, Fuzhou 350002,Fujian;

3. Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs, National R&D Center for Aquatic Product Processing, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, Guangdong

Abstract :To advance the development and application of *Nannochloropsis gaditana*, this study utilised *Nannochloropsis gaditana* protein as the raw material. Computer-aided virtual proteolysis was employed to identify the optimal protease type for obtaining ACE-inhibitory peptides, whilst single-factor experiments and response surface optimisation were used to determine the optimal proteolysis process for these peptides. The various fractions were separated and analysed by ultrafiltration to identify the fraction with the highest activity. Based on the optimised conditions, the amino acid sequence was characterised, and bioinformatics tools were employed for prediction and screening; finally, molecular docking was performed to elucidate the molecular binding mode between the peptide and ACE. The results indicated that the use of bromelain yielded the highest efficiency in producing ACE-inhibitory peptides from *Nannochloropsis gaditana* ($\Sigma A_{\text{ACE inhibition}}$ = 0.69), with the optimal enzymatic hydrolysis conditions being a reaction time of 3.7 h, an enzyme-to-substrate ratio of 2060 U/g, a reaction time of 3.20 h, and a temperature of 53 °C. Among these,

low-molecular-weight fraction III (<3 kDa) exhibited a significant ACE inhibitory activity, with an ACE inhibition rate of 92.76 ± 0.26%. High-resolution liquid chromatography–mass spectrometry (UPCL) identified 1,970 peptide fragments, from which four new peptides–DAGYF, FDPW, WRDNF and WDPI–were screened. These peptides form hydrophobic interactions, hydrogen bonds, van der Waals forces and π–cation interactions with the ACE active site, enabling them to bind effectively to ACE. DAGYF, FDPW, WRDNF and WDPI were synthesised via solid-phase synthesis and tested for in vitro ACE inhibitory activity; among these, FDPW and WDPI exhibited strong ACE inhibitory activity with IC_{50} values of 0.303 ± 0.03 and 0.585 ± 0.01 mg/ml, respectively. The results of this study indicate that micro-Nostoc possesses significant potential for the preparation of ACE-inhibiting peptides, providing a theoretical basis and technical support for the targeted production of ACE-inhibiting peptides derived from microalgae and their application in antihypertensive functional foods.

Key words: *Nannochloropsis gaditana*;In silico enzymatic hydrolysis; Process optimization; ACE-inhibitory peptides; Molecular docking

微藻蛋白界面网络调控食品泡沫与乳液稳定性的多尺度机制

刘松奇，胡亚芹*

海南热带海洋学院，海南三亚，572022

摘要：目的：微藻因蛋白含量高（20%~70%）、培养效率高且不依赖耕地，被视为未来可持续蛋白质的重要来源。除营养价值外，微藻蛋白还具有良好的界面稳定能力，在泡沫/乳液体系中展现出替代合成表面活性剂及乳清蛋白、蛋清蛋白等动物源蛋白的潜力。本研究旨在从多尺度解析微藻蛋白的界面行为及其调控泡沫/乳液稳定性的机制。方法：通过物理、化学、机械等多种破壁方式制备微藻蛋白，并结合界面扩张流变、界面剪切流变和石英晶体微天平（QCM-D）等手段，系统研究其界面吸附动力学、构象重排、网络形成及黏弹行为，进一步关联界面结构与泡沫/乳液宏观稳定性的关系。结果：微藻蛋白在气-水及油-水界面可快速吸附并发生构象重排，形成具有较高弹性模量的界面网络，其界面黏弹特性与蛋白浓度、破壁方式及分子柔性密切相关；该界面网络的强度与泡沫/乳液的长期稳定性呈正相关。结论：本研究建立了“蛋白性质–界面网络–宏观稳定性”的跨尺度关联，为揭示微藻蛋白稳定泡沫/乳液的机制提供了理论基础，并为其作为可持续植物基食品界面稳定剂的开发与应用提供了参考。

关键词：微藻蛋白；界面流变学；界面网络；界面稳定剂

基金项目：国家自然科学基金（32603375）；海南热带海洋学院高层次人才项目（RHDRC202117）；海南热带海洋学院青年人才项目（RHDRC202307；RHDRCZK202624).

通讯作者：胡亚芹，女，博士，教授，研究方向为海洋生物资源利用，15868109010，1004346262@qq.com.

From interfacial microalgae protein networks to foam/emulsions stability: A multiscale perspective on food foams/emulsion

Songqi Liu[1], Yaqin Hu[1,*]

1. Faculty of Food Science and Technology, Hainan Tropical Ocean University, 572022, Sanya, Hainan, China

Abstract: [Objective] Microalgae are considered promising sources of sustainable proteins due to their high protein

content (20%~70%), high cultivation efficiency, and independence from arable land. Beyond their nutritional value, microalgal proteins also exhibit favorable interfacial stabilization properties, showing potential as alternatives to synthetic surfactants and animal-derived proteins such as whey and egg proteins in foam and emulsion systems. This study aims to elucidate the interfacial behavior of microalgal proteins and their mechanisms in regulating foam and emulsion stability from a multiscale perspective. [Methods] Microalgal proteins were prepared using multiple cell-disruption strategies, including physical, chemical, and mechanical methods. Interfacial dilatational rheology, interfacial shear rheology, and quartz crystal microbalance with dissipation monitoring (QCM-D) were employed to systematically investigate their interfacial adsorption kinetics, conformational rearrangement, network formation, and viscoelastic behavior. These interfacial characteristics were further correlated with the macroscopic stability of foams and emulsions. [Results] Microalgal proteins rapidly adsorbed at air-water and oil-water interfaces and underwent conformational rearrangement, forming interfacial networks with high elastic moduli. Their interfacial viscoelastic properties were closely related to protein concentration, cell-disruption methods, and molecular flexibility. The strength of the interfacial network was positively correlated with the long-term stability of foams and emulsions. [Conclusion] This study establishes a cross-scale relationship among protein properties, interfacial network formation, and macroscopic stability, providing a theoretical basis for elucidating the stabilization mechanisms of microalgal proteins in food foams and emulsions, and supporting their development as sustainable plant-based interfacial stabilizers.

Key words: Microalgal proteins; Interfacial rheology; Interfacial networks; Interfacial stabilizers

五种鲢鱼副产物组织来源对明胶结构、理化性质及乳化性能的影响

阚广懿[1,2]，陈鑫[1,2]，张璟琪[1,2]，李心悦[1,2]，王锡昌[1,*]，钟建[1,2,*]

1、 国家淡水水产品加工技术研发分中心（上海）、农业农村部水产品加工副产物综合利用技术综合科研基地、上海水产品加工与贮藏工程技术研究中心、上海海洋大学食品学院，上海 201306

2、 上海交通大学医学院新华医院、上海市儿科医学研究所、上海市儿童胃肠营养重点实验室，上海 200092

摘要：探讨鲢鱼副产物的五种组织来源（鱼皮、鱼鳞、鱼鳍、鱼头和鱼骨）对明胶结构、理化性质及乳化性能的影响，为鲢鱼副产物的高值化利用提供依据。采用乙酸预处理法从五种鲢鱼副产物组织中提取明胶，分别利用 ATR-FTIR、SDS-PAGE、SEM 和 AFM 分析其结构特征；测定凝胶强度、持水性、持油性、浊度和流变学性质等理化指标；并通过乳液制备与贮藏稳定性、乳化活性指数、乳化稳定性指数、界面张力和表观黏度评价其乳化性能。明胶产率随组织来源不同而变化，依次为鱼皮 > 鱼鳞 > 鱼头 > 鱼鳍 > 鱼骨。β-折叠含量以及 SDS-PAGE 中 β、α1 和 α2 链的总条带强度呈现相似趋势：鱼皮 ≈ 鱼鳞 > 鱼鳍 ≈ 鱼头 > 鱼骨。骨相关明胶（鱼头和鱼骨）的持水性和持油性较低。凝胶强度为鱼皮 ≈ 鱼鳍 > 鱼鳞 > 鱼骨 ≈ 鱼头。鱼鳞和鱼骨明胶溶液的表观黏度显著较低。鱼皮、鱼鳞和鱼鳍明胶在 10 g/L 时乳液贮藏期间无明显乳析，而骨相关明胶在 6 和 10 g/L 时乳液乳析指数较高。界面张力和乳液表观黏度均依赖于明胶组织来源和浓度。组织来源显著影响鲢鱼副产物明胶的结构、理化性质和乳化性能；不同组织来源明胶具有不同的功能特性，这对鲢鱼副产物明胶在食品及其他工业中的应用具有重要意义。

关键词：鱼油；凝胶强度；鲢鱼；界面张力；黏度

王锡昌*：男，博士，教授，河蟹，风味，营养，15692165510，xcwang@shou.edu.cn，中国国家重点研究发展计划 (2018YFD0901006) 和上海市农委 2023 大闸蟹产业体系项目(批准号 202204)

钟建：男，博士，研究员，特医食品，乳液，13816286796，jzhong@shsmu.edu.cn，国家自然科学基金（No.32272338）、上海市加强公共卫生体系建设三年行动计划（2023-2025）学科带头人项目（GWVI11.2-XD19）

Five tissue sources of silver carp by-products on the structure, physicochemical and emulsifying properties of gelatin

Guangyi Kan[a,b], Huaiyue Sun[a,b], Xiaoyu Du[a,b], Xinyue Li[a,b], Xichang Wang[a,*], Jian Zhong[a,b*]

a National R&D Branch Center for Freshwater Aquatic Products Processing Technology (Shanghai), Integrated Scientific Research Base on Comprehensive Utilization Technology for By-Products of Aquatic Product Processing, Ministry of Agriculture and Rural Affairs of the People's Republic of China, Shanghai Engineering Research Center of Aquatic-Product Processing and Preservation, College of Food Science & Technology, Shanghai Ocean University, Shanghai, 201306, China

b Xinhua Hospital, Shanghai Institute for Pediatric Research, Shanghai Key Laboratory of Pediatric Gastroenterology and Nutrition, Shanghai Jiao Tong University School of Medicine, Shanghai, 200092, China

Abstract: Five gelatins were extracted from different silver carp by-products by an acetic acid-pretreated method. Their structural properties were characterized by ATR-FTIR, SDS-PAGE, SEM and AFM. Physicochemical properties, including gel strength, water-holding capacity, fat-binding capacity, turbidity and rheological properties, were measured. The production yields depended on tissue sources: skin > scale > head > fin > bone. The β-sheet percentages and total SDS-PAGE band intensities of β, α1 and α2 chains showed similar dependence: skin ≈ scale > fin ≈ head > bone. Bone-related gelatins (head and bone) showed lower water-holding capacity and fat-binding capacity. Gel strength followed the order: skin ≈ fin > scale > bone ≈ head. Scale and bone gelatin solutions had significantly lower apparent viscosities. Skin, scale and fin gelatins induced no obvious creaming at 10 g/L during emulsion storage, whereas bone-related gelatins induced higher creaming index values at 6 and 10 g/L. Interfacial tension and emulsion apparent viscosity depended on gelatin tissue sources and concentrations. Tissue sources significantly affect the structural, physicochemical and emulsifying properties of silver carp by-product gelatins. Gelatins from different tissue sources possess different functional properties, which are important for their application in food and other industries.

Key words: Fish oil; Gel strength; Hypophthalmichthys molitrix; Interfacial tension; Viscosity

硒化卡拉胶的工艺优化及结构表征

施莉明 [1,2]，戚勃 [2*]，杨少玲 [2*]

1. 上海海洋大学 食品学院，上海 201306;

2. 中国水产科学院南海水产研究所/农业农村部水产品加工重点实验室/国家水产品加工技术研发中心，广东广州 510300

摘要：为了优化硒化卡拉胶(Selenized Carrageenan，Se-CG)制备工艺，本文采用以产物总硒含量和有机硒占比为评价指标，考察反应温度、反应时间、物料配比、酸添加量对反应的影响；再采用响应面法优化制备工艺，借助结构表征技术分析硒化卡拉胶分子结构变化。结果表明，硒元素成功共价结合至卡拉胶多糖骨架，优化工艺显著缩短反应时长，试验验证结果与模型预测值高度吻合。紫外和红外光谱结果表明卡拉胶官能团改变，未破坏多糖链的主体结构；产物粒径减小；SEM 形貌表示由团聚状转变成片状，多糖分子链发生重排。该研究建立了高效稳定的硒化卡拉胶制备工艺，明确了硒化改性的结构变化规律，可为海藻硒多糖的研究应用提供理论依据。

关键词：硒化卡拉胶；工艺优化；结构表征

第一作者：施莉明，女，硕士研究生，研究方向为海藻加工与利用。E-mail：mkbk0609@163.com

通讯作者：戚勃，男，副研究员，硕士，研究方向为海藻加工与利用。E-mail：qibo780210@163.com

杨老师，女，副研究员，硕士，研究方向为海藻加工与利用。E-mail：shaoling278@163.com

基金项目：国家藻类产业技术体系（CARS-50)；国家重点研发项目（2024YFD2401805）

虾加工副产物作为可持续资源用于可生物降解活性食品包装膜的研究进展

Wondemu Bogale Teseme [1,2], 张俊 [1,2]*, 刘书成 [1,2]*

1.广东海洋大学食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋生物制品工程实验室，广东省海洋食品工程技术研究中心，广东省水产预制食品加工与品质控制工程技术研究中心，广东湛江，524088；

2.海洋食品精深加工关键技术省部共建协同创新中心，大连工业大学，辽宁大连，116034

摘要：石油基塑料造成的日益严重的环境负担，以及水产品加工副产物资源利用不足的问题，推动了以可再生资源为原料开发可持续食品包装材料的研究。虾加工过程中产生的虾壳、虾头和虾尾等副产物富含甲壳素、蛋白质、矿物质、脂质以及虾青素等类胡萝卜素，是极具开发价值的海洋生物质资源。本文系统评述了虾加工副产物作为综合性原料用于制备可生物降解活性食品包装膜的研究进展，重点讨论虾加工副产物的产生及其生化组成、主要功能组分的提取技术，以及提取组分向成膜材料的转化与利用。重点概括了酶法、超声辅助提取、微波辅助提取和深共熔溶剂等传统与新兴绿色提取技术，并分析不同提取过程对聚合物纯度、分子结构及成膜性能的影响。在此基础上，进一步总结了虾源成膜材料的配方设计及其力学性能、阻隔性能、热稳定性、光学性能、抗氧化活性、抗菌性能和生物降解特性。现有研究表明，以虾加工副产物为原料制备的生物基聚合物，尤其是壳聚糖及蛋白质基材料，在易腐食品活性包装领域具有良好的应用潜力。然而，材料的湿敏性和脆性、原料组成波动、加工成本以及规模化制备受限等问题，仍是其产业化应用面临的主要障碍。因此，虾加工副产物为构建资源循环利用、高值化转化和功能化包装相结合的可持续食品包装体系提供了良好平台。未来应进一步发展绿色高效的功能组分提取技术，强化多功能复合成膜材料的理性设计，并建立兼顾食品安全、材料性能与经济性的规模化制备技术，以推动虾加工副产物基可持续包装材料由实验室研究向产业化应用转变。

关键词： 活性包装；虾青素；可生物降解膜；甲壳素；壳聚糖；虾加工副产物

通讯作者：张俊，zhangjun@gdou.edu.cn; 刘书成，liusc@gdou.edu.cn

基金项目：广东省重点研发领域研发计划项目(2025B1111140001)；国家虾蟹产业技术体系（CARS-47）；广东省普通高校青年创新人才项目（2023KQNCX025）

Shrimp Processing By-Product as Sustainable Resources for Biodegradable and Active Food Packaging Films: A Review

Wondemu Bogale Teseme [a,c], , Jun Zhang [a, b] *, Shucheng Liu [a, b]*

[a] College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Guangdong Province Engineering Laboratory for Marine Biological Products, Guangdong Provincial Engineering Technology Research Center of Seafood, Guangdong Provincial Engineering Technology Research Center of Prefabricated Seafood Processing and Quality Control, Zhanjiang 524088, China

[b] Collaborative Innovation Center of Seafood Deep Processing, Dalian Polytechnic University，Dalian, 116034

ABSTRACT： The growing environmental burden of petroleum-based plastics and the underutilization of seafood-processing residues have intensified interest in renewable materials for sustainable food packaging. Among marine by-products, shrimp-processing waste, including shells, heads, and tails, represents a particularly valuable biomass because it contains chitin, proteins, minerals, lipids, and carotenoids such as astaxanthin. This review critically examines shrimp as integrated feedstocks for the development of biodegradable and active food packaging films. This review discusses the generation and biochemical composition of shrimp residues, recent advances in the extraction of key functional constituents, and their subsequent conversion into film-forming materials. Particular attention is given to conventional and emerging green extraction approaches, including enzymatic treatments, ultrasound-assisted and microwave-assisted processes, and deep eutectic solvent systems, as well as their effects on polymer purity, molecular structure, and film performance. This review further evaluates formulation strategies and the resulting mechanical, barrier, thermal, optical, antioxidant, antimicrobial, and biodegradation properties of shrimp derived films. Current evidence indicates that shrimp-based biopolymers, especially chitosan and protein based systems, offer strong potential for application in the active packaging of highly perishable foods. However, moisture sensitivity, brittleness, raw material variability, processing cost, and scaleup limitations remain major barriers to commercialization. Overall, shrimp processing

byproducts provide a promising platform for circular, value-added packaging innovation, and future progress will depend on greener recovery methods, multifunctional film design, and scalable manufacturing routes that meet food safety and industrial performance requirements.

Keywords: active packaging; astaxanthin; biodegradable films; chitin ;chitosan; shrimp by-products

暹罗鳄加工副产物的高值化利用：油脂提取与酶法改性

邹硕 1，张震 2，汪勇 2，王琦 1，陈季旺 1

[1] 武汉轻工大学食品科学与工程学院，湖北武汉，430023

[2] 暨南大学中国-马来西亚“一带一路”油脂加工与安全联合实验室，广东广州，510632

摘要：针对暹罗鳄加工副产脂肪利用不足的问题，本研究采用干法熬炼提取鳄鱼油，并以脂肪酶 Novozym 435 催化甘油解调控甘油酯组成，系统考察其脂质组成、热行为、乳液特性及透皮递送性能。结果表明，鳄鱼油得率为 73.20%，不饱和脂肪酸占 76.97%；TAG 转化符合一级衰减动力学，DAG 含量最高达 50.72%。酶法改性显著改善了鳄鱼油的乳液性能，乳滴粒径最低由 446.0 nm 降至 86.1 nm，铺展性和储藏稳定性明显提高；其中 CO-DAG20 乳液的 α-生育酚 24 h 累积透过量达 14.33 μg/cm²，透皮增强比为 1.60。值得注意的是，进一步提高 DAG 含量并未带来乳液性能的持续提升，表明甘油解程度与功能特性之间存在适宜的调控区间。研究揭示了甘油酯组成、热物性与乳液递送性能之间的关联，为暹罗鳄副产脂肪高值化利用提供了理论依据。

关键词：暹罗鳄；加工副产物；鳄鱼油；酶法甘油解；甘油二酯

资助项目：国家重点研发计划（2024YFE0214900）；国家自然科学基金（32272341）。

第一作者介绍：邹硕，女，博士，讲师，主要从事功能脂质及水产加工副产物高值化利用研究。电话：18861819283；E-mail：zoushuo98@163.com。

Valorization of Crocodylus siamensis Processing Byproducts through Oil Extraction and Enzymatic Modification

Shuo Zou[1], Zhen Zhang[2], Yong Wang[2], Qi Wang[1], Jiwang Chen[1]

1. College of Food Science and Engineering, Wuhan Polytechnic University, Wuhan 430023, Hubei;

2. JNU-UPM International Joint Laboratory on Plant Oil Processing and Safety, Department of Food Science and Engineering, Jinan University, Guangzhou 510632, Guangdong.

Abstract: To address the underutilization of fat-rich processing byproducts from *Crocodylus siamensis*, crocodile

oil was recovered by dry rendering and subsequently modified through Novozym 435-catalyzed glycerolysis to regulate its acylglycerol composition. The lipid composition, thermal behavior, emulsion properties, and transdermal delivery performance of the resulting oils were systematically evaluated. The oil yield reached 73.20%, with unsaturated fatty acids accounting for 76.97% of total fatty acids. TAG conversion during glycerolysis followed first-order decay kinetics, and the DAG content reached up to 50.72%. Enzymatic modification markedly improved the emulsion performance of crocodile oil, reducing the droplet size from 446.0 nm to as low as 86.1 nm while enhancing spreadability and storage stability. Notably, the CO-DAG20 emulsion achieved a 24-h cumulative α-tocopherol permeation of 14.33 μg/cm^2, corresponding to an enhancement ratio of 1.60. Further increasing the DAG content, however, did not result in a continuous improvement in emulsion performance, suggesting the existence of an optimal glycerolysis range for functional property regulation. These findings reveal the relationships among acylglycerol composition, thermal properties, and emulsion delivery performance, providing a theoretical basis for the value-added utilization of *C. siamensis* fat byproducts.

Key words: *Crocodylus siamensis*; processing byproducts; crocodile oil; enzymatic glycerolysis; diacylglycerol

小龙虾各部位脂质提取特征比较及抗氧化能力评价

章巍滔[1]，陈艳菲[1]，彭瑞琪[1]，邹硕[1,2]，王 琦[1,2,3*]，陈季旺[1,2,3]

（1.武汉轻工大学食品科学与工程学院，湖北 武汉 430023；2.湖北省农产品加工与转化重点实验室，湖北 武汉 430023；3.国家小龙虾加工技术研发分中心（潜江），湖北 潜江 433100）

摘要: [目的]为进一步开发利用小龙虾资源，本研究对小龙虾各部位提取脂质的特征组成进行了分析，并对其抗氧化能力进行了综合评价。**[方法]**分别采用索氏抽提法和 Folch 法提取去肝胰腺虾头、肝胰腺、虾尾肉、虾尾壳及虾蝥脂质，测定甘油三酯、磷脂及总虾青素含量，以熵权 TOPSIS 评价体外抗氧化能力。**[结果]**Folch 法提取虾尾壳脂质中的磷脂含量较索氏抽提法高 65.76%，总虾青素含量为 24.05±1.28mg/g 脂质，在所有脂质提取物中最高，经熵权 TOPSIS 综合评价体外抗氧化能力评分为 0.95，在所有脂质提取物中排名首位。**[结论]**本研究发现，提取方法和部位是小龙虾脂质抗氧化能力分析与评价中需要同时考虑的因素，Folch 法提取虾尾壳脂质具有显著高于其他部位的总虾青素含量及最佳的综合抗氧化表现。

关键词：小龙虾；脂质；磷脂；虾青素；抗氧化能力

*通讯作者：王琦，E-mail: wqsys313@163.com

Comparison of Lipid Extraction Characteristics and Evaluation of Antioxidant Capacity across Crayfish Anatomical Parts

ZHANG Weitao[1], CHEN Yanfei[1], PENG Ruiqi[1], ZOU Shuo[1,2], WANG Qi[1,2,3*], CHEN Jiwang[1,2,3]

(1. School of Food Science and Engineering, Wuhan Polytechnic University, Wuhan 430023, Hubei; 2. Key Laboratory of Agricultural Products Processing and Transformation in Hubei Province, Wuhan 430023, Hubei; 3. National R & D Branch Center for Crayfish Processing (Qianjiang), Qianjiang 433100, Hubei)

Abstract:**[Objective]** To support the further development and utilization of crayfish resources, the composition of lipid extracts from different anatomical parts of crayfish was characterized and their antioxidant capacities were comprehensively evaluated. **[Methods]** Lipids were extracted from crayfish heads after removing the hepatopancreas, hepatopancreas, tail meat, tail shells, and claws using the Soxhlet and Folch methods. Triglyceride, phospholipid, and total astaxanthin contents were determined. A comprehensive evaluation of in vitro antioxidant capacity was performed using the entropy-weighted technique for order preference by similarity to an ideal solution (TOPSIS). **[Results]** The phospholipid content of the tail shell lipid extract obtained using the Folch method was 65.76% higher than that of the corresponding Soxhlet extract. Its total astaxanthin content was 24.05 ± 1.28 mg/g lipid, the highest among all lipid extracts. In the comprehensive evaluation of in vitro antioxidant capacity using entropy-weighted TOPSIS, this extract achieved a score of 0.95, ranking first among all lipid extracts. **[Conclusion]** Both extraction method and anatomical part should be considered when analyzing and evaluating the antioxidant capacity of crayfish lipids. The lipid extract obtained from crayfish tail shells using the Folch method exhibited a significantly higher total astaxanthin content than extracts from other anatomical parts and ranked highest in the comprehensive evaluation of antioxidant capacity.

Key words: crayfish; lipid; phospholipids; astaxanthin; antioxidant capacity

新鲜与冷冻罗非鱼片不同部位营养品质的比较

白宝颖，汪莹莹，盘赛昆，王红丽*

江苏海洋大学海洋食品与生物工程学院，连云港，222000

摘要：罗非鱼（*Oreochromis niloticus*）作为全球性重要养殖经济鱼类，具有较高的营养价值；阐明其在冷冻过程中营养品质的部位特异性变化规律，对于优化采后品质保持工艺具有重要意义。本研究系统分析了新鲜与冷冻罗非鱼片在背肉（dorsal muscle, DM）、腹肉（belly muscle, BM）和尾肉（tail muscle, TM）三个部位的营养品质差异。常规成分分析结果表明，无论处于何种状态，各部位均保持较高的水分（76.50%~79.18%，湿基）和蛋白质（18.39%~20.88%，湿基）含量。冷冻处理导致脂质含量显著下降（$P<0.05$），其中尾肉降幅最为显著。与冷冻组相比，新鲜样品的总氨基酸与必需氨基酸含量更高，而各部位肌肉均维持较优的氨基酸组成模式。多不饱和脂肪酸（PUFA）构成脂肪酸的主要组分（36.71%~45.66%），且新鲜状态下背肉的 PUFA 含量达到最高水平。脂质品质指数进一步印证了罗非鱼的营养优势：新鲜鱼片较冷冻样品具有更优的 PUFA 组成和更有利的心血管风险指数（即更低的致动脉粥样硬化指数与致血栓形成指数）。冷冻使游离氨基酸含量分别下降 13.25%（背肉）、15.22%（腹肉）和 20.19%（尾肉）。多元统计分析（主成分分析 PCA 与正交偏最小二乘判别分析 OPLS-DA）一致显示，新鲜与冷冻样品间存在显著营养差异，且冷冻组中背肌的变化最为突出。综上，新鲜罗非鱼片（尤其背肉部位）表现出更优的营养物质保留效果。

关键词：罗非鱼片；解冻方式；冻藏时间；游离氨基酸；呈味核苷酸

资助项目：江苏海洋大学高层次人才科研启动基金（KQ23021）和连云港市重点研发计划（产业前瞻与关键计划）项目（CG2531）

通讯作者：王红丽，讲师，博士，研究方向：水产品加工与贮藏 E-mail: hlwang@jou.edu.cn

Comparative Analysis of Nutritional Quality in Fresh and Frozen Tilapia (Oreochromis niloticus) Fillet: A Focus on Region- Specific Variations

Baoying Bai, Yingying Wang, Saikun Pan, Hongli Wang*

School of Marine Food and Bioengineering, Jiangsu Ocean University, Lianyungang, 222000, China;

Abstract: As tilapia (*Oreochromis niloticus*) is a globally important aquaculture species with high nutritional value, understanding the region-specific nutrient quality variations during freezing is critical for optimizing post-harvest quality preservation. This study systematically investigated region-specific variations in nutritional quality between fresh and frozen tilapia fillets, focusing on dorsal (DM), belly (BM), and tail (TM) muscle segments. Proximate analysis revealed all regions retained high moisture (76.50-79.18% ww) and protein (18.39-20.88% ww) regardless of state. Freezing led to significant lipid reduction ($P < 0.05$), most notably in TM. Fresh samples exhibited higher total and essential amino acid contents than frozen counterparts, while all muscle segments maintained favorable amino acid profiles. Polyunsaturated fatty acids (PUFAs) constituted the predominant fraction (36.71-45.66%), with DM exhibiting peak levels in fresh state. Lipid quality indices confirmed the nutritional advantages of tilapia, particularly in fresh fillets which showed more favorable PUFA profiles and lower cardiovascular risk indices than frozen samples. Freezing depleted free amino acid content by 13.25% (DM), 15.22% (BM), and 20.19% (TM). Multivariate statistical analysis [principal component analysis (PCA) and orthogonal projections to latent structures discriminant analysis (OPLS-DA) models] consistently demonstrated significant nutritional disparities between fresh and frozen samples, with DM exhibiting marked variations in the frozen group. Overall, fresh tilapia fillets, especially DM, demonstrated superior nutrient preservation.

Key words: tilapia fillets; thawing methods; frozen durations; free amino acids; nucleotides

星辉互映启发的新型交织式金纳米阵列 SERS 平台用于食品危害物检测

王鹏翔[1]，林洪[1]，曹立民[1]，隋建新[1]，王秀丹[1]，王凯强[1*]

1.中国海洋大学食品科学与工程学院，中国 青岛 266000

摘要：针对液液界面自组装 SERS 基底热点利用率低、检测灵敏度受限的问题，本研究提出“颗粒互嵌、填隙增密”的热点重构思想，受星辉互映启发，采用三相界面共组装策略，将不同粒径 AuNPs 协同组装，构建交织式金纳米阵列（SSIN）。小粒径 AuNPs 嵌入大粒径 AuNPs 间隙，实现纳米间隙的二次填充与热点增密，并使等离子体吸收向 785 nm 激光波长匹配。SSIN 阵列对 10-4 mol/L MBA 的 SERS 信号较两种单粒径基底分别提高 39.32 倍和 4.55 倍，孔雀石绿检出限达 0.392 ng/L，并可用于水产品实际样品检测。该研究利用不同粒径 AuNPs 的尺寸互补效应调控界面组装结构，实现纳米间隙填充与热点增密，为高活性、低成本 SERS 基底的构筑及食品污染物现场筛查提供了新思路。

关键词：表面增强拉曼散射（SERS）；界面共组装；交织式金纳米阵列；食品污染物检测

资助项目：本研究得到了国家自然科学基金（32472426）、山东省自然科学基金（ZR2024QC242）、国家重点研发计划（2023YFD2401405）、中国农业研究体系（CARS-47）、中国海洋大学食品科学与工程学院青年跨学科创新研究计划的支持（2024105）。

通讯作者介绍：王凯强、男、博士、副教授、0532-82032389、wkq@ouc.edu.cn。主要从事食品品质和风险因子快速无损检测、多孔纳米材料构建与应用、拉曼光谱和激光诱导击穿光谱检测等研究工作。

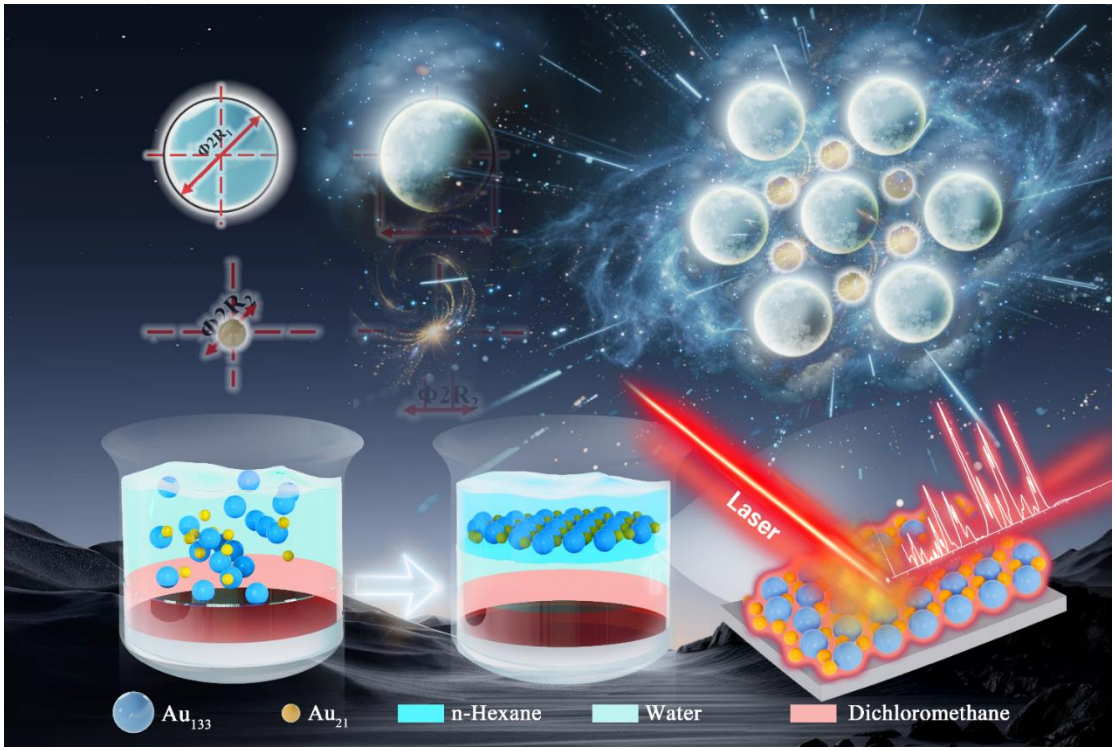
Stellaris Somnia-inspired interlaced gold nanoarray as a novel hotspot-optimized SERS platform for food hazards detection

Pengxiang Wang[1], Hong Lin[1], Limin Cao[1], Jianxin Sui[1], Xiudan Wang [1], Kaiqiang Wang [1*]

1.College of Food Science and Technology, Ocean University of China, Qingdao 266000, Shandong

Abstract: To address the low hotspot utilization and limited detection sensitivity of SERS substrates fabricated by liquid-liquid interfacial self-assembly, this study proposes a hotspot-optimization concept based on particle intercalation and gap filling. Inspired by Stellaris Somnia, a three-phase interfacial co-assembly strategy was developed to synergistically assemble Au nanoparticles (AuNPs) of different sizes, thereby constructing a Stellaris Somnia-inspired interlaced gold nanoarray (SSIN). Small AuNPs were intercalated into the gaps between large AuNPs, enabling secondary filling of nanoscale voids and pronounced hotspot densification. Meanwhile, the plasmonic absorption was shifted toward the 785 nm excitation wavelength, further enhancing the SERS response. For 10-4 mol/L MBA, the SSIN exhibited SERS signal intensities 39.32 and 4.55 times higher than those of the corresponding substrates composed of AuNPs with a single particle size, respectively. A limit of detection of 0.392 ng/L was achieved for malachite green, and the SSIN was successfully applied to the analysis of real aquatic product samples. By exploiting the size complementarity of AuNPs to optimize the interfacial nanoarchitecture and hotspot distribution, this study provides a simple and effective strategy for constructing high performance and low-cost SERS platforms for rapid on-site detection of food hazards.

Keywords: Surface-enhanced Raman scattering (SERS); interfacial co-assembly; Stellaris Somnia-inspired interlaced gold nanoarray; food hazards detection



Schematic illustration of the as-proposed fabrication process of a SSIN SERS substrate.

鲟鱼皮胶原水解物在冻融循环中对鱼糜的冷冻保护作用及其抗冻肽的构效关系

于嘉淇，洪惠，罗永康，谭雨青

食品科学与营养工程学院，中国农业大学，北京，10083

摘要：尽管胶原来源的肽已被广泛开发用于鱼糜的冷冻保护，但其构效关系仍缺乏深入认识。本研究以鲟鱼副产物为原料，结合蛋白酶筛选、肽组学和分子对接技术开发抗冻肽。在 3 种商业蛋白酶中，Alcalase®酶解制得的 ACP 表现出最高的水解度和最高比例的 500-2000 Da 组分，并具有最强的热滞后活性（0.520 ℃）。在鲢鱼鱼糜体系中，经过 4 次冻融循环后，2% ACP 的冷冻保护效果优于 8%蔗糖-山梨醇，能够减少水分流失和蛋白质损伤，并形成更加致密的凝胶网络。通过多级筛选和分子对接，从 ACP 中鉴定出 5 种具有不同结构特征的抗冻肽，且均表现出较强的抗冻活性。较长的肽链、构象柔性、空间分布的氢键以及 Janus 型两亲性可能有助于增强抗冻活性。本研究阐明了水解物及抗冻肽的构效关系，为抗冻肽的理性设计提供了结构模板。

关键词：鲟鱼；抗冻肽；鱼糜冷冻保护；构效关系

资助项目：国家重点研发计划（2024YFD2101200）

通讯作者：谭雨青，女，博士，副教授，水产品加工及天然产物功能评价，yuqingtan@cau.edu.cn

Cryoprotective effects of sturgeon skin collagen hydrolysates on surimi during freeze-thaw cycles and structure-activity relationship of its antifreeze peptides

Jiaqi Yu, Hui Hong, Yongkang Luo, Yuqing Tan*

College of Food Science and Nutritional Engineering, China Agricultural University, Beijing, 10083

Abstract: Although collagen-derived peptides have been widely developed as cryoprotectants for surimi, their structure-activity relationships remain poorly understood. We developed antifreeze peptides from underutilized sturgeon by-products using proteolytic screening, peptidomics and molecular docking. Among the three commercial proteases, ACP produced by Alcalase® hydrolysis showed the highest degree of hydrolysis and the highest

proportion of 500-2000 Da components, and exhibited the strongest thermal hysteresis activity (0.520 ºC). In silver carp surimi, 2% ACP outperformed 8% sucrose-sorbitol over four freeze-thaw cycles, reducing water loss and protein damage and forming a denser gel network. Through multistage screening and molecular docking, five potential antifreeze peptides with distinct structural features were identified from ACP, and they exhibited stronger antifreeze activity. Longer peptide chains, conformational flexibility, spatially distributed hydrogen bonds, and Janus amphiphilicity may enhance antifreeze activity. These findings clarified the structure-activity relationships of hydrolysates and antifreeze peptides, providing templates for rational antifreeze peptide design.

Key words: Sturgeon; Antifreeze peptide; Surimi cryoprotection; Structure-activity relationship

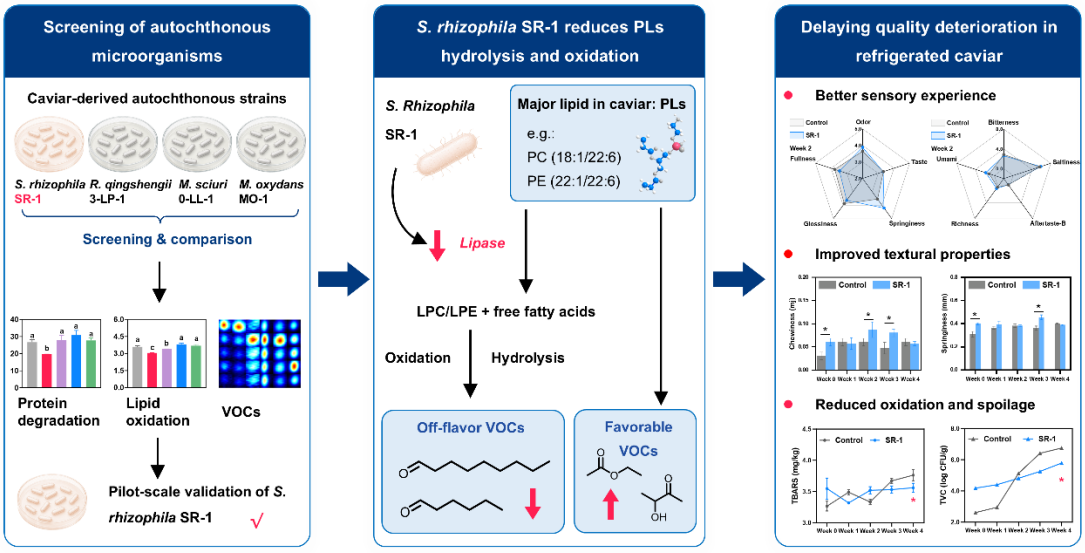
鲟鱼子酱自生微生物 *Stenotrophomonas rhizophila* SR-1 延缓冷藏鲟鱼子酱贮藏品质劣变的作用及机制

韩贵新 1，徐新星 1，赵元晖 1*

1. 中国海洋大学 食品科学与工程学院，山东青岛，266000

摘要：本研究评估了鲟鱼子酱自生微生物 *Stenotrophomonas rhizophila* SR-1 在延缓冷藏鲟鱼子酱品质劣化方面的作用。实验室筛选结果显示，SR-1 的 TVB-N（19.68 mg/100 g）和 TBARS（3.05 mg/kg）含量最低，而 *Mammaliicoccus sciuri* 0-LL-1 则表现出更明显的劣化趋势。中试生产规模中，添加 SR-1 的鱼子酱感官与质地更好，第 4 周的 TVB-N 仅为 18.71 mg/100 g，对照组和 0-LL-1 组分别为 19.65 和 21.93 mg/100 g（P < 0.05）。与对照组相比，SR-1 降低了 1-戊烯-3-酮、戊醛和 2-甲基-3-呋喃硫醇的含量，同时增加了 3-羟基-2-丁酮的含量。脂质组学鉴定出 1046 种脂质，其中以甘油磷脂为主（62.81%）。与 0-LL-1（> 150 种差异脂质）相比，SR-1 引起的脂质变化较少。体外磷脂发酵模型表明 SR-1 将脂肪酶活性从 2.71 降低至 1.80 μM/min/mL，显著降低了磷脂氧化。这些结果为鲟鱼子酱风味品质提升提供了新的方案。

关键词：鲟鱼子酱；贮藏品质；嗜根寡养单胞菌；磷脂代谢；挥发性化合物



羊栖菜中无机砷提取及脱除工艺研究

陶慧林，邓建朝

福建农林大学，食品科学学院，福建福州，350000；中国水产科学院南海水产研究所，广东省广州市，510220

摘要：羊栖菜营养价值丰富，但其高毒性的无机砷严重制约其食用安全与产业发展，因此高效、绿色的无机砷提取检测及脱除工艺是保障羊栖菜产品质量安全的关键。本研究以干制羊栖菜为原料，采用微波辅助提取方式，依托高效液相色谱-氢化物发生-原子荧光光谱联用技术，找到最佳的无机砷提取条件，并探究微波辅助耦合有机酸浸提的绿色脱砷新工艺。结果表明：有机酸浸提可有效破坏羊栖菜的细胞壁结构，微波辅助处理可显著强化传质效率。缩短脱砷的时间，在最优脱除工艺条件下，找到了脱除效果比较好营养价值兼容的一个最佳条件。本研究建立的无机砷检测方法与绿色脱除工艺，可以为高砷海藻食用化加工、质量安全控制及产业化应用提供技术支撑与理论依据。

关键词：羊栖菜；微波辅助提取；高效液相色谱-氢化物-原子荧光光谱；有机酸脱除

邓建朝，男，博士研究生，副研究员，15989157919，djc9801@foxmail.com

Study on Extraction and Removal Process of Inorganic Arsenic from Sargassum fusiforme

Tao Huilin，Deng Jianchao

School of Food Science, Fujian Agriculture and Forestry University,Fuzhou,350000,Fujian;2 South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou, 510220, Guangdong

Abstract : Sargassum fusiforme possesses high nutritional value. However, the presence of highly toxic inorganic arsenic seriously restricts its food safety and industrial development. Therefore, efficient and green processes for the extraction, determination and removal of inorganic arsenic are critical to guarantee the quality and safety of *Sargassum fusiforme* products. In this study, dried *Sargassum fusiforme* was used as raw material. Microwave-assisted extraction combined with high-performance liquid chromatography-hydride generation-atomic fluorescence spectrometry (HPLC-HG-AFS) was employed to determine the optimal extraction conditions for inorganic arsenic. A

novel green arsenic removal process combining microwave assistance and organic acid leaching was further investigated. The results demonstrated that organic acid leaching could effectively disrupt the cell wall structure of *Sargassum fusiforme*, and microwave-assisted treatment significantly enhanced mass transfer efficiency and shortened the arsenic removal duration. Under the optimal conditions, an optimum scenario with favorable arsenic removal performance while retaining nutritional properties was obtained. The established inorganic arsenic determination method and green removal process in this work can provide technical support and theoretical basis for edible processing, quality safety control and industrial application of high-arsenic seaweeds.

Key words: Sargassum fusiforme; microwave-assisted extraction (MAE); high-performance liquid chromatography-hydride generation-atomic fluorescence spectrometry (HPLC-HG-AFS); Organic Acid-mediated Arsenic Removal

贻贝肽-低聚半乳糖美拉德复合物的结构表征与促锌吸收机制研究

于雪凝[1]，刘潇阳[1*]，周大勇[1]

1. 大连工业大学，辽宁省大连市，116034

摘要：本研究通过美拉德反应，在优化条件下（pH 8.0、120 °C、180 min）制备了贻贝肽（MP）与低聚半乳糖（GOS）的偶联物（MPG），并进一步构建了一种新型锌递送系统（MPGZn）。MPGZn 具有 70.94%的锌结合能力。非靶向代谢组学揭示了增强锌配位的关键代谢物。MPGZn 在 5 mg/mL 浓度下对 DPPH 自由基和 ABTS 自由基表现出强烈的清除活性（分别为 54.54%和 87.71%），并保护 TM3 细胞免受 H_2O_2诱导的氧化损伤。细胞摄取与 Occludin-1 和锌转运蛋白（ZnT1）的上调表达相关。在锌缺乏小鼠中，MPGZn 显著提高了血清锌水平，缓解了肠道炎症，改善了肝肾功能，并降低了氧化应激标志物。这些发现表明，MPGZn 通过涉及锌递送和抗氧化活性的双重机制缓解锌缺乏。

关键词：锌递送体系构建；非靶向代谢组学；抗氧化活性；锌离子转运

Structural Characterization and Mechanisms of Enhanced Zinc Absorption of Mussel Peptide-Galactooligosaccharide Maillard Complexes

Xuening Yu[1], Xiaoyang Liu[1*], Dayong Zhou[1]

1. School of Food Science and Engineering, Dalian Polytechnic University , Dalian, 116034, Liaoning

Abstract: In this study, a conjugate (MPG) of mussel peptide (MP) and galactooligosaccharides (GOS) was prepared via the Maillard reaction under optimized conditions (pH 8.0, 120 °C, 180 min), and a novel zinc delivery system (MPGZn) was further constructed. MPGZn exhibited a zinc-binding capacity of 70.94%. Non-targeted metabolomics revealed key metabolites that enhanced zinc coordination: at a concentration of 5 mg/mL, MPGZn showed strong scavenging activities against DPPH and ABTS radicals (54.54% and 87.71%, respectively) and protected TM3 cells from

H_2O_2-induced oxidative damage. Cellular uptake was associated with the upregulated expression of Occludin-1 and the zinc transporter protein (ZnT1). In zinc-deficient mice, MPGZn significantly increased serum zinc levels, alleviated intestinal inflammation, improved liver and kidney function, and reduced oxidative stress markers. These findings indicate that MPGZn mitigates zinc deficiency through a dual mechanism involving zinc delivery and antioxidant activity.

Key words: Construction of zinc delivery system; Non-targeted metabolomics; Antioxidant activity; Zinc ion transport

益生元介导美拉德反应改善鲢鱼蛋白水解物品质及其肠道免疫调节作用

窦佩佩

鲢鱼蛋白水解物（SCH）具有良好生物活性，但鱼腥味和苦味等感官缺陷限制了其食品化利用。本研究以 SCH 为原料，引入益生元低聚糖进行美拉德反应修饰，筛选适宜糖基供体并优化反应配比，评价其风味、抗氧化活性及安全性，并采用环磷酰胺（CTX）诱导的免疫抑制小鼠模型探究其免疫调节作用。结果表明，与低聚半乳糖、低聚果糖、水苏糖和低聚异麦芽糖相比，低聚木糖（XOS）具有较高反应活性，可促进 SCH 糖基化及特征香气物质形成，增强焦糖样和烤香风味，降低鱼腥味和苦味，并提高抗氧化能力，其中 XOS:SCH 为 1:1 和 2:1 时总体接受度较高。SCH-MRPs 中未检出丙烯酰胺，消化产物对 Caco-2 细胞无明显毒性。动物实验表明，SCH-MRPs 可缓解 CTX 诱导的脾脏萎缩和结肠损伤，提高免疫球蛋白水平，恢复紧密连接蛋白表达，调节炎症因子和 NF-κB 信号，并改善肠道菌群结构、促进短链脂肪酸产生及 $CD4^+$、$CD8^+$ T 细胞恢复。综上，益生元介导的美拉德反应可协同改善 SCH 的感官品质和功能活性，并通过调节肠道稳态与黏膜免疫缓解免疫抑制，为淡水鱼蛋白资源高值利用提供理论依据。

“一夜埕”金鲳鱼低钠复合盐配方优化及品质与风味特性研究

张云云[1]，孙钦秀[1,*]

1.广东海洋大学食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研究中心，广东省高等学校水产品精深加工重点实验室，广东 湛江 524088

摘要：为降低传统“一夜埕”金鲳鱼（*Trachinotus ovatus*）的钠含量，以 KCl、$CaCl_2$和 L-丙氨酸部分替代 NaCl，采用单因素试验和 Box-Behnken 响应面法优化复合盐配方，并评价产品感官、理化、微生物及挥发性风味特性。在复合盐总添加量为鱼肉质量 20%的条件下，优化配方为 NaCl 64%、KCl 18%、$CaCl_2$ 11%和 L-丙氨酸 7%，模型预测感官评分为 42.24 分，验证值为 42.22 分。与 20% NaCl 对照组相比，低钠组的盐含量和钠含量分别降低 31.2%和 48.9%，水分含量提升了 6.62%，钾、钙含量增加；硬度、内聚性和咀嚼性无显著差异，弹性显著升高（$P<0.05$）。低钠组菌落总数升高了 0.14 lg（CFU/g）（$P<0.05$）。GC-IMS 共鉴定 29 种挥发性化合物，低钠组 1-辛烯-3-醇、（E）-2-庚烯醛和 1-辛烯-3-酮等土腥及氧化相关化合物信号强度降低，而 2,5-二甲基吡嗪和三甲基噻唑等信号强度升高，表明低钠复合盐可减弱土腥及氧化气味，并增强烘烤和肉香特征。综合来看，该复合盐配方可显著减钠并保持主要品质，同时调节挥发性风味特征。

关键词：“一夜埕”金鲳鱼；低钠复合盐；响应面法；品质特性；挥发性风味

基金项目：广东省普通高校青年创新人才类项目（2020KQNCX028）；

[*]**通讯作者：**孙钦秀，女，博士后，教授，研究方向为海洋食品贮藏与加工

E-mail: sunqinxiugo@163.com

Optimization of Low-Sodium Compound Salt Formulation and Quality and Flavor Characteristics of “Yi Ye Cheng” Golden Pompano (Trachinotus ovatus)

Yunyun Zhang[1], Qinxiu Sun[1,*]

[1] College of Food Science and Technology, Guangdong Ocean University, Guangdong Provincial Key Laboratory of Aquatic Product Processing and Safety, Zhanjiang, 524088, China.

Abstract: To develop a low sodium salt blend for “Yi Ye Cheng” golden pompano (*Trachinotus ovatus*), NaCl was partially substituted with KCl, $CaCl_2$, and L alanine. Single factor tests and Box Behnken response surface methodology optimized the formulation. Sensory, physicochemical, microbiological, and volatile flavor properties were characterized. At a total salt addition of 20% fish mass, the optimal blend contained 64% NaCl, 18% KCl, 11% $CaCl_2$, and 7% L alanine. The predicted and experimental sensory scores reached 42.24 and 42.22, respectively. Compared with the 20% NaCl control, this low sodium formulation reduced total salt and sodium contents by 31.2% and 48.9%, and increased moisture by 6.62%. Potassium and calcium contents increased; hardness, cohesiveness, and chewiness were unchanged, whereas springiness increased ($P < 0.05$). Total viable count in the low sodium group increased by 0.14 lg CFU/g ($P < 0.05$). GC IMS detected 29 volatile compounds. In the low-sodium group, the signal intensities of 1-octen-3-ol, (E)-2-heptenal, and 1-octen-3-one, which are associated with earthy and oxidative odors, were decreased, whereas those of 2,5-dimethylpyrazine and trimethyl thiazole were increased, indicating that the low-sodium compound salt could reduce earthy and oxidative odors while enhancing roasted and meaty aroma characteristics. Overall, the optimized salt blend reduces sodium content, preserves core quality attributes, and modulates volatile flavor. The slight rise in viable count indicates weaker microbial inhibition than the full NaCl control.

Key words: “Yi Ye Cheng” golden pompano; low-sodium salt blend; response surface methodology; quality attributes; volatile flavor

鱿鱼新型甲醛清除剂开发及其保鲜研究

王寒冰 ，许长华*

上海海洋大学，上海，200120

摘要：

鱿鱼，因其口味鲜美，营养价值高等深受大众喜爱，但因其自身和外源产生的甲醛，不仅影响鱿鱼品质，甲醛带来的危害也使得不少人对其谨慎选择。市场上鱿鱼的干制品较多，也使得不法商家有了可趁之机，在干制品的泡制过程非法添加甲醛，使得鱿鱼甲醛的含量超标。冷藏期内中随时间的增长，鱿鱼的鲜度质量下降；其次，在腐败过程中通过鱼体内酶的作用也会使得甲醛的含量增加。

茶多酚和壳聚糖作为天然提取物，甲醛能够与其结构上的氨基结合，基于此条件将其应用于甲醛清除剂方面，能够达到安全高效的去除甲醛效果。其次，茶多酚和壳聚糖在食品保鲜方面的应用较广泛，因此开发高效、安全、无污染、可食用的鱿鱼新型甲醛清除剂，同时又能够达到食品保鲜的效果，达到一举两得的效果，可对今后相关食品甲醛的清除以及保鲜提供理论参考。

针对市场上鱿鱼甲醛含量易超标，探究紫外分光光度法的条件下鱿鱼甲醛的检测的优化条件；研究单一因素条件下茶多酚结合壳聚糖对鱿鱼甲醛的去除效果，并且对条件进行效果优化，得到最优的复配型鱿鱼甲醛清除剂；在复配型甲醛清除剂的基础上，通过鲜度指标评定了茶多酚和壳聚糖对鱿鱼的保鲜效果，主要研究内容如下：

1. 为提高鱿鱼甲醛的检测效率，进行单因素实验，选取样品的前处理过程中样品浸泡时间、收集的蒸馏液体积、显色剂用量以及显色时间为指标，基于 Box-Behnken 设计原理，确定了四种条件下乙酰丙酮法定量检测鱿鱼甲醛含量的最佳条件：样品浸泡时间为 25.21 min、收集蒸馏液体积为 95.94 mL、显色剂用量为 1.47 mL、显色时间为 25.01 min。在最佳条件下得到的标准曲线，线性较好，回收率为 82%～98%，对精密度进行分析，相对标准偏差<5%，均符合方法学要求，适用于鱿鱼中甲醛的测定。

2. 基于茶多酚和壳聚糖能够与甲醛结合，将其应用于甲醛清除剂方面，能够达到安全高效的去除甲醛效果。通过建立模型探讨最佳复配比例以达到最优的甲醛去除率。通过模型分

析及验证实验得到甲醛去除的最佳条件是：茶多酚的浓度 0.6%，壳聚糖的浓度 2%，茶多酚和壳聚糖的体积比为 3:2，复配剂的 pH 为 3，鱿鱼在复配剂中浸没 60 min 后，鱿鱼甲醛的去除率可达到 85%以上。综合考虑，茶多酚和壳聚糖作为甲醛清除剂复配成分是一种有效去除鱿鱼甲醛的重要方式，不仅具有安全可食性，也可为后续相关实验的研究提供理论支持。

3. 依据上述复配型鱿鱼甲醛清除剂的复配结果，以茶多酚、壳聚糖以及其复合溶液作为保鲜剂，通过测定五种鲜度标准来探讨鱿鱼在冷藏期内的品质的变化。结果表明经过保鲜剂处理的鱿鱼体内甲醛的含量下降 72.4%。复配型保鲜剂的对鱼体的保藏时间为 7 天，同比对照组延长 1-2 天，并且复配后的保鲜效果比单一成分的茶多酚和壳聚糖的保鲜效果好。

关键词：鱿鱼；甲醛；清除剂；复配型；保鲜

New Formaldehyde Scavenger Development and Preservation of Squid

Hanbing Wang[1], Canghua Xu*

1 Shanghai Ocean University , Shanghai, 200120

Abstract :

The squid is loved by the public for its delicious taste and high nutritional value. But its own production and the external addition of formaldehyde has influenced the quality of squid, and more and more people to switch from their favorite attitude to wait and see attitude. There are many dry products in the market. It also enables illegal businesses to take advantage of it. Formaldehyde is added illegally in the manufacture process of dried products, so that the content of squid formaldehyde exceeds standard. During cold storage, the quality of squid is decreased with the extension of time. In addition, the decomposition of trimethylaminase in the body of squid during the process of corruption also increases the content of formaldehyde.

Tea polyphenols and chitosan are natural extracts. Formaldehyde can be combined with the amino group of their structure, and it can be applied to formaldehyde scavenging agent based on this condition, which can achieve safe and efficient removal of formaldehyde effect. Secondly, the application of tea polyphenols and chitosan in food preservation is widely, and the development of

efficient, safety, no pollution, edible squid new formaldehyde scavenger, at the same time can achieve the effect of food preservatives. Therefore, the development of efficient, safe, pollution-free, edible squid new formaldehyde scavenger can achieve the effect of food preservation. It can provide theoretical reference for the removal and preservation of related food formaldehyde.

The content of squid formaldehyde in the market is easy to exceed, The optimal conditions for detection of squid formaldehyde under ultraviolet spectrophotometry were studied. And the removal effect of tea polyphenol combined with chitosan on squid formaldehyde was studied. In addition, the condition was optimized to obtain the optimal recombinant squid formaldehyde scavenger. On the basis of compound formaldehyde scavenger, The preservation effect of tea polyphenols and chitosan on squid was evaluated by the index of freshness. The main research contents are as follows:

1. In order to improve the detection efficiency of squid formaldehyde, on the basis of single factor test, the sample soaking time, distilled liquid product, the amount of chromogenic agent and the color time of the sample were selected. The absorbance value of formaldehyde detection was the response value. Based on the design principle and response surface analysis of Box-Behnken, the prediction model of quadratic polynomial regression equation was established. The optimal conditions for the quantitative detection of squid formaldehyde in four conditions: the sample soaking time was 25 min, the distilled liquid was collected as 96 mL, the amount of chromogenic agent was 1.5ml, and the color display time was 25 min. Then, drawing the standard curve under optimized conditions, the regression equation was $y = 0.2323x + 0.0085$($R^2 = 0.9998$). Linear was good, the recovery rate was 82% ~ 98%, the precision is analyzed, the relative standard deviation was <5%, all conforms to the methodological requirements, and applies to the determination of formaldehyde in squid.

2. Based on the combination of tea polyphenol and chitosan can be applied to formaldehyde scavenging agent, and the effect of formaldehyde removal can be achieved safely and efficiently. he efficiency evaluation of formaldehyde removal from squid was conducted by establishing the response surface model. The optimum conditions for formaldehyde removal with more than 85% by model analysis and verification was: 0.6% of tea polyphenol in concentration, 2% of chitosan, 3:2 of the volume ratio of tea polyphenols and chitosan, 3 of the compound pH, 60 min of reaction time. In one word, tea polyphenols and chitosan as formaldehyde scavenger compound with

composition not only was an important way to effectively remove the squid formaldehyde, but also had the characteristics of safe and reliable, and also provided the test basis for the other aquatic products of formaldehyde removal.

3. On the basis of the complexation of the compound squid formaldehyde scavenger, tea polyphenols, chitosan and its composite solution were used as preservatives. The quality changes of soft fish in the squid were discussed through the measurement of the freshness index. The freshness date of the compound preservative was 7 days, 1 to 2 days longer than the blank group. In addition, the preservation effect of the compound group was better than that of single ingredient tea polyphenol and chitosan.

Key words: squid,;formaldehyde,;scavenger,;compound,;fresh

油炸温度和时间对面包虾理化特性和挥发性风味的影响

刘永兰[1]，肖乃勇[1]，刘书成[1*]

1.广东海洋大学 食品科技学院，广东省水产品加工与安全重点实验室，广东省海洋食品工程技术研发中心，广东省海洋生物制品工程重点实验室，水产品深加工广东普通高校重点实验室，广东 湛江 524088

摘要：【目的】本文旨在明确油炸温度与时间对面包虾理化特性和风味的影响，为工业化油炸工艺优化提供依据。【方法】以南美白对虾为原料，经裹面包糠制成面包虾，设置 150、170、190 ℃油炸温度及 20、30、40、50 s 油炸时间，考察其色泽、质构、水分分布、挥发性风味及感官品质。【结果】随油炸温度升高和时间延长，面包虾的 L 值和自由水含量逐渐降低，a 值、硬度和咀嚼性逐渐增加；从油炸样品中共鉴定出 64 种挥发性化合物，包括 18 种醛、24 种醇、12 种酮和 10 种酯类。随油炸温度和时间的增加，醛类、醇类和酯类挥发性化合物的含量逐渐增加；感官评估结果证实，经油炸温度 190℃，时间 30 s 处理的面包虾色泽、质地和可接受度评分最高。【结论】研究结果可为高品质预制面包虾油炸工艺优化提供数据支撑和理论参考。

关键词：面包虾；油炸；品质；挥发性风味。

通讯作者：刘书成（1979—），男，博士，教授，研究方向为海洋食品保鲜与加工。E-mail： Lsc771017@163.com

资助项目：广东省重点研发计划项目（2025B1111140001）

Effects of Frying Temperature and Time on the Physicochemical Properties and Volatile Flavor of Breaded Shrimp

Liu Yonglan[1], Xiao Naiyong[1], Liu Shucheng[1]*

[1]. School of Food Science and Technology, Guangdong Ocean University; Key Laboratory of Aquatic Product Processing and Safety of Guangdong Province; Guangdong Provincial Engineering Technology Research Center for Marine Food; Key Laboratory of Marine Bioproducts Engineering of Guangdong Province; Key Laboratory of Deep Processing of Aquatic

Products in Guangdong Universities, Zhanjiang, Guangdong 524088, China

Abstract:【Objective】To clarify the effects of frying temperature and time on the quality and flavor of breaded shrimp. 【Methods】Experiments were conducted at temperatures of 150, 170, and 190℃ with frying times ranging from 20 to 50 seconds to investigate color, texture, moisture distribution, flavor profile, and sensory attributes. 【Results】As temperature increased and frying time extended, the L* value decreased (dropping from 50.57 to 39.07 at 150℃, and reaching 31.99 at 190℃for 50 s), while the a* value rose to 13.45 and the b* value to 48.46. Hardness and chewiness increased (chewiness reached 322.02 at 190℃ for 50s compared to 120.72 at 150℃for 50s), whereas springiness decreased at 50s. Moisture migrated from the exterior to the interior, characterized by a sharp loss of free water and a slight increase in bound water; T_{22} showed a significant negative correlation with hardness and chewiness ($P<0.05$). GC-MS identified 64 volatile compounds, including 18 aldehydes, 24 alcohols, 12 ketones, and 10 esters. Key aldehydes and alcohols peaked at 170℃for 20s ((E,E)-2,4-decadienal at 278.37μg/kg and 1-octen-3-ol at 66.48μg/kg). At 190℃for 30 s, (E,E)-2,4-decadienal was retained (214.08μg/kg), accompanied by the formation of methylpyrazine (11.85weig/kg) and 2,3-dimethylpyrazine (8.38μg/kg), along with alcohols (24.92μg/kg), ketones (3.72μg/kg), and esters (138.86μg/kg), resulting in a more balanced flavor profile. 【Conclusion】The treatment at 190℃ for 30 s yielded the highest sensory acceptability, identifying it as the optimal processing condition.

Keywords: Breaded shrimp; Frying; Quality; Volatile flavor.

Corresponding Author: Shucheng Liu (1979 -), Doctor, Professor, Research Focus: Preservation and Processing of Marine Food Products E-mail： Lsc771017@163.com

Funding Project: Guangdong Key R&D Program Project (2025B1111140001)

鱼胶水发工艺优化及机理研究

陈奕欣 1、苏永昌 2*，刘智禹 2

1. 福建农林大学，福建 福州 350002；2. 福建省水产研究所，福建省海洋生物增养殖与高值化利用重点实验室，福建 厦门 361013

摘要：目的：优化预处理协同酸水发鱼胶的工艺，改善泡发品质、揭示水发机理。方法：以巴沙鱼鱼胶为原料，对比 4 种预处理方式筛选最适预处理工艺；比较 4 种泡发方法对鱼胶的泡发效果，筛选最佳泡发方法，进行工艺优化和泡发机理研究。结果：煮制为最适预处理方式，柠檬酸为最适泡发试剂，采用单因素和 Box-Behnken 响应面法优化获得最优工艺为煮制 5 min、1%柠檬酸 4℃浸泡 4 h；质构与泡发倍率结果显示，酸泡时间、煮制时间、酸浓度对综合评分影响显著且交互作用极显著；通过羟脯氨酸试剂盒检测，热加工和酸处理使胶原蛋白含量减少红外光谱检测结果显示，而热加工后的胶原三螺旋结构被破坏、氢键断裂，结构有序度降低；低场核磁与扫描电镜结果显示，水发过程中不易流动水含量升高、微观孔隙增多。结论：柠檬酸-煮制复合水发可有效改善花胶泡发效率，可为工业化泡发提供参考。

关键词：花胶；泡发；柠檬酸；响应面；水发机理

鱼胶原蛋白基皮克林乳液的构建及其在功能性沙拉酱中的应用

续旭

深圳大学生命与海洋科学学院，中国深圳，518060

摘要：鱼胶原蛋白（COL）营养价值突出，但界面活性不足，限制了其在皮克林乳液中的应用。本研究利用氧化硫酸软骨素（OCS）对 COL 进行界面改性，通过席夫碱反应构建鱼胶原蛋白-氧化硫酸软骨素（COL-OCS）复合纳米颗粒，并以其为稳定颗粒构建负载虾青素（AST）的功能性沙拉酱。研究表明，改性后 COL 水产腥味得到有效改善，COL-OCS 平均粒径为 273.43±12.95 nm，具备适宜的界面特性，可形成结构稳定的皮克林乳液。所构建的负载 AST 的功能性沙拉酱具有良好流变特性、抗氧化活性和 AST 稳定性，室温贮藏 7 d 及紫外照射 24 h 后 AST 保留率分别达 82.60%和 82.92%，且整体风味达市售产品要求。本研究为鱼胶原蛋白的高值化利用及水产来源功能性沙拉酱的开发提供了新思路。

关键词： 鱼胶原蛋白；氧化硫酸软骨素；虾青素；皮克林乳液；功能性沙拉酱。

Fabrication of a Fish Collagen-Based Pickering Emulsion for Functional Salad Dressing

Xu Xu

College of Life Sciences and Oceanography, Shenzhen University, Shenzhen, 518060, Guangdong.

Abstract: Fish collagen (COL) is of high nutritional value, but its limited interfacial activity restricts its application in Pickering emulsions. In this study, oxidized chondroitin sulfate (OCS) was employed to modify COL through a Schiff-base reaction, forming fish collagen-oxidized chondroitin sulfate (COL-OCS) composite nanoparticles, which were subsequently used as stabilizing particles to construct an astaxanthin (AST)-loaded functional salad dressing. The results showed that COL-OCS exhibited suitable interfacial properties and enabled the formation of structurally stable Pickering emulsions. OCS modification also reduced the fishy odor of COL. The resulting AST-loaded functional salad dressing exhibited favorable rheological properties,

antioxidant activity, and AST stability, with overall flavor characteristics comparable to those of commercial salad dressings. This study provides a new approach for the high-value utilization of fish collagen and the development of functional salad dressings from aquatic-derived resources.

Key words: Fish collagen; Oxidized chondroitin sulfate; Astaxanthin; Pickering emulsion; Functional salad dressing.

资助项目：国家自然科学基金面上项目（No. 32572556）。

*通讯作者：续旭，女，博士，教授，博士生导师。2000 年在中国海洋大学食品工程系药物化学专业获医学学士学位；2003 年在中国海洋大学药物研究所获医学硕士；2001-2002 年公派赴日本长崎大学水产学部留学；2003 年-2006 年获日本国费文部省奖学金，赴日本九州大学（日本七所帝国大学之一）生物资源环境科学府攻读博士学位；随后，赴瑞士伯尔尼大学药理研究所进行博士后研究。2008 年回国任教于深圳大学生命与海洋科学学院，2017 年被聘为教授。2019-2020 年作为访问学者公派至美国马萨诸塞大学安默斯特分校食品科学系交流。长期从事药食同源活性物质的筛选及分子营养学研究；海洋营养功效因子的稳态化保持与靶向递送及精准营养干预研究；海藻活性多糖/寡糖的发现及药用化创制等深度应用研究。主持国家自然科学面上基金、国家重点研发计划课题、国家重点研发计划任务、广东省自然科学基金、深圳市基础研究面上项目等。近年以第一作者或通讯作者在 *Carbohyd Polym*、*Food Hydrocolloid*、*Crit Rev Food Sci*、*Food Chem*、*J Agric Food Chem*、*FASEB J* 等国际学术刊物上发表研究论文 40 余篇，其中中科院二区以上论文 30 余篇。以第一发明人获国家发明专利授权 10 项，PCT 专利 20 余项。入选广东省千百十人才工程校级培养对象（第七批）、深圳市高层次人才、深圳市海外高层次（孔雀计划）人才。联系电话：13510670466，E-mail：xuxu@szu.edu.cn。

玉米纤维胶对带鱼肌原纤维蛋白功能特性及鱼丸品质的影响

吾成龙，孙小红*

浙江海洋大学 食品与药学学院，浙江舟山，邮编 316022

摘要：【目的】针对带鱼肌原纤维蛋白（MP）氧化聚集及功能劣变问题，探究玉米纤维胶（CFG）提取方式与添加量对MP结构、凝胶和乳化特性的影响，并验证其在鱼丸中的品质改良效果。【方法】以玉米麸皮为原料，采用碱法、酸法和酶法提取CFG，比较其组成、结构及功能特性。通过光谱、氧化指标、粒径、Zeta电位、质构、流变及微观结构分析，评价不同CFG对MP的影响，筛选适宜提取方法。进一步设置0%～10%的酶提CFG添加梯度，考察MP凝胶与乳化功能，并评价带鱼鱼丸的保水性、质构、凝胶强度、抗氧化活性及感官品质。【结果】（1）碱法提取率最高（20.90%）；酶提CFG的阿拉伯木聚糖含量为（77.40±2.27）%，阿拉伯糖/木糖比值为0.85±0.05，总酚含量和自由基清除活性较高，乳化稳定性较好。（2）酶提CFG对MP的综合改良效果较优，使羰基含量由（1.05±0.02）降至（0.67±0.01）nmol/mg蛋白，并改善分散性、凝胶持水性与乳化稳定性。光谱和微观结构结果提示，其作用可能与蛋白构象调节及非共价相互作用有关。（3）MP体系中，8%组凝胶持水率和硬度分别为（80.30±2.40）%和（247.65±8.40）g，较对照提高49.53%和349.13%；80 °C时储能模量为1231.79 Pa。该组凝胶网络较致密均匀，乳液贮藏20 d后的液滴聚集与宏观分层减轻。（4）鱼丸8%组的蒸煮损失率降至（6.56±0.19）%，较对照降低20.30%；持水率达（60.70±2.80）%，凝胶强度提高34.92%。该组感官评分最高，与6%组无显著差异。CFG提高了鱼丸DPPH和ABTS自由基清除活性，但10%组部分质构和保水指标下降，凝胶孔隙增多。【结论】酶提CFG可改善带鱼MP的氧化稳定性及凝胶、乳化功能，并提升鱼丸保水性与感官品质。本研究条件下，6%～8%添加量具有较好的综合改良效果。研究为CFG在水产蛋白食品中的应用提供了依据。

关键词：玉米纤维胶；带鱼；肌原纤维蛋白；凝胶特性；鱼丸品质

Effects of Corn Fiber Gum on the Functional Properties of Hairtail Myofibrillar Protein and Fish Ball Quality

Chenglong Wu, Xiaohong Sun*

School of Food and Pharmacy, Zhejiang Ocean University, Zhoushan 316022, Zhejiang, China

Abstract: [Objective] To address oxidative aggregation and functional deterioration of hairtail myofibrillar protein (MP), this study investigated the effects of the extraction method and addition level of corn fiber gum (CFG) on MP structure, gelation, and emulsifying properties and evaluated its ability to improve fish ball quality. [Methods] CFG was extracted from corn bran using alkaline,

acid, and enzymatic methods, and its compositional, structural, and functional characteristics were compared. Spectroscopic analyses and measurements of oxidation markers, particle size, zeta potential, texture, rheology, and microstructure were used to evaluate the effects of different CFG preparations on MP and select a suitable extraction method. Enzymatically extracted CFG was subsequently tested at addition levels ranging from 0% to 10% to assess its effects on MP gelation and emulsifying properties, as well as the water-holding capacity, texture, gel strength, antioxidant activity, and sensory quality of hairtail fish balls. [Results] (1) Alkaline extraction produced the highest yield (20.90%). Enzymatically extracted CFG had an arabinoxylan content of (77.40 ± 2.27) % and an arabinose-to-xylose ratio of 0.85 ± 0.05, together with relatively high total phenolic content and radical-scavenging activity and good emulsion stability. (2) Enzymatically extracted CFG provided greater overall improvements in MP functionality, reducing the carbonyl content from (1.05 ± 0.02) to (0.67 ± 0.01) nmol/mg protein and improving dispersibility, gel water-holding capacity, and emulsion stability. Spectroscopic and microstructural findings suggested that these effects might be associated with changes in protein conformation and noncovalent interactions. (3) In the MP system, the 8% CFG group exhibited a gel water-holding capacity of (80.30 ± 2.40) % and a hardness of (247.65 ± 8.40) g, representing increases of 49.53% and 349.13%, respectively, compared with the control. The storage modulus at 80 °C was 1231.79 Pa. This group exhibited a relatively dense and uniform gel network, while its emulsions showed reduced droplet aggregation and macroscopic phase separation after 20 days of storage. (4) In fish balls, 8% CFG addition reduced cooking loss to (6.56 ± 0.19)%, representing a 20.30% decrease compared with the control. Water-holding capacity reached (60.70 ± 2.80) %, and gel strength increased by 34.92%. This group achieved the highest sensory score, with no significant difference from the 6% group. CFG enhanced the DPPH and ABTS radical-scavenging activities of fish balls; however, at 10% addition, some textural and water-holding properties declined, and more pores were observed in the gel network. [Conclusion] Enzymatically extracted CFG improved the oxidative stability, gelation, and emulsifying properties of hairtail MP and enhanced the water-holding capacity and sensory quality of fish balls. Under the conditions of this study, addition levels of 6%–8% provided favorable overall quality improvements. These findings support the application of CFG in aquatic protein-based foods.

Key words: corn fiber gum; hairtail; myofibrillar protein; gel properties; fish ball quality

鱼子酱碳点的抑菌特性研究及其在鲟鱼子酱冷藏保鲜中的应用

王 伟，卢佳欣，徐新星，赵元晖*

中国海洋大学食品科学与工程学院，山东青岛，266003

摘要：本研究针对鲟鱼子酱保鲜难题，开发基于碳点的绿色保鲜剂。首先筛选鉴定鲟鱼子酱 4°C 冷藏优势腐败菌，以三种鱼子酱（鲟鱼、虹鳟鱼、大马哈鱼）为原料，水热法合成碳点，系统研究其理化性质、抗氧化活性、抑菌性能及生物安全性，并探究抑菌机理与冷藏保鲜应用。其优势腐败菌为 *Shewanella baltica* 和 *Brochothrix thermosphacta*；三种碳点分散性、荧光稳定性和抗氧化性良好，其中鲟鱼子酱碳点抑菌最强且生物安全；处理使货架期从 15 d 延至 20 d 以上，显著抑制菌落总数、TVB-N 和 TBARS 升高，维持质构色泽，减少腥味，稳定氨基酸和不饱和脂肪酸。抑菌机制为破坏细胞壁、增加膜通透性、诱导氧化应激。鱼子酱碳点可通过多重抑菌途径延长冷藏鲟鱼子酱货架期并保持品质，为水产品保鲜提供新型绿色技术支撑。

关键词：碳点；鲟鱼子酱；优势腐败菌；抑菌机理；保鲜应用

Study on the antibacterial properties of caviar carbon dots and their application in the refrigerated preservation of sturgeon caviar

Wang Wei, Lu Jiaxin, Xu xinxing, Zhao Yuanhui*

College of Food Science and Engineering, Ocean University of China, Qingdao, 266003, Shandong

Abstract: This study addressed the preservation challenge of refrigerated sturgeon caviar by developing carbon dots (CDs) as green preservatives. The dominant spoilage bacteria in sturgeon caviar stored at 4 °C were first identified. CDs were then hydrothermally synthesized from three types of caviar (sturgeon, rainbow trout, and chinook salmon), and their physicochemical properties, antioxidant and antibacterial activities, and biosafety were systematically characterized. The antibacterial mechanism and preservation efficacy on refrigerated sturgeon caviar were further investigated. *Shewanella baltica* and *Brochothrix thermosphacta* were identified as the dominant spoilage bacteria. All three CDs exhibited good dispersibility, fluorescence stability, and antioxidant activity, with sturgeon caviar-

derived CDs showing the strongest antibacterial effects and favorable biosafety. CD treatment extended the shelf life of sturgeon caviar from 15 to over 20 days, significantly suppressing increases in total viable counts, TVB-N, and TBARS, while preserving texture and color, reducing off-odor volatiles, and stabilizing free amino acids and unsaturated fatty acids. Mechanistically, the CDs disrupted cell wall integrity, increased membrane permeability, and induced oxidative stress. Collectively, caviar-derived CDs effectively prolong the shelf life and maintain the quality of refrigerated sturgeon caviar through multiple antibacterial pathways, providing a novel green technological strategy for aquatic product preservation.

Keywords: carbon dots; sturgeon caviar; dominant spoilage bacteria; antibacterial mechanism; preservation application

通讯作者介绍:赵元晖，男，博士，教授，博导，中国海洋大学食品科学与工程学院副院长，主要研究方向为水产资源的精深加工与综合应用开发，电话：0532-60895508，邮箱：zhaoyuanhui@ouc.edu.cn。

原花青素调控冷藏草鱼肌肉脂质氧化与代谢：基于脂质组学的解析

叶元娇[1]　鲁 浩[1]　王建辉[1]　李 慧[1*]

（[1]长沙理工大学食品与生物工程学院　长沙　410114）

摘要：草鱼宰后冷藏过程中，内源酶介导的脂质水解及富含多不饱和脂肪酸（PUFA）的膜脂氧化是导致其品质劣变的重要因素。本研究采用不同浓度原花青素（PAs）处理新鲜草鱼肌肉，并于 4 ℃下冷藏 7 d，考察 PAs 对脂质氧化及脂质代谢的调控作用。结果表明，PAs 可有效延缓冷藏草鱼品质劣变，其中 3.0 g/L 处理效果最优。冷藏 7 d 时，3.0 g/L PAs 处理组 TBARS、过氧化值（PV）和酸价（AV）较对照组分别降低 60.1%、31.0%和 42.9%，蛋白羰基积累亦受到抑制。同时，PAs 显著抑制脂肪酶和脂氧合酶（LOX）活性，并减缓了冷藏过程中 PUFA 组成的变化。脂质组学分析共筛选出 13 种关键差异脂质，主要涉及磷脂酰胆碱（PC）、磷脂酰乙醇胺（PE）、磷脂酰甘油（PG）及溶血磷脂等甘油磷脂分子种类的丰度变化，并显示亚油酸及长链 PUFA 相关脂质分子的组成发生改变。综上，PAs 可能通过降低脂质水解与氧化程度、调节甘油磷脂分子组成变化，并减缓 PUFA 相关脂质的氧化劣变，从而延缓冷藏草鱼肌肉的品质劣变。本研究为原花青素在淡水鱼冷藏保鲜中的应用提供了理论依据。

关键词：原花青素；草鱼；脂质氧化；脂质代谢；脂质组学

基金项目：国家自然科学基金青年项目（32302188）；湖南省自然科学基金青年项目（2025JJ60195）；国家重点研发计划子课题（2024YFD2401601）

通信作者：李慧，女，长沙理工大学副教授，博士。研究方向：水产品加工与贮藏保鲜，电话：15046687609，E-mail: huili@csust.edu.cn。

Proanthocyanidins Modulate Lipid Oxidation and Metabolism in Refrigerated Grass Carp Muscle: Insights from Lipidomics

Yuanyuan Ye[1], Hao Lu[1], Jianhui Wang[1], Hui Li[1]*

1.School of Food and Biological Engineering, Changsha University of Science and Technology, Changsha, 410114, Hunan

Abstract: Lipid hydrolysis mediated by endogenous enzymes and the oxidation of membrane lipids rich in polyunsaturated fatty acids (PUFAs) are important contributors to quality deterioration in grass carp during postmortem refrigerated storage. In this study, fresh grass carp muscle was treated with different concentrations of procyanidins (PAs) and stored at 4 °C for 7 days to investigate the regulatory effects of PAs on lipid oxidation and lipid metabolism. The results showed that PAs effectively delayed quality deterioration during refrigerated storage, with the 3.0 g/L treatment exhibiting the most pronounced protective effect. On day 7, the 3.0 g/L PA treatment reduced thiobarbituric acid reactive substances (TBARS), peroxide value (PV), and acid value (AV) by 60.1%, 31.0%, and 42.9%, respectively, compared with the control, while also suppressing protein carbonyl accumulation. In addition, PAs significantly inhibited lipase and lipoxygenase (LOX) activities and attenuated changes in PUFA composition during storage. Lipidomic analysis identified 13 key differential lipids, mainly involving changes in the abundances of glycerophospholipid species, including phosphatidylcholine (PC), phosphatidylethanolamine (PE), phosphatidylglycerol (PG), and lysophospholipids, together with alterations in the composition of linoleic acid- and long-chain PUFA-related lipid species. Collectively, PAs may delay quality deterioration in refrigerated grass carp muscle by reducing lipid hydrolysis and oxidation, modulating glycerophospholipid composition, and alleviating the oxidative deterioration of PUFA-related lipids. These findings provide a theoretical basis for the application of procyanidins in the refrigerated preservation of freshwater fish.

Key words: proanthocyanidins; grass carp; lipid oxidation; lipid metabolism; lipidomics

基金项目：国家自然科学基金青年项目（32302188）；湖南省自然科学基金青年项目（2025JJ60195）；国家重点研发计划子课题（2024YFD2401601）

通信作者：李慧，女，长沙理工大学副教授，博士。研究方向：水产品加工与贮藏保鲜，电话：15046687609，E-mail: huili@csust.edu.cn

栅栏因子结合含气调理低强度杀菌技术调控即食海带品质的研究

王致君[1,2,3]，陈温馨[1,2,3]，刘婧怡[123]，刘舒[1,2,3]，张晗[1,2,3]，马艺超[1,2,3]，任丹丹[1,2,3]，汪秋宽[1,2,3]，何云海[1,2,3*]

1.大连海洋大学 食品科学与工程学院，辽宁 大连 116023；2.国家海藻加工技术研发分中心，辽宁 大连 116023；3.辽宁省水产品加工及综合利用重点实验室，辽宁 大连 116023

摘要：即食海带在加工与贮藏过程中易发生质地软烂、色泽衰退，导致货架期受限；传统高温杀菌技术难以平衡微生物控制与产品品质。本研究针对该瓶颈，构建了由酸度调控、水分活度调节、气调包装结合低热处理组成的联合低强度加工体系。采用全因素实验结合主成分分析，以 pH、水分活度、色泽、质构、菌落总数及感官评分等为综合评价指标，对栅栏因子组合进行筛选与优化，并结合气相色谱-离子迁移谱（GC-IMS）、气相色谱-质谱（GC-MS）及相对气味活度值（ROAV）分析对产品挥发性风味特征进行表征。结果表明，1% NaCl、1%白醋与 N_2 包装组合综合品质较优。进一步优化含气调理低强度杀菌工艺，90 ℃ 25 min 一段式杀菌及 90 ℃ 9 min+95 ℃ 11 min 二段式杀菌工艺均能有效降低微生物并减缓色泽和质构劣变。加速贮藏试验 Q10 模型估算 20 ℃下贮藏期约 360 d，产品品质稳定性提高。优化加工的产品其挥发性风味物质相对空白海带及某市售产品种类更加丰富。研究结果可为高品质即食海带加工与保藏提供理论与技术参考。

关键词： 即食海带；栅栏技术；气调包装；低强度杀菌；风味物质

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）

通讯作者：何云海，男，教授，藻类加工及资源利用，13840847973，hyh@dlou.edu.cn

Study on the Regulation of Ready-to-Eat Kelp Quality by Hurdle Factors Combined with Modified-Atmosphere-Assisted Mild Thermal Processing

Zhijun Wang[123], Wenxin Chen[123], Jingyi Liu[123], Shu Liu[123], Han Zhang[123], Yichao Ma[123], Dandan

Ren[123], Qiukuan Wang[123], Yunhai He[123*]

1. College of Food Science and Engineering，;2. National R＆D Branch Center For Seaweed Processing;3. Key Laboratory of Aquatic Product Processing and Utilization of Liaoning Province, Dalian Ocean University , Dalian 116023, China

Abstract: Ready-to-eat kelp is prone to texture softening and color deterioration during processing and storage, resulting in a limited shelf life. Conventional high-temperature sterilization is often unable to achieve an optimal balance between microbial control and product quality. To address these limitations, a combined mild processing system integrating acidity regulation, water activity adjustment, modified atmosphere packaging, and mild thermal treatment was developed in this study. A full-factorial experimental design combined with principal component analysis was used to screen and optimize hurdle-factor combinations using pH, water activity, color, texture, total viable count, and sensory scores as comprehensive evaluation indices. In addition, volatile flavor characteristics were investigated using gas chromatography-ion mobility spectrometry (GC-IMS), gas chromatography-mass spectrometry (GC-MS), and relative odor activity value (ROAV) analysis. The results showed that the combination of 1% NaCl, 1% white vinegar, and N_2 packaging provided superior overall quality. Further optimization of the modified-atmosphere-assisted mild thermal treatment demonstrated that both a single-stage treatment at 90 °C for 25 min and a two-stage treatment at 90 °C for 9 min followed by 95 °C for 11 min effectively reduced microbial loads while mitigating deterioration in color and texture. Based on accelerated storage tests and the Q_{10} model, the estimated shelf life at 20 °C was approximately 360 days, indicating improved product stability. Moreover, the optimized product exhibited a greater diversity of volatile flavor compounds than untreated kelp and a selected commercial product. These findings provide theoretical and technical support for the processing and preservation of high-quality ready-to-eat kelp.

Keywords: ready-to-eat kelp; hurdle technology; modified atmosphere packaging; mild thermal processing; volatile flavor compounds

整合多传感器追踪与代谢组学揭示豹纹鳃棘鲈（*Plectropomus leopardus*）在运输过程中的环境应激及代谢机制

张鑫 [1]，李川 [1,*]

海南大学食品科学与工程学院，海南海口，邮编 570228

摘要：【目的】探讨运输时间和温度对豹纹鳃棘鲈（*Plectropomus leopardus*）运输水质、氧化应激及血清代谢的影响，为高价值活体海鲜运输应激表征与宰前处理优化提供依据。【方法】设置不同运输温度和时间，连续监测运输水体环境变化，测定血清氧化应激及酶活性指标，并结合水质—血清响应建模和代谢组学分析评价运输应激及代谢变化。【结果】运输过程中水体逐渐酸化是主要环境变化，运输时间延长导致丙二醛（MDA）升高并引起血清酶活性变化，而 16 ℃低温可缓解氧化应激和肝脏损伤。运输末期 30 min 的 pH 值和溶解氧低值（第 10 百分位数）被筛选为互补环境指标（R^2=0.749），MDA、谷胱甘肽过氧化物酶（GSH-Px）和丙氨酸氨基转移酶（ALT）被筛选为代表性血清指标（R^2=0.817）。代谢组学结果表明，低温运输可减轻代谢紊乱，而长时间运输主要改变肌酸、组胺和棕榈酸水平，涉及精氨酸和脯氨酸代谢及甘油磷脂代谢通路。【结论】运输时间和温度共同影响豹纹鳃棘鲈的水质环境、生理应激及代谢稳态，低温运输有助于减轻运输胁迫，筛选出的环境和血清指标可为高价值活体海鲜运输应激评价及宰前处理优化提供理论依据。

关键词：豹纹鳃棘鲈；运输；氧化应激；留一温度验证；代谢组学；

Integrated multi-sensor tracking and metabolomics uncover transport environmental stress and metabolic mechanisms in leopard coral grouper (Plectropomus leopardus)

Xin Zhang [1], Chuan Li [1,*]

1. Key Laboratory of Seafood Processing of Haikou, Hainan International Joint Research Center for Innovative Utilization of Tropical Seafood Resources, School of Food Science and Engineering, Hainan University, Haikou 570228, China

Abstract: [Objective] To investigate the effects of transport time and temperature on water-quality dynamics, oxidative stress, and serum metabolism in leopard coral grouper (*Plectropomus leopardus*), and to identify potential indicators for characterizing transport stress in high-value live seafood. [Methods] Leopard coral grouper were

subjected to different transport temperatures and durations. Water-quality parameters were continuously monitored, serum oxidative stress and enzyme activities were measured, and water-quality data were integrated with serum responses for indicator screening. Metabolomic analysis was further performed to characterize transport-induced metabolic alterations. [Results] Progressive acidification was a major environmental change during transport. Prolonged transport increased MDA levels and altered serum enzyme activities, whereas transport at 16 °C alleviated oxidative stress and hepatic injury. Integration of continuous water-quality measurements with serum responses identified final-30-min pH and low-level dissolved oxygen (10th percentile) as complementary environmental indicators ($R^2 = 0.749$), while MDA, GSH-Px, and ALT were selected as representative serum indicators ($R^2 = 0.817$). Metabolomic analysis showed that low-temperature transport attenuated metabolic disturbances, whereas prolonged transport altered creatine, histamine, and palmitic acid levels, mainly involving arginine and proline metabolism and glycerophospholipid metabolism. [Conclusion] Transport time and temperature jointly affected water quality, physiological stress, and metabolic homeostasis in leopard coral grouper. Low-temperature transport mitigated transport-induced disturbances, and the identified environmental and serum indicators may provide a basis for characterizing transport stress and optimizing pre-slaughter handling of high-value live seafood.

Keywords: Leopard coral grouper, transportation, oxidative stress, nested leave-one-temperature-out (LOTO) validation, Metabolomic

资助项目：海南省科技专项基金项目（GHYF2024022、GHYF2024011）和海南大学一流学科突破计划项目（XKTP2025B02）资助

通讯作者：李川，男，博士、教授；研究领域为热带海洋食品科学与营养工程，食品绿色加工与品质控制，食品智能制造；E-mail: lichuan@hainanu.edu.cn

植物提取物协同等离子体及无氧气调包装对虹鳟冷藏保鲜和品质的调控

王兴娜，江宁*

江苏省农业科学院农产品加工研究所，江苏　南京　210014

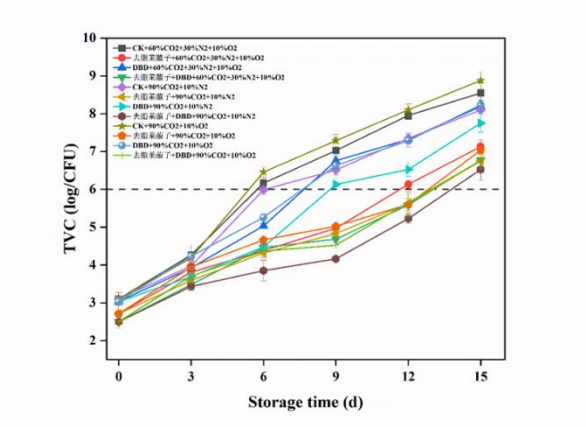
摘要：本研究旨在探究去脂莱菔子提取物（DRS）、介质阻挡放电（DBD）等离子体与不同气调包装（MAP）的协同作用，以开发一种可显著延长冷藏虹鳟货架期的复合保鲜方案。虹鳟经 DBD、DRS 及其联合（DRS+DBD）预处理后，分别采用 3 种气调包装，并于 4°C 冷藏。每 3 天系统监测样品菌落总数（TVC）、挥发性盐基氮（TVB-N）、pH 值、汁液流失率、硫代巴比妥酸反应物（TBARS）、质构、色泽（L*，a*，b*）及风味（电子舌、电子鼻）等指标的变化。结果表明， DRS+DBD+无氧气调（90%CO_2+10%N_2）处理组表现出最全面的保鲜效果。该组合能最有效地抑制微生物生长，延缓 TVB-N 和 TBARS 上升，维持较低汁液流失率、较高硬度和弹性，并最好地保持了鱼肉鲜红色泽与纯正的滋味气味。该绿色保鲜技术通过物理杀菌、生物抑菌及无氧环境调控，可增长保质期，抑制品质劣变。

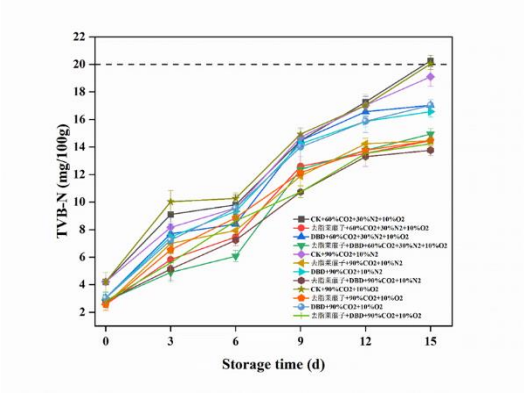
关键词：植物提取物；冷等离子体；贮藏保鲜；品质调控

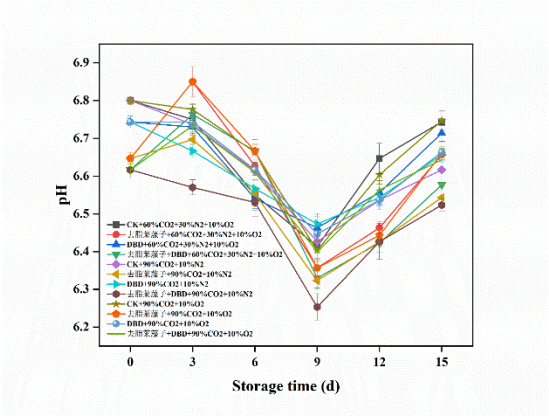
作者简介：王兴娜（1978-），女，博士，副研究员，研究方向：食品加工与保鲜，电话：18905181754，E-mail:xingnawang.nn@163.com

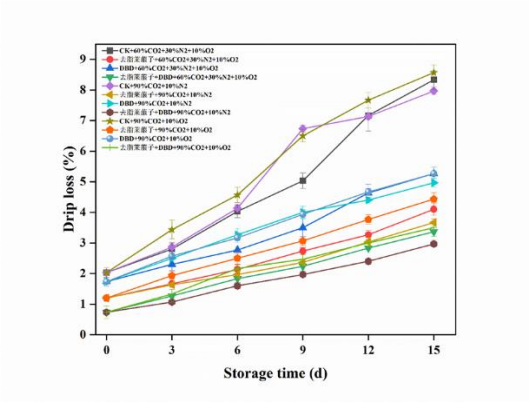
*通信作者：江宁（1983-），男，博士，研究员，研究方向：水产品加工与保鲜，E-mail：jaas_jiangning@163.com

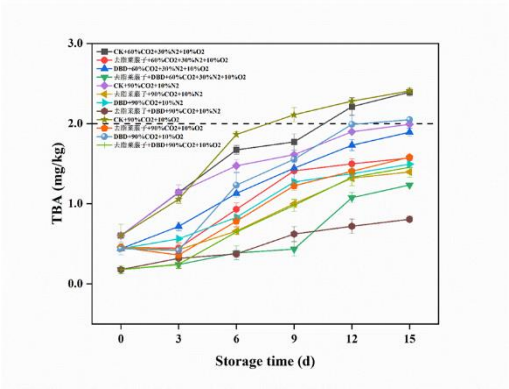
基金项目：国家重点研发项目（2024YFD2100501，2024YFD2100502）

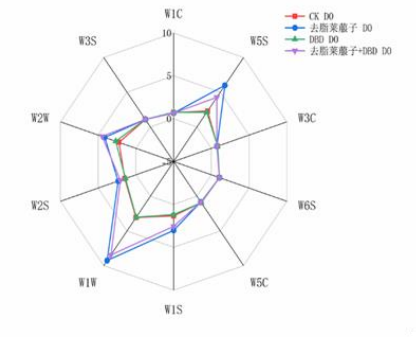


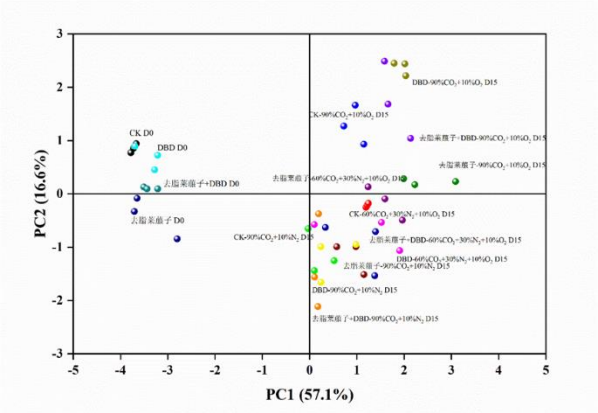


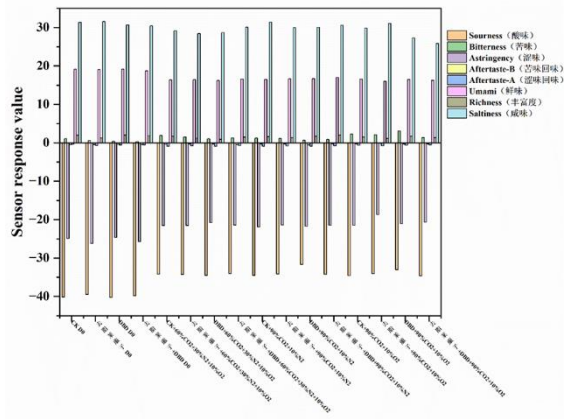

pH
Storage time (d)

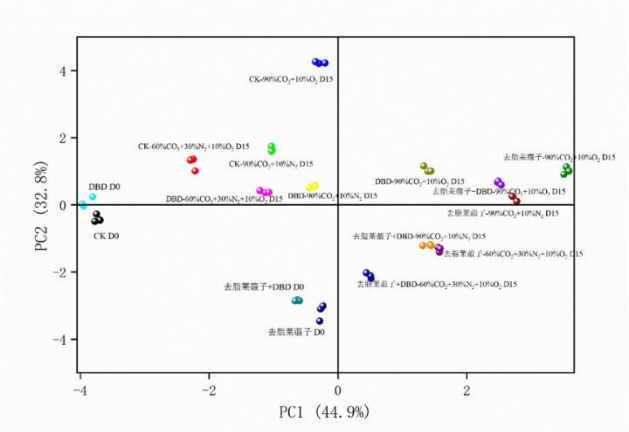

Drip loss (%)
Storage time (d)

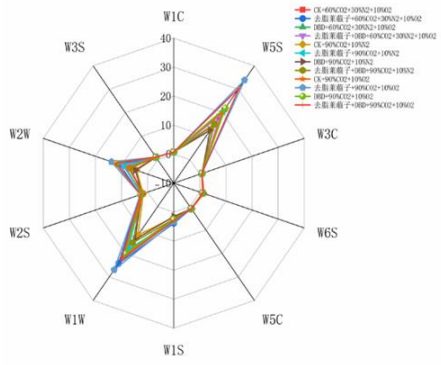

TBA (mg/kg)
Storage time (d)


CK D0
去脂茉莉子 D0
DBD D0
去脂茉莉子+DBD D0
W1C
W2C
W3C
W5S
W6S
W1W
W1S
W2S
W3S
W5C


PC2 (16.6%)
PC1 (57.1%)
CK D0
DBD D0
去脂茉莉子+DBD D0
去脂茉莉子 D0


Sensor response value
Sourness（酸味）
Bitterness（苦味）
Astringency（涩味）
Aftertaste-B（苦味回味）
Aftertaste-A（涩味回味）
Umami（鲜味）
Richness（丰富度）
Saltiness（咸味）


PC2（32.8%）
PC1（44.9%）
DBD D0
CK D0
去脂茉莉子+DBD D0
去脂茉莉子 D0


W1C
W2C
W3C
W5S
W6S
W1W
W1S
W2S
W3S
W5C

贮藏鲟鱼子酱关键膜磷脂结构重塑的多尺度表征

张唯嘉[1]，汪金林[2]，赵元晖[1]，徐新星[1*]

[1] 中国海洋大学食品科学与工程学院　山东青岛　266003

[2] 衢州鲟龙水产食品科技开发有限公司，浙江　衢州 324002

摘要：本研究首次通过多尺度表征系统解析了鲟鱼子酱膜及其膜磷脂在贮藏过程中的结构演变，并利用计算化学与多变量统计筛选出与膜重塑相关的关键磷脂酰胆碱分子。膜结构表征显示，新鲜样品具有致密稳定的膜表面（Rq=12.2nm）。在两周内因水合软化与磷脂重排，膜厚度和质量分别降至 1.53nm 和 157.34 ngcm⁻²；三至四周后膜发生氧化聚集与碎片化。石英晶体微天平(QCM-D)分析表明，膜磷脂层厚度与质量在前两周从 2.804nm 和 289.38ng cm^{-2} 降至 1.526nm 和 157.34ng cm^{-2}，随后因氧化聚集部分恢复。荧光各向异性与拉曼光谱显示，酰基链先短暂有序化后发生氧化重排，一周后 1650cm^{-1}（C=C）及 1300/1440cm^{-1}（CH_2）等带宽显著减弱（$p < 0.05$），证实了氧化诱导的膜磷脂结构重塑。基于分子描述符和 ECFP4 指纹分析，确定了膜磷脂的关键结构特征（EState、PEOE、SlogP 及甘油骨架、酯键等片段）。基于膜理化指标的偏最小二乘判别分析（PLS-DA）模型成功区分 5 个贮藏组（Q2 截距-1.098），普氏分析表明 PC 分子谱与膜理化指标高度协同（M^2=0.66, P=0.01）。通过 VIP > 1 筛选 18 个指标构建膜综合指数（MSEI），经 Spearson 相关性（|rho| > 0.7）锁定 4 个核心 PC 分子，最终多元线性回归确立 PC(18:0/22:6)和 PC(16:0/20:4)为最关键分子（R^2=0.766），其含量变化是驱动 MSEI 改变的直接因素。这些发现为鲟鱼子酱贮藏过程中品质演化提供了新的机制见解，并为通过调控膜磷脂改善其贮藏品质奠定了理论基础。

关键词：鲟鱼子酱；膜结构；磷脂；贮藏品质；相关性分析

Multiscale characterization of key membrane phospholipid structure remodeling in stored sturgeon caviar

Weijia Zhang[1], Jinlin Wang[2], Yuanhui Zhao[1], Xinxing Xu[1*]

[1] College of Food Science and Engineering, Ocean University of China, Qingdao, Shandong, 266003.

[2]Quzhou Sturgeon Aquatic Food Science and Technology Development Co.，Ltd.，Quzhou 324002，China)

Abstract: Herein, we systematically elucidated the structural evolution of sturgeon caviar membrane phospholipids (PLs) during storage through multiscale characterization and identified key phosphatidylcholine (PC) molecules governing membrane remodeling via computational chemistry and multivariate statistics. Fresh samples exhibited a dense and stable membrane surface (Rq = 12.2 nm). Within two weeks, membrane thickness and mass declined to 1.53 nm and 157.34 ng cm^{-2}, respectively, attributable to hydration-induced softening and phospholipid rearrangement; after three to four weeks, oxidative aggregation and fragmentation occurred. QCM-D analysis revealed that phospholipid layer thickness and mass decreased from 2.804 nm and 289.38 ng cm^{-2} to 1.526 nm and 157.34 ng cm^{-2} within two weeks, followed by partial recovery due to oxidative aggregation. Fluorescence anisotropy and Raman spectroscopy demonstrated transient acyl chain ordering followed by oxidative rearrangement, with significant reductions in band widths at 1650 cm^{-1} (C=C) and 1300/1440 cm^{-1} (CH_2) after one week ($p < 0.05$). Computational chemistry based on molecular descriptors and ECFP4 fingerprints identified key structural features, including EState, PEOE, SlogP, and bit fragments within the glycerol backbone, ester bonds, and unsaturated acyl chains. The PLS-DA model successfully discriminated the five storage groups (Q2 intercept = -1.098), and Procrustes analysis revealed strong synergy between PC profiles and membrane physicochemical indices ($M^2 = 0.66$, P = 0.01). Eighteen indices were screened via VIP > 1 to construct the membrane synthesis index (MSEI). Pearson correlation (|rho| > 0.7) identified four core PC molecules, and multiple linear regression established PC(18:0/22:6) and PC(16:0/20:4) as the most critical molecules ($R^2 = 0.766$), whose content changes directly drive MSEI alterations. These findings offered novel mechanistic insights into quality evolution of sturgeon caviar during storage and provided a theoretical basis for quality improvement via membrane PLs modulation.

Key words: Sturgeon caviar; Membrane structure; Phospholipids; Storage quality; Correlation analysis

通讯作者：徐新星，女，副教授，18801290977，xxx@ouc.edu.cn，主要从事食品感官科学研究。主持国家及省市级项目 8 项。以第一作者或通讯作者在 *Trends in Food Science & Technology*、*Food Chemistry* 等国际 TOP 期刊上发表 SCI 论文 34 篇，授权国家发明专利 9 项，副主编《走进鲟鱼》，参编《食品风味化学与分析》第二版。

资助项目：国家自然科学基金项目（32102040，32673132）