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COF 基材料在电化学检测抗生素中的应用与机理研究

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摘要: 民以食为天, 食以安为先。随着经济快速发展和人民生活水平的提高, 人们越来越注重食品质量与安全。近年来, 食品安全问题频发, 农兽药等化学危害物残留会通过食物链传递进入人体, 对人体的肝脏、肾脏等器官造成不可逆的损伤。为保障食品安全和人体健康, 建立能够快速、灵敏检测兽药残留等危害物的快速检测技术是非常有必要的。本文以共价有机框架材料 (COF) 为基底, 设计一系列新型纳米材料, 与分子印迹技术结合, 构建电化学传感器, 实现对食品中的抗生素的快速、灵敏检测。对建立的新方法的检测性能、稳定性、重复性和重现性等进行评估。添加回收实验和实际样检测结果说明建立的新方法具有较好的准确性和应用性。材料的设计合成与传感器的构建策略为其他危害物的快速检测提供了新的思路。

关键词: 食品安全; 抗生素; 电化学传感器; 共价有机框架材料

The Application and Mechanism Study of COF-based Nanomaterials in Electrochemical Detection of Antibiotics

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Abstract: Food is the essential to people, and safety comes first in food. With the rapid economic development and the improvement of people's living standards, people pay more and more attention to food quality and safety. In recent years, food safety problems have occurred frequently, and the residues of chemical hazards such as agricultural and veterinary drugs will be transmitted into the human body through the food chain, causing irreversible damage to human organs including liver and kidney. In order to ensure food safety and human health, it is necessary to establish a rapid detection technology that can quickly and sensitively detect harmful substances. In this paper, a series of novel nanomaterials based on covalent organic framework materials (COF) were designed and combined with molecular imprinting technology to construct electrochemical sensors to realize rapid and sensitive detection of antibiotics in food. The detection performance, stability, repeatability and reproducibility of the new method were evaluated. The results of recovery experiment and actual sample test show that the new method has good accuracy and application. The design and synthesis of materials and the construction strategy of sensors provide a new idea for the rapid detection of other hazards.

Key words : Food Safety; Antibiotic; Electrochemical Sensor; Covalent organic framework.

CRISPR/Cas12a 检测鼠伤寒沙门菌方法的建立与应用

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摘要: 沙门菌是一种常见的食源性致病菌, 具有高发病率和致死率。鼠伤寒沙门菌是沙门菌属中最常见的病菌之一, 感染后的发病率居沙门菌属首位。CRISPR/Cas12a 是一种新型核酸检测技术, 可快速检测任何已知的核酸序列, 与现有分子诊断技术相比, CRISPR/Cas12a 检测具有灵敏、特异、快速和低成本等优势, 但通常需要对样品中的靶标进行扩增, 使得检测周期变长、成本增高。研究表明, 当金属粒子与荧光基团之间的距离大于一定距离时, 金属粒子会提高荧光基团的荧光强度。本研究采用在金纳米颗粒表面包覆二氧化硅层的方法控制其与荧光基团的距离, 同时在检测过程中使用多 crRNA 方法辅助, 极大地提高了荧光基团的强度, 使得检测方法在无需扩增的情况下具有较高灵敏度, 且降低了检测成本, 与其他常见食源性致病菌检测无交叉反应。建立的方法在检测人工污染的食品样品时具有较高的灵敏度和准确性, 在食品安全领域具有广阔的应用前景。

关键词: CRISPR/Cas12a; 鼠伤寒沙门菌; 金属增强荧光; 多 crRNA 检测

Establishment and application of CRISPR/Cas12a method for detection of *Salmonella typhimurium*

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Abstract: *Salmonella* is a common foodborne pathogen with high morbidity and mortality. *Salmonella typhimurium* is one of the most common bacteria in the *Salmonella* genus, whose incidence rate after infection ranks first in the *Salmonella* genus. CRISPR/Cas12a is a new nucleic acid detection technology that can quickly detect any known nucleic acid sequence. Compared with the existing molecular diagnostic technologies, CRISPR/Cas12a detection has the advantages of sensitivity, specificity, rapidness and low cost. However, CRISPR/Cas12a usually requires the preamplification of the target, which makes the detection time longer and the cost increase. It is reported that when the distance between the metal particles and the fluorophores is greater than a certain distance, the metal particles will increase the fluorescence intensity. In this study, the distance between gold nanoparticles and fluorophores was controlled by coating silica layer. At the same time, multi-crRNAs were used in the detection process, which greatly improved the strength of fluorophores, improving the sensitivity of detection method without amplification, and reducing the detection cost. Moreover, there was no cross reaction with other common foodborne pathogens. The established method has high sensitivity and accuracy in detecting artificially contaminated food samples, and has broad application prospects in the field of food safety.

Key words: CRISPR/Cas12a; *Salmonella typhimurium*; metal enhanced fluorescence; multiple crRNA detection

DHA 和 EPA 通过调节铁-线粒体自噬预防慢性睡眠剥夺诱导的认知障碍

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摘要: 睡眠不足导致的认知障碍已成为当代社会关注的重大公共卫生问题, 由于缺乏对其分子机制的阐明, 目前尚无有效的治疗方法。本研究旨在探讨二十二碳六烯酸(DHA)和二十碳五烯酸(EPA)对慢性睡眠剥夺(CSD)模型小鼠认知障碍的预防作用, 并阐明其作用机制。结果表明, CSD 小鼠在 Morris 水迷宫测试中表现出明显的认知功能障碍, 并伴有明显的神经元损伤。同时, 我们观察到 CSD 小鼠皮层内铁代谢相关蛋白(IRP1, TfR1, DMT1 和 FPN1)的表达失调, 铁沉积增加, 神经元脂质过氧化水平升高。进一步的分析结果显示, 线粒体呼吸链复合物 (I-V) 的蛋白质表达水平下降, FXN 介导的线粒体自噬水平上调。此外, Sirt3-Nrf2 通路及其下游抗氧化分子(如 GPX4、HO-1、SOD2 和 NQO1)受到抑制。然而, 膳食预防性补充 DHA 或 EPA 可通过激活 Sirt3-Nrf2 信号通路调节铁-线粒体自噬稳态抑制神经元铁死亡, 从而减轻 CSD 诱导的认知障碍。值得注意的是, 相较于 DHA, EPA 在预防 CSD 认知障碍方面展现出了一定的优越性, 这一优势或许可归因于 EPA 与 Sirt3 之间更强的结合力。
关键词: DHA, EPA, 睡眠剥夺, 认知障碍, 铁稳态, 线粒体自噬, Sirt3

DHA and EPA protect against cognitive impairment induced by chronic sleep deprivation through regulating iron-mitophagy homeostasis

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Abstract: The cognitive impairments resulting from insufficient sleep have emerged as a significant public health concern in contemporary society, lacking effective treatments due to the absence of elucidation regarding its molecular mechanism. This study aimed to investigate the efficacy of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) against cognitive deficits in a mouse model of chronic sleep deprivation (CSD), and to elucidate the underlying mechanisms. CSD mice display significant cognitive deficits in the Morris water maze task with obviously neuronal damage. We observed that dysregulation of iron transport proteins (IRP1, TfR1, DMT1, and FPN1) in CSD mice resulted in iron deposition in the cortex. Subsequent assessment revealed upregulation of mitophagy and neuronal lipid peroxidation and downregulation of proteins in the mitochondrial respiratory chain complexes (I-V). Further molecular analysis revealed inhibition of the Sirt3-Nrf2 pathway and its downstream antioxidant molecules (e.g. GPX4, HO-1, SOD2, and NQO1). In contrast, dietary supplementation with DHA or

EPA alleviated CSD-induced cognitive impairment by inhibiting neuronal ferroptosis through regulating iron-mitophagy homeostasis. Notably, EPA showed superior efficiency in ameliorating cognitive impairment, potentially due to its stronger interaction with Sirt3 compared to DHA.

Keywords: DHA, EPA, sleep deprivation, cognitive deficiency, ironhomeostasis, mitophagy, Sirt3

MOF 载体金属离子对固定化壳聚糖酶的活化作用

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摘要: 酶的固定化是提高其稳定性和重复利用率的关键技术, 然而传统固定化方法常因改变酶的微环境和构象而导致活性降低。基于团队前期发现的特定金属离子可显著增强海洋多糖降解酶活性的特性, 本研究提出了利用 MOF 表面开放金属位点与酶相互作用增强酶活的酶固定化新策略。以壳聚糖酶 OUC-CsnCA 为模式酶, 通过铜基 MOF (Cu-BTC) 表面开放 Cu²⁺ 位点与壳聚糖酶的相互作用, 将 CsnCA@Cu-BTC 的催化活性提高到游离酶的 200% (413.46 U/mg)。同时, 酶催化转化数 (k_{cat}) 提升近 2 倍 (从 361.75 min⁻¹ 增加至 704.41 min⁻¹), 稳定性、贮藏稳定性等酶学性能也明显增强。通过分子对接模拟及金属离子结合位点预测等手段初步解析 MOF 表面开放 Cu²⁺ 对 CsnCA 活性增强的原因: (1) Cu²⁺ 结合改变酶的催化口袋大小, 影响底物与酶关键残基的结合, 进而调控反应速率。(2) 结合在关键催化残基 D102 周围的 Cu²⁺ 可以充当 Lewis 酸促进底物糖苷键的断裂。该策略对于海洋多糖降解酶具有普适性, 固定化卡拉胶酶 (OUC-CgiA-Lf) 和琼胶酶 (A33) 均表现出酶活性的提升。本研究为开发高效、稳定的固定化海洋多糖降解酶提供了新思路, 有望在生物催化等领域得到广泛应用。

关键词: 金属有机框架 (MOF); 酶固定化; 海洋多糖降解酶; 催化作用

The activation effect of metal ions of MOF carriers on immobilized chitosanase

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Abstract: Immobilization is a crucial strategy for enhancing the stability and reusability of enzymes. However, conventional immobilization methods often compromise enzyme activity due to alterations in the microenvironment

and conformation of enzyme. Recognizing the potential of specific metal ions to enhance the activity of marine polysaccharide degrading enzymes, this study presents a novel immobilization strategy leveraging the interaction between enzymes and the open metal sites on MOF's surface to boost enzymatic activity. Using chitosanase OUC-CsnCA as a model enzyme, immobilization on a copper-based MOF (Cu-BTC) resulted in a 2-fold increase in catalytic activity (413.46 U/mg). The immobilized enzyme (CsnCA@Cu-BTC) also exhibited a nearly two-fold increase in turnover number (k_{cat}), from 361.75 min⁻¹ to 704.41 min⁻¹, along with enhanced stability and other enzymatic properties. Molecular docking simulations and Cu²⁺-binding sites prediction revealed a dual mechanism for Cu²⁺-mediated activation: (1) Cu²⁺-binding modulates the catalytic pocket, influencing substrate binding and reaction rates; (2) Cu²⁺ acting as a Lewis acid by binding near the crucial catalytic residue D102, facilitating the cleavage of glycosidic bonds in the substrate. This strategy demonstrated broad applicability to other marine polysaccharide-degrading enzymes, with immobilized κ -carrageenase (OUC-CgiA-Lf) and agarase (A33) exhibiting enhanced activities. This study provides a novel avenue for developing efficient and stable immobilized marine polysaccharide degrading enzymes with potential applications in biocatalysis and related fields.

Key words: Metal-organic frameworks (MOFs); Enzyme immobilization; Marine polysaccharide degrading enzymes; Catalysis

SIMYC2 在 MeJA 介导自噬调控采后番茄果实抗病中的作用及机制

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摘要: 由葡萄孢菌 (*Botrytis cinerea*) 侵染引起的灰霉病是果实采后最主要的真菌性病害之一。同时, 茉莉酸甲酯 (Methyl jasmoate, MeJA) 作为一种植物内源性激素, 广泛参与采后果实抗病性调控, 并诱导植物的自噬活性。但目前关于 MeJA 对采后果实自噬活性的诱导效应及机制尚不明确, 对自噬在 MeJA 介导采后果实抗病中的作用也不清楚。本研究表明, MeJA 激活自噬活性, 参与采后番茄果实病害抗性。转录因子 SIMYC2 靶向结合并激活自噬相关基因 *SIATGs* 表达, 参与 MeJA 介导的自噬活性调控。且, 甲硫氨酸亚砷还原酶 SIMsrB5 可以作为激活子, 通过与 SIMYC2 互作, 调节 SIMYC2 的氧化还原状态、DNA 结合能力和转录活性, 参与 MeJA 介导的采后番茄果实自噬活性调控。综上, 本研究通过 SIMsrB5-SIMYC2-*SIATGs* 调控模块, 深入解析了 MeJA 调控自噬活性、诱导采后果实病害抗性的分子机制, 为采后果实病害抗性机制的揭示提供了新的研究思路。

关键词: 采后番茄果实; 茉莉酸甲酯; 自噬; SIMYC2

The Role and Mechanism of SIMYC2 in MeJA-induced Autophagy Regulates Disease Resistance in Postharvest Tomato Fruit

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Abstract: Gray mold caused by *Botrytis cinerea* is one of the most important fungal diseases in postharvest fruits. Methyl jasmonate (MeJA), as an endogenous hormone in plants, is widely involved in the regulation of postharvest fruit disease resistance and can induce autophagic activity in plants. However, the induction effect and mechanism of MeJA on postharvest fruit autophagic activity are currently unclear, and the role of autophagy in MeJA mediated postharvest fruit disease resistance is also unclear. This study suggested that MeJA activates autophagic activity and is involved in postharvest tomato fruit disease resistance. The transcription factor SIMYC2 could target and activate the expression of autophagy related genes *SLATGs*, participating in MeJA mediated regulation of autophagic activity. Moreover, methionine sulfoxide reductase SIMsrB5 can act as an activator to regulate the redox state, DNA binding ability, and transcriptional activity of SIMYC2 through interaction with SIMYC2, participating in MeJA mediated regulation of postharvest tomato fruit autophagic activity. In summary, this study deeply analyzed the molecular mechanism of MeJA regulating autophagic activity and inducing postharvest fruit disease resistance through the SIMsrB5-SIMYC2-*SLATGs* regulatory module, providing new research ideas for revealing the mechanism of postharvest fruit disease resistance.

Key words: Postharvest tomato fruit; Methyl jasmonate; autophagy; SIMYC2

阿胶多肽的抗氧化机制及其铁离子结合模式研究

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摘要: 本研究以阿胶为研究对象, 优化阿胶蛋白肽的最佳酶解工艺。而后, 借助可控酶解和膜分离技术制备出不同分子量的五组阿胶蛋白肽, 分析了各组分蛋白肽的抗氧化强弱及氨基酸组成、官能团、二级结构等特性。研究发现分子量较小的阿胶蛋白肽抗氧化效果好, 不同组分阿胶蛋白肽的氨基酸组成含量、官能团的峰值强度及二级结构含量存在差异, 这些差异可能会导致不同组分抗氧化活性的不同。对抗氧化活性最强的组分进行结构鉴定, 获得了 26 条阿胶五/六肽, 并优选出 PGPAP 为活性最强的序列。借助氧化损伤 HepG2 细胞模型, 发现阿胶抗氧化肽对 HepG2 氧化损伤细胞具有显著保护作用, 并且能够协助细胞对抗 H₂O₂ 诱导的氧化应激反应。此外, 经分子动力学模拟研究发现 PGPAP 与 Keap1 蛋白能够稳定结合,

并发挥相应的生物学功能。另一方面，食源性肽-铁螯合物具有良好的促铁吸收能力，同时还能避免常用补铁制剂易引起的胃肠道不适等副作用。本研究利用小分子阿胶肽与铁离子进行螯合，获得阿胶肽铁螯合物；通过分析阿胶肽铁螯合物的氨基酸组成、官能团、二级结构等信息，初步解析了阿胶抗氧化肽与亚铁离子的结合模式。

关键词：阿胶；肽；抗氧化机制；肽铁螯合；结合模式

Research on antioxidative mechanism and iron binding mode of colla corii asini polypeptide

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Abstract: The optimal enzymatic hydrolysis process of colla corii asini (CCA) peptide was optimized. Then, five groups of CCA peptides with different molecular weight were prepared by controlled enzymatic hydrolysis and membrane separation technology. The antioxidant activity, amino acid composition, functional group and secondary structure of each component were analyzed. It was found that the smaller molecular weight of CCA peptides had a good antioxidant effect, and the amino acid composition, peak strength of functional groups and secondary structure contents of different components of CCA peptides were different, which might lead to different antioxidant activities of different components. The structures of the most active components were identified, 26 penta/hexapeptides were obtained, and PGPAP was selected as the most active sequence. Based on the model of oxidative damage HepG2 cells, it was found that antioxidative peptides of CCA can significantly protect HepG2 cells from oxidative damage, and can assist cells to resist the oxidative stress induced by H₂O₂. In addition, the molecular dynamics simulation study found that PGPAP and Keap1 protein can bind stably and play corresponding biological functions. On the other hand, foodborne peptid-iron chelate has a good ability to promote iron absorption, and can avoid gastrointestinal discomfort and other side effects that are easily caused by commonly used iron supplements. In this study, the iron chelate of ejiao peptide was obtained by chelating small molecules of ejiao peptide with iron ion. By analyzing the amino acid composition, functional group and secondary structure of iron chelate of ejiao peptide, the binding mode of antioxidative peptide and ferrous ion was analyzed.

Key words: Colla corii asini; Peptide; Antioxidant mechanism; Peptide iron chelate; Associative model

靶向治疗金黄色葡萄球菌肠炎纳米运载体系的创建及应用

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摘要：受细菌成孔毒素对细胞膜损伤作用的启发，本研究采用薄膜-超声分散法，通过聚乙二醇(PEG)修饰制备了一种以大豆卵磷脂为主要壁材、载有白藜芦醇和乳酸链球菌素组合(RN)的纳米脂质体(RN-NPs)用于靶向治疗耐甲氧西林金黄色葡萄球菌(MRSA)肠炎。通过SEM、FCM和凝胶电泳验证了RN对MRSA的协同抑制作用。RN-NPs不仅具有良好

的稳定性和抗胃酸侵蚀的能力,而且能够针对 MRSA 肠炎实现特异性释放。在动物实验中,与游离 RN 和阳性药相比, RN-NPs 对金黄色葡萄球菌肠炎的治疗效果更好。因此, RN-NPs 被证明是一种十分有应用潜力的治疗金黄色葡萄球菌肠炎的靶向给药系统。本研究对未来开发针对肠炎的靶向给药系统具有重要的指导意义。

关键词: 白藜芦醇; 乳酸链球菌素; 纳米脂质体; 金黄色葡萄球菌肠炎; 靶向治疗

Establishment and Application of Nano-carrier System for Targeted Therapy of *Staphylococcus aureus* Enteritis

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Abstract : Inspired by the damage caused by bacterial pore-forming toxins to cell membranes, this study utilized the film-ultrasound dispersion method and polyethylene glycol (PEG) modification to prepare resveratrol and nisin-loaded nanoliposomes (RN-NPs) using soy lecithin as the main encapsulating material. These RN-NPs were designed for targeted therapy against Methicillin-resistant *Staphylococcus aureus* (MRSA) enteritis. The synergistic inhibitory effects of resveratrol and nisin (RN) on MRSA were confirmed through SEM, FCM, and gel electrophoresis. In addition to being highly stable and resistant to erosion by stomach acid, RN-NPs can also be specifically released to treat MRSA enteritis. In animal experiments, RN-NPs exhibited superior therapeutic effects against *S. aureus* enteritis compared to free RN and positive drugs. Consequently, RN-NPs have been proven to be a very promising targeted drug delivery system for the management of *S. aureus* enteritis. This study has important guiding significance for the future development of targeted drug delivery systems for enteritis.

Key words: Resveratrol; Nisin; Nanoliposomes; *S. aureus* enteritis; Targeted therapy

白酒酒糟谷蛋白提取方法构建及其功能研究

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摘要: 酒糟是白酒蒸馏后的剩余固体残渣, 本研究针对其中含量较高的蛋白成分进行提取并对其潜在利用的可能性进行研究, 通过脉冲电场辅助提取法来提升蛋白提取效率, 对酒糟蛋白中的谷蛋白 (Jiuzaoglutelin, JG) 进行提取。首次研究 JG 的种属类别, 二级结构和功能特性。首次基于 JG 结合多糖 (普鲁兰多糖、右旋糖苷、羧甲基壳聚糖、果胶和阿拉伯树胶) 美拉德产物构建槲皮素、白藜芦醇、大黄酸和核黄素等生物活性成分为代表的疏水活性因子食品递送体系。建立使用不同蛋白酶水解 JG 方法制备抗氧化肽, 构建偶氮二咪唑啉基丙烷

引发氧化损伤 Sprague Dawley (SD) 大鼠模型来评估其体内抗氧化活性。JG 的利用提升了酒糟副加值，同时也减少大量酒糟对环境造成的负担。

关键词：酒糟谷蛋白；美拉德反应；纳米乳液；纳米颗粒；抗氧化肽

Construction of Baijiu Jiuzao glutelin extraction method and its functional study

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Abstract: XXX Jiuzao is the remaining solid residue after baijiu distillation. This thesis extracts the protein components from Jiuzao and explores its potential application. The pulsed electric field assisted extraction method is employed to enhance protein extraction efficiency from Jiuzao. Jiuzao glutelin (JG) is extracted and purified. This thesis explores the species classification, secondary structure, and functional properties of JG for the first time. The thesis delves into the creation of a food delivery system using JG-polysaccharides Maillard reaction conjugates, such as Pullulan, Dextran, carboxymethyl chitosan, pectin, and Gum Arabic, to delivery hydrophobic active compounds, such as quercetin, resveratrol, rhein, and riboflavin for the first time as well. The thesis further investigates different protease hydrolysis conditions to produce bioactive peptides with antioxidant activity. Additionally, an AAPH-induced oxidative damage Sprague Dawley (SD) rat model is established to evaluate the in vivo antioxidant activities of these peptides. The utilization of JG increases the added value of Jiuzao, and at the same time minimizes the burden of their environmental impact.

Key words: Jiuzao glutelin; Maillard reaction; Nanoemulsion; Nanoparticles; Antioxidant peptides

保加利亚乳杆菌发酵乳中奶酪香气关键风味成分研究

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摘要：发酵剂对酸奶的风味具有决定性影响，为发掘特色风味菌株，开发特色风味的酸奶发酵剂，我们采用气相色谱质谱联用仪 (GC-MS) 分析和多元统计学分析并结合外标法定量分析、香气活度值 (OAV) 分析及三点检验等实验对具有不同奶酪香气强度的保加利亚乳杆菌发酵乳的关键风味物质进行分析，发现丁酸与己酸是保加利亚乳杆菌发酵乳奶酪香气最为的关键的两种风味化合物。最后，结合香气添加实验和感官评价，发现在奶酪香气较弱的发酵乳中添加丁酸与己酸后发酵乳的奶酪香气强度显著提高，奶酪香气变得更加浓郁，但两者的添加量超过一定浓度后，则会影响发酵乳的整体香气和接受度，本研究发现当丁酸含量为

9458.98 ~ 13353.87 $\mu\text{g}/\text{kg}$ 、己酸为 2334.83 ~ 2936.84 $\mu\text{g}/\text{kg}$ 范围时, 发酵乳奶酪香气更接近于真实奶酪香气, 感官评价最高。本研究表明丁酸和己酸的浓度范围或许可以作为未来靶向筛选发酵菌株的标准, 以获得具有理想奶酪香气特征的发酵剂及发酵乳产品。

关键词: 发酵乳; 德氏保加利亚乳杆菌; 奶酪味; 有机酸; 多元统计学分析

Illumination of the key compounds featuring cheesy aroma produced by *Lactobacillus delbrueckii subsp. bulgaricus* in fermented milk

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Abstract: The choice of starter culture has a decisive impact on the flavor of yogurt. To explore distinctive flavor strains and develop unique yogurt starters, we used gas chromatography-mass spectrometry (GC-MS) analysis, multivariate statistical analysis, external standard quantitative analysis, odor activity value (OAV) analysis and triangle test to investigate the key aroma compounds in *Lactobacillus delbrueckii subsp. bulgaricus* (*L. bulgaricus*) fermented milk with different cheesy aroma intensities. It was found that butanoic acid and hexanoic acid are the two key aroma compounds crucial for the cheesy aroma in *L. bulgaricus*-fermented milk. Finally, through the integration of aroma addition experiments and sensory evaluation, it was observed that the addition of butanoic acid and hexanoic acid to fermented milk with a weak cheesy aroma significantly enhanced the intensity of the cheesy aroma, resulting in a more pronounced richness. However, when the concentrations of these compounds exceeded a certain threshold, they adversely affected the overall aroma profile and sensory acceptability of the fermented milk. This study found that when butanoic acid concentrations are within the range of 9458.98 to 13353.87 $\mu\text{g}/\text{kg}$ and hexanoic acid concentrations are between 2334.83 to 2936.84 $\mu\text{g}/\text{kg}$, the cheesy aroma of the fermented milk closely approximates that of authentic cheese, yielding the highest scores in sensory evaluation. This study suggests that the concentration ranges of butanoic acid and hexanoic acid may serve as standards for future targeted screening of fermentation strains, aiming to obtain starters and fermented milk products with desirable cheesy aroma characteristics.

Key words: Fermented milk; *Lactobacillus delbrueckii subsp. bulgaricus*; Cheesy aroma; Organic acids; Multivariate statistical analysis

变性大豆蛋白对虾肌原纤维蛋白凝胶特性的影响及其作用机制

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摘要: 大豆蛋白应用于鱼糜制品中能够改善其质构、风味和营养特性, 但由于天然大豆蛋白与动物

蛋白在加工过程中较难实现共凝胶化, 可能导致产品质地不均一。因此, 本研究对大豆蛋白变性处理后, 探究其对虾肌原纤维蛋白 (MP) 结构和凝胶特性的影响, 并阐明其影响蛋白凝胶特性的作用机制。结果表明, 天然大豆蛋白 (SPI) 和变性大豆蛋白 (dSPI) 均能显著提高复合蛋白凝胶的凝胶强度、弹性、咀嚼性、持水力和储存模量 (G')。但是, 不同添加量的 SPI 对 MP 结构无显著影响, SPI-MP 凝胶形成以氢键为主要化学键, 揭示了 SPI-MP 以物理填充为主的凝胶增强机制; 而 dSPI 通过增加总巯基含量和表面疏水性形成稳定的三级结构, dSPI-MP 凝胶形成以疏水键和二硫键为主要化学键, 揭示了 dSPI-MP 以共价与非共价交联为主的凝胶增强机制, 有利于形成更致密的凝胶网络结构, 为改善虾糜制品品质提供理论基础。

关键词: 天然/变性大豆蛋白, 对虾肌原纤维蛋白, 凝胶增强机制, 物理填充, 共价与非共价交联

Effect of denatured soy protein on gel properties of shrimp myofibrillar protein and its mechanism

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Abstract: The application of soy protein in surimi products can improve its texture, flavor and nutritional properties. However, it is difficult to achieve co-gelation of natural soy protein and animal protein during processing, which may lead to uneven product texture. This study investigated the effects of denatured soy protein on the structure and gel properties of shrimp myofibrillar protein (MP), and clarified the mechanism of action on protein gel properties. The results showed that both natural soy protein (SPI) and denatured soy protein (dSPI) could significantly improve the gel strength, springiness, chewiness, water holding capacity, and storage modulus (G') of the composite protein gels. However, different addition amounts of SPI had no significant effect on the structure of MP, and hydrogen bonds were the main chemical bonds formed in SPI-MP gel, revealing the gel enhancement mechanism of SPI-MP based on physical filling. The dSPI formed a stable tertiary structure by increasing the total sulfhydryl group content and surface hydrophobicity. The hydrophobic bonds and disulfide bonds were the main chemical bonds in dSPI-MP gel formation, revealing the covalent and non-covalent cross-linking mechanism of dSPI-MP. The addition of dSPI is conducive to the formation of a denser gel network structure, which provides a theoretical basis for developing high-quality of shrimp products.

Key words: Natural/denatured soy protein, shrimp myofibrillar protein, gel enhancement mechanism, physical filling, covalent and non-covalent cross-linking

不同不饱和度脂肪酸协同胆盐胶束装载虾青素前后的相互作用力特性研究

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摘要: 虾青素 (astaxanthin, Asta) 是一种具有抗氧化功能的重要营养素, 其生物利用度受脂质类型的显著影响。研究表明, 脂质消化产物能够与胆盐形成胶束, 进而包封虾青素以促进其在肠道中的吸收。本研究探讨了不同不饱和度的脂肪酸 (Oleic acid, $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$; Linoleic acid, $\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$; Linolenic acid, $\text{CH}_3-(\text{CH}_2\text{CH}=\text{CH})_3-(\text{CH}_2)_7\text{COOH}$) 如何影响胆盐胶束中虾青素的装载及其分子间的相互作用力。研究结果表明, 不饱和脂肪酸协助的胆盐胶束能更均匀地分布虾青素, 其中亚麻酸表现出与虾青素最强的氢键作用, 其次是油酸和亚油酸。红外光谱、拉曼光谱、氢谱和液相色谱的结果均显示出这一趋势。此外, QCM-D 和 ITC 的实验结果进一步验证了脂肪酸与胆盐之间的静电相互作用及络合能力的差异。本研究为理解脂肪酸类型对虾青素生物利用度的影响提供了分子层面的见解。

关键词: 胶束; 脂肪酸; 虾青素; 胆盐; 相互作用机制

The interaction characteristics of different unsaturated fatty acids with bile salt micelles before and after loading astaxanthin : A Comparative Study

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Abstract : Astaxanthin (Asta), known for its antioxidant characteristics, has its bioavailability greatly influenced by the lipid type. Research indicates that byproducts of lipid digestion can create micelles containing bile salts, subsequently enveloping astaxanthin to enhance intestinal absorption. This study explores various unsaturated fatty acids (Oleic acid, $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$; Linoleic acid, $\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$; the impact of Linolenic acid, $\text{CH}_3-(\text{CH}_2\text{CH}=\text{CH})_3-(\text{CH}_2)_7\text{COOH}$) on astaxanthin accumulation and its molecular interplay in bile salt micelles. Findings indicated a more uniform distribution of astaxanthin in bile salt micelles, aided by unsaturated fatty acids, with linoleic acid exhibiting the most robust hydrogen bonds with astaxanthin, succeeded by oleic acid and linoleic acid. This pattern is evident in the outcomes of the infrared, Raman, hydrogen spectra, and liquid chromatography analyses. Furthermore, the findings from QCM-D and ITC further confirmed the variances in electrostatic interactions and complexation abilities among fatty acids and bile salts. The research offers insights at the molecular scale into how different types of fatty acids impact the bioavailability of astaxanthin.

Key words : micelle; fatty acids; astaxanthin; bile salt; interaction mechanism

不同蛋白酶制备海参触须水解物的特性及生物活性稳定性

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摘要: 本研究旨在评价碱性蛋白酶、胰蛋白酶、风味蛋白酶和中性蛋白酶对海参触须水解物中生物活性成分的结构特性和稳定性的影响。结果表明, 风味蛋白酶水解物具有最高的水解度(DH)和较低的分子量(MW), 导致不同的紫外吸收、傅里叶变换红外光谱(FTIR)和荧光强度。氨基酸组成分析表明, 海参触须不含半胱氨酸和色氨酸, 而风味蛋白酶和碱性蛋白酶水解物含有组氨酸。Zeta 电位和粒径结果表明, 与其它蛋白酶相比, 风味蛋白酶处理的水解物呈聚集状, 颗粒尺寸更大。海参触须的抗氧化性能表现出良好的热稳定性、pH 稳定性和较好的模拟胃肠道消化稳定性。这些发现为海参触须水解物在食品中作为天然抗氧化剂替代品的利用提供有力的支撑。

关键词: 海参触须水解物; 蛋白酶; 理化性质; 结构特性; 抗氧化活性稳定性; 模拟胃肠道消化

Characteristics and bioactivity stability of hydrolysates from sea cucumber tentacles obtained by different proteases

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Abstract: This study aimed to assess the impact of alcalase, trypsin, flavourzyme, and neutrase on the structural properties and stability of bioactive components in hydrolysates derived from sea cucumber tentacles (SCTHs). The results demonstrated that flavourzyme hydrolysates exhibited the highest degree of hydrolysis (DH) and lower molecular weight (MW), leading to different ultraviolet absorption, Fourier transform infrared spectroscopy (FTIR), and fluorescence intensity. Amino acid composition analysis revealed that SCTHs did not contain Cys and Trp, while the hydrolysates of flavourzyme and alcalase contained His. Zeta potential and particle size measurements showed that hydrolyzed peptides treated with flavourzyme appeared aggregated and presented larger particle sizes compared to other hydrolases. The antioxidant properties of SCTHs exhibited good thermal stability, pH stability, and better simulated gastrointestinal digestive stability. These findings provide strong support for the utilization of SCTHs in food products as natural antioxidant alternatives.

Keywords: Sea cucumber tentacles hydrolysate; protease; physicochemical property; structural characteristic; stability of antioxidant activity; simulated gastrointestinal digestion

不同分子量大蒜低聚糖的靶向肠道益生活性

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摘要: 大蒜是一种食药同源的食材, 富含多糖、有机硫化合物等多种营养成分, 具有抗菌、降血压和促进心脏健康等多种生物活性。利用水提醇沉法提取大蒜多糖, 使用酸水解并结合超滤的方法对混合物进行分级, 并利用液相色谱、离子色谱、红外光谱等仪器确定大蒜低聚糖的结构, 然后利用体外消化实验、益生菌实验和小鼠模型评价大蒜低聚糖的有益作用。获得了三种大蒜低聚糖组分, 酸水解并未破坏低聚糖的主要官能团, 具有相似的单糖组成; 大蒜低聚糖在唾液和肠液中高度稳定, 在胃液中相对稳定, 对双歧杆菌和嗜乳酸杆菌显示出较好的益生活性并对健康小鼠有较好的免疫作用和调节肠道菌群作用, 以及通过调节肠道微生物介导的胆汁酸代谢改善小鼠便秘症状。本研究可为大蒜低聚糖的高效提取、大蒜低聚糖系列功能产品开发、精准指导加工提供理论依据, 从而更好地发挥大蒜的食药两用价值。

关键词: 大蒜低聚糖; 结构解析; 消化特性; 肠道益生活性

Targeted Gut Beneficial Properties of Garlic Oligosaccharides with Different Molecular Weights

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Abstract: Garlic is a food and medicine ingredient, rich in polysaccharides, organosulfur compounds and other nutrients, with various biological activities (eg. antibacterial, lowering blood pressure, and promoting heart health). garlic polysaccharides (GPs) were extracted using hydroalcoholic precipitation, and then the Garlic Oligosaccharides were obtained by acid hydrolysis and ultrafiltration. The structure of garlic oligosaccharides (GOs) was determined using liquid chromatography, ion chromatography, and infrared spectroscopy. Then the beneficial effects of garlic oligosaccharides were evaluated using in vitro digestive assays, probiotic assays, and mouse models. Three garlic oligosaccharide fractions were obtained, and acid hydrolysis did not destroy the main functional groups of the oligosaccharides, which had a similar monosaccharide composition. They showed a highly stable in saliva and intestinal fluids and relatively stable in gastric fluids. Meanwhile, they showed well-beneficial effects on Bifidobacterium and Lactobacillus, and had good immunological effects on healthy mice and regulated gut microbiota. In addition, they improved mice constipation symptoms by modulating gut microbe-mediated bile acid metabolism. This study can provide a theoretical basis for the efficient extraction of GOs, the development of a series of functional products of garlic oligosaccharides, and the precise guidance of processing, to better utilize the value of garlic for food and medicine.

Key words: Garlic Oligosaccharides; Structural Analysis; Digestive Properties; Intestinal Beneficial Properties.

不同高压交变电场（HAEF）作用方式对微冻贮藏凡纳滨对虾新鲜度及代谢物的作用

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摘要: 高压交变电场 (HAEF) 是一种非热物理加工技术, 在延长水产品保质期和提升水产品贮藏品质等方面有其特有优势。本研究主要探讨了不同 HAEF 作用方式 (6 h 预处理 (SHAEF)、12 h 间歇处理 (IHAEF)、持续处理 (CHAEF)) 对微冻贮藏凡纳滨对虾的保鲜作用及代谢物的变化。结果显示, 与对照组相比, HVEF 处理在减缓微生物繁殖速度、通过抑制 PPO 活化来预防黑变、减少脂质氧化和腐败产生等方面效果显著, 尤其是 CHAEF 处理保鲜效果最好。此外, 非靶向代谢组学结果显示, 在微冻贮藏期间, 在 SHAEF 预处理组、IHAEF 间歇处理组及 CHAEF 处理组中分别鉴定出 174、283 和 56 种差异代谢物。磷脂酰胆碱、氧化神经酰胺和 DHA 分别被鉴定为 SHAEF 预处理、IHAEF 间歇处理及 CHAEF 处理的潜在生物标志物。这表明不同的 HAEF 作用方式可能通过不同的代谢途径有效地抑制对虾的脂质氧化。本研究证实持续的 HAEF 处理能够有效的抑制脂质氧化, 提升对虾的新鲜度, 这可能与降低内源酶活性和抑制微生物的生长有关。

关键词: 高压交变电场; 凡纳滨对虾; 微冻贮藏; 代谢组学; 脂质氧化

Effects of different modes of high-voltage alternating electric field action on the freshness and metabolites of *Litopenaeus vannamei* during partial freezing storage

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²XXX)

Abstract: High voltage alternating electric field (HAEF) is a kind of non-thermal physical processing technology, which has its unique advantages in extending the shelf life and improving the storage quality of aquatic products. The present study investigated the variations of freshness and metabolite of shrimp (*Litopenaeus vannamei*) in partial freezing (PF) storage assisted by different modes of high-voltage alternating electric field (HAEF) action, including single-used HAEF (SHAEF), interval-used HAEF (IHAEF), and continuous-used HAEF (CHAEF). The results showed that compared with the control group, HVEF treatment had significant effects on slowing down microbial reproduction, preventing blackening by inhibiting PPO activation, and reducing lipid oxidation and spoilage, especially CHAEF treatment had the best preservation effect. In addition, non-targeted metabolomics results showed that 174, 283, and 56 different metabolites were identified with the SHAEF, IHAEF and CHAEF groups, respectively, during the PF storage. Phosphatidylcholine, oxidized ceramide and DHA were identified as potential biomarkers of the SHAEF, IHAEF and CHAEF treatment groups, respectively. This suggested that different HAEF action modes might effectively inhibit lipid oxidation in shrimp through different metabolic pathways. This study confirmed that continuous HAEF treatment could effectively inhibit lipid oxidation and improve the quality of shrimp, which might be related to the reduction of endogenous enzyme activity and the inhibition of microbial growth.

Keywords: High-voltage alternating electric field; *Litopenaeus vannamei*; Partial freezing storage; Metabolomics; Lipid oxidation

不同酿造工艺对黑果腺肋花楸干红感官品质的影响

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摘要: 黑果腺肋花楸是一种集食用、药用、园林等价值于一身的新兴经济树种, 其果实中富含多类活性物质, 随着我国黑果腺肋花楸的种植面积日益扩大, 对其精深加工的基础研究以及相关产品的开发迫在眉睫。本文研究目的在于通过调整酿造工艺优化黑果腺肋花楸干红的感官特性, 采用了清汁发酵、半浸渍发酵、浸渍发酵以及在半浸渍发酵之后进行苹果发酵, 共四种酿造工艺。通过测定样品的基础理化指标、总花色苷含量、总单宁含量、CIELab 颜色参数、香气成分, 并结合感官评价来评估不同酿造工艺对黑果腺肋花楸干红的感官品质影响。结果表明清汁发酵得到的干红具有最浓郁的浆果香气, 关键呈香组分包括 β -大马士酮、乙酸异戊酯、异戊酸、丁酸、辛酸、乙酸乙酯等, 同时口感更顺滑。浸渍发酵得到的干红具有明显的草本植物香气并且颜色最深, 但涩感最重, 半浸渍发酵得到的干红在颜色、香气及口感上介于前两者之间。在经过苹果发酵之后, 酒的新鲜果香有所减弱, 口感变得更加顺滑。本研究为提升黑果腺肋花楸干红的风味提供了新思路, 为酿造工艺的选择提供了数据支撑。
关键词: 黑果腺肋花楸; 酿造工艺; 颜色; 香气; 口感

Effect of different vinification processes on chemistry and sensory properties of *Aronia melanocarpa* wines

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Abstract: *Aronia melanocarpa* is an emerging economic tree species that embodies edible, medicinal, and ornamental values. Its fruits are rich in various bioactive compounds. With the increasing cultivation area in China, there is an urgent need for fundamental research on its deep processing and the development of related products. The objective of this study was to optimize the sensory properties of *Aronia melanocarpa* wines by adjusting the vinification process. The following four treatments were applied: non-maceration (NM), short maceration for three days (SM), long maceration until the end of alcoholic fermentation (LM), and SM followed by malolactic fermentation (MLF). The effects of these treatments on the sensory properties of the wine were evaluated by measuring basic physicochemical parameters, total anthocyanin content, total tannin content, CIELab color parameters, aroma components, and conducting sensory assessments. Results indicated that the NM exhibited the most intense berry aroma and a smoother mouthfeel. Key aromatic components identified included β -damascenone, isoamyl acetate, isovaleric acid, butyric acid, octanoic acid, and ethyl acetate. Conversely, the LM displayed a pronounced herbal aroma, highest astringency intensity, and darkest color. The SM presented characteristics that were intermediate between the former two. Notably, the MLF's

aroma was slightly diminished, while its mouthfeel became notably smoother. This research offers new insights for flavor optimization of *Aronia melanocarpa* wines and provides data support for the selection of vinification treatments.

Key words: *Aronia melanocarpa*; vinification processes; color; aroma; taste

不同牛皮原料及前处理对黄明胶品质影响研究

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摘要: 利用黑毛牛皮、白毛牛皮、黄毛牛皮及牦牛皮为原料, 采取不同去毛工艺处理通过单因素实验优化黄明胶制胶工艺制作出 5 种黄明胶产品。通过理化检测测定水分、脂肪含量、蛋白质含量、吸光度等指标, 并采用 ICP-MS、GC-IMS 分析了不同工艺黄明胶在微量元素、挥发性有机物等方面的品质差异。研究结果表明, 不同牛皮原料和脱毛处理制得的黄明胶成分含量有较大差异, 其中白毛牛皮制得样品脂肪含量和蛋白质含量最高, 分别为 1.1 g/100 g 和 78 g/100 g。黑毛牛皮制得样品铅含量最高, 为 0.143 mg/kg。在 400 nm 测得黄毛牛皮样品透光率最高, 为 45.08%。通过 ICP-MS 检测了不同工艺黄明胶中微量元素及重金属 (K、Ca、Na、Mg、Al、Fe、Cu、Zn、As、Pb、Hg) 含量差异, 通过 GC-IMS 检测发现黄明胶样品中含有酯类物质、酮类物质、醛类物质和醇类物质, 还有少量吡嗪类物质、酸类物质和含硫化合物, 而且牦牛皮、脱毛牦牛皮样品含较高的香气化合物。该研究为黄明胶产品的原料选择和安全性等品质改善提供了一定的理论依据。

关键词: 牛皮; 牦牛皮; 黄明胶; GC-IMS; 品质分析

Influence of different cowhide raw materials and pretreatment on the quality of yellow gelatin

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Abstract: Using cowhide raw materials with different colour including (black, white, yellow) and yak skin as raw materials, 5 types of yellow gelatin products were produced by optimizing the yellow gelatin gelatinization process through single factor experiments using different dehairing processes. By measuring indicators such as moisture, fat content, protein content, trace elements, and absorbance, and using ICP-MS and GC-IMS to analyze the quality differences of different processed yellow gelatin in terms of trace elements, volatile organic compounds, and other

aspects. The results indicate that there are significant differences in the composition of yellow gelatin produced from different cowhide materials and depilation treatments. Among them, the sample made from white cowhide has the highest fat content and protein content, which are 1.1 g/100 g and 78 g/100 g, respectively. The lead content of the sample made from black cowhide is the highest, at 0.143 mg/kg. The highest transmittance of the yellow cowhide sample was measured at 400 nm, which was 45.08%. The differences in the content of trace elements and heavy metals (K, Ca, Na, Mg, Al, Fe, Cu, Zn, As, Pb, Hg) in different processes of yellow gelatin were detected by ICP-MS. GC-IMS detection revealed that the yellow gelatin samples contained esters, ketones, aldehydes, and alcohols, as well as a small amount of pyrazines, acids, and sulfur-containing compounds. Moreover, yak skin and depilated yak skin samples contained high levels of aromatic compounds. This study provides a theoretical basis for the quality improvement of raw material selection and safety of gelatin products.

Key words: Cowhide; Yak skin; Yellow gelatin; GC-IMS; Quality analysis

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不同制备方式对山药淀粉结构与加工特性影响的研究

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摘要: 淀粉分离制备是了解淀粉特性和进行适宜性加工生产的前提, 本研究采用超声波、微波、酶解技术辅助传统水法、碱法制备山药淀粉, 系统比较和分析了不同制备方式对山药淀粉结构和加工特性的影响, 以期为山药淀粉的高效提取和利用提供理论参考。研究发现: 碱性环境制备的山药淀粉, 在淀粉原始特性的维持和改善方面, 优于中性环境; 不同辅助技术对山药淀粉的影响显示为超声>微波>酶解的基本规律; 超声辅助碱提山药淀粉的提取率(94.77%)和纯度(96.62%)显著高于其他样品, 且其淀粉颗粒完整度最佳, 拥有较高的直链淀粉含量(267.20 mg/g)、冻融稳定性(析水率 6.24%)、抗凝沉性(上清液占比 49.76%)、膨胀度(23.45 g/g)、糊化粘度(3767.33 cP)和回生值(1624.00cP), 使其具有优良的抗回生性能、水合能力, 以及形成抗性淀粉的能力, 在冷冻食品、增稠剂及凝胶制品等领域具有一定的开发潜力。

关键词: 山药淀粉; 不同制备方式, 淀粉结构特性; 淀粉加工特性

Study on the influence of different preparation methods on the structure and processing characteristics of yam starch

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Abstract : Separation and preparation of starch is the prerequisite for understanding the characteristics of starch and suitable processing and production. In this study, ultrasonic, microwave, and enzymatic hydrolysis techniques were used to assist the traditional neutral and alkali methods to prepare yam starch. The effects of different preparation methods on the structure and processing characteristics of yam starch were systematically compared and analyzed, in order to provide theoretical reference for the efficient extraction and utilization of yam starch. The study found: The yam starch prepared in alkaline environment was better than that prepared in neutral environment in maintaining and improving the original characteristics of starch; The effects of different auxiliary technologies on yam starch showed the basic rule of ultrasound > microwave > enzymatic hydrolysis. The extraction rate (94.77%) and purity (96.62%) of yam starch were significantly higher than those of other samples. The integrity of starch particles was the best, with high amylose content (267.20 mg/g), freeze-thaw stability (6.24%), anti-coagulability (49.76% of the supernatant), swelling degree (23.45 g/g), gelatinization viscosity (3767.33 cP) and recovery value (1624.00cP). It had excellent anti-regeneration properties, hydration ability, and the ability to form resistant starch, and had certain development potential in the fields of frozen food, thickener and gel products.

Key words: Yam starch; Different preparation methods, Starch structure characteristics; Starch processing characteristics

超高通量进化辅助食品工业酶与微生物表达系统改良

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摘要: 工业酶是生物催化的核心, 在食品、医药等领域应用广泛。近年来, 合成生物学与自动化等技术的成熟应用进一步推动酶工程的发展。报告将围绕食品工业酶与微生物蛋白表达系统, 介绍微生物体内连续进化、超高通量筛选以及丝状真菌多位点基因组编辑等技术的开发, 并初步探索其在食品酶分子高通量定向进化改造、米曲霉等丝状真菌高效蛋白表达系统构建与调控等方面的应用, 为高性能食品工业酶制剂与微生物细胞工厂开发提供参考。

关键词：工业酶；超高通量筛选；体内定向进化；微生物表达系统

Ultra-high throughput evolution AIDS the improvement of enzymes and microbial expression systems

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Abstract: Industrial enzymes are the core of biological catalysis and are widely used in fields such as food and pharmaceuticals. In recent years, the application of synthetic biology and automation has further promoted the development of enzyme engineering. The report will introduce the development of microbial in vivo continuous evolution, ultra-high-throughput screening, and multi-site genome editing technologies in fungi, and explore their initial applications in high-throughput directed evolution of food enzyme molecules, the construction and regulation of high-efficiency protein expression systems in fungi such as *Aspergillus*, and provide reference for the development of high-performance food industrial enzyme preparations and microbial cell factories.

Key words: Industrial enzymes; Ultra-high throughput screening; In vivo directed evolution; Microbial expression system

赤霉素通过 *AcDELLAs* 基因抑制猕猴桃采后软化

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摘要: 赤霉素 (GA) 在高等植物的生长发育中起着重要的调控作用。在猕猴桃采后保鲜方面, 赤霉素也发挥着重要作用, 外源 GA₃ 处理采后猕猴桃可有效维持果实硬度、延缓后熟进程。DELLA 蛋白是赤霉素激素信号途径中的核心作用元件和关键负调控因子, 猕猴桃基因组中共鉴定出 8 个 *AcDELLAs* 基因, 并按染色体定位顺序命名为 *AcDELLA1-AcDELLA8*。基因结构分析表明, 所有 *AcDELLAs* 的 DNA 序列均只含有一个外显子, 且无内含子。序列分析表明, 8 个 *AcDELLAs* 蛋白的 N 端均含有高度保守的 DELLA 和 TVHYNP 结构域。荧光定量 PCR 结果显示外源 GA₃ 处理显著诱导 *AcDELLA3/4/5/6/8* 基因表达。生理指标与 *AcDELLA* 基因的相关性分析表明, GA₃ 处理能全面、有效地抑制猕猴桃采后成熟。以上研究丰富了赤霉素对果实采后保鲜作用的认识, 并为 *AcDELLA* 基因的功能研究奠定了基础。

关键词: 猕猴桃; 赤霉素; DELLA 家族; 果实成熟

Gibberellin inhibits postharvest kiwifruit softening may through *AcDELLAs* gene family

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Abstract: Gibberellin (GA) plays an important regulatory role in the growth and development of higher plants. We found that exogenous GA₃ significantly delay the reduction of post-harvest ‘Cuixiang’ kiwifruit fruit firmness, the increase of total soluble solids (TSS) and starch, the degradation of the cell wall, and the rate of ethylene production. A total of eight *AcDELLAs* genes were identified from the kiwifruit genome and named as *AcDELLA1* to *AcDELLA8* by the order of chromosomal localization. Gene structure analysis showed that all eight *AcDELLAs* DNA sequences had only one exon with no intron. Sequence analysis showed that all eight *AcDELLAs* proteins contained highly conserved DELLA and TVHYNP motifs at the N-terminus. Evolutionary tree analysis showed that *AcDELLA1*, *AcDELLA3*, *AcDELLA5* and *AcDELLA6* clustered together. The expression of most of these *AcDELLA* genes were significantly induced by GA₃ treatment. The correlation analysis between physiological indicators and the *AcDELLA* genes showed that GA₃ treatment could comprehensively and effectively inhibit kiwifruit postharvest ripening. The above study enriches our understanding of how GA prolong the post-harvest kiwifruit storage time, and lays the foundation for subsequent functional study of *AcDELLA* genes.

Keywords: Kiwifruit; gibberellins; DELLA family; fruit ripening

赤藓糖醇衍生低值物料制备饲用益生菌剂的技术研究

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摘要: 赤藓糖醇生产过程中会产生大量含丰富生物质的废液废渣, 使用膜过滤等传统方式处理不但会污染环境, 而且会大大增加企业成本。因此, 对赤藓糖醇废液的全利用研究对企业具有重要意义。本研究主要利用赤藓糖醇废液作为益生菌发酵基质, 制备具有促消化和抑菌功能的饲用益生菌剂, 为赤藓糖醇废液的有效利用提供方法和理论依据。本研究从自然发酵废液中分离菌株, 筛选出一株具有高纤维素酶活的枯草芽孢杆菌。金黄色葡萄球菌是畜禽易感染且危害较大的致病菌株, 对筛选出的枯草芽孢杆菌进行体外抑菌测试, 发现其对金黄色

葡萄球菌具有良好的抑制性。通过模拟胃肠液的耐受实验,菌体细胞粘附性实验发现该菌株具有在肠道良好的定植能力。益生菌剂存储稳定性测试结果表明,菌体数量以及纤维素酶活稳定性良好。本研究分离得到了可以应用于制备饲用益生菌剂的潜力菌株,既解决了企业废液处理的难题,又可为家畜养殖业提供益生菌剂,对企业具有重要的应用价值和经济效益。

关键词: 赤藓糖醇废液; 枯草芽孢杆菌; 饲用益生菌剂

Study on the preparation of feeding probiotics from low value materials derived from erythritol

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Abstract: The production process of erythritol produces a large amount of waste liquid and residue containing abundant biomass. Traditional methods such as membrane filtration will not only pollute the environment but also greatly increase the cost of enterprises. Therefore, the research on the full utilization of waste liquid is of great significance for enterprises. In this study, the waste liquid of erythritol was used as the fermentation substrate of probiotics to prepare feeding probiotics with pro-digestion and antibacterial functions, which provided methods and theoretical basis for the effective utilization of erythritol waste solution. Strains were isolated from the waste liquid of natural fermentation, and then screened out with the ability to produce digestive enzymes. A *Bacillus subtilis* strain with high cellulase production was isolated from natural fermentation waste. *Staphylococcus aureus* is a pathogenic strain easily infected by livestock and poultry, and it was found that the obtained *Bacillus subtilis* exhibited good inhibition to *Staphylococcus aureus* by *in vitro* bacteriostatic test. Furthermore, the strain had good colonization ability in intestinal tract through the tolerance test of simulated gastric and intestinal fluid and the cell adhesion test. The results of storage stability test of probiotics showed that the number of bacteria and cellulase activity were stable. In this study, the potential strains that can be used in the preparation of feeding probiotics were isolated, which not only solved the problem of waste liquid treatment in enterprises, but also provided probiotics for livestock breeding industry. The research results have important application value and economic benefits for enterprises.

Key words: Erythritol waste liquor; *Bacillus subtilis*; Feeding probiotics

大豆分离蛋白与海藻酸钠复合颗粒共稳 Pickering 高内相乳液的制备与表征

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摘要: 本项目旨在开发基于大豆分离蛋白(SPI)和海藻酸钠(SA)的高内相 Pickering 乳液(HIPPE), 研究 SPI/SA 复合胶体颗粒的乳化及稳定性能, 重点探讨其在冻融循环、加热及储存等条件下对乳液稳定性的提升作用。通过优化 SPI 和 SA 的比例, 本项目希望解决食

品工业中乳液长期稳定性的问题。此外，项目还将探索 HIPPE 生产工艺，克服天然乳化剂工业化过程中存在的技术障碍，为食品工业中可持续、高稳定性乳化剂的应用奠定基础。通过本研究，旨在为天然高效食品乳化剂的配方开发提供新思路，并推动其大规模应用。

关键词：高内相 Pickering 乳液；大豆分离蛋白；海藻酸钠；乳液稳定性

The preparation and characterization of Pickering high internal phase emulsions stabilized by composite particles of soy protein isolate and sodium alginate

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Abstract: This project aims to develop a high internal phase Pickering emulsion (HIPPE) utilizing soy protein isolate (SPI) and sodium alginate (SA) as the primary stabilizing agents. The study focuses on examining the emulsifying and stabilizing properties of SPI/SA composite colloidal particles, with particular emphasis on their capacity to improve emulsion stability under freeze-thaw cycles, thermal treatment, and prolonged storage. By optimizing the SPI/SA ratio, this project aims to tackle the challenge of achieving long-term emulsion stability, a critical concern in the food industry. Additionally, the project will investigate the production processes of HIPPE, with the goal of overcoming technical barriers in the industrialization of natural emulsifiers, thereby laying the groundwork for the application of sustainable, high-stability emulsifiers in food products. Through this research, the objective is to introduce new strategies for formulating natural, high-efficiency food emulsifiers, facilitating their large-scale application in the food industry.

Key words: High internal phase Pickering emulsion; Soy protein isolate; Sodium alginate; Emulsion stability

低温嫩化条件下钙离子对海参体壁结构的影响

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摘要：海参的主要食用部分是体壁，胶原纤维对体壁组织结构的完整性有着十分重要的作用。低温嫩化技术可通过降低体壁组织结构的稳定性，来提高产品的嫩度。在肉制品中添加 Ca^{2+} 已被证明可以改善产品嫩度并调节化学相互作用的水平。为了深入研究海参嫩化的分子机制，本研究在嫩化条件下 (37°C) 不同浓度的 CaCl_2 溶液处理海参体壁，研究其结构变化。首先将新鲜海参体壁浸泡在 0、2.5、5、10、20、40 mM 的 CaCl_2 溶液中 37°C 孵育 12 h，观察组织块的形态学变化。同时，新鲜海参体壁采用相同条件进行实验。采用 TPA、VG 染色和 Cryo-SEM，对海参体壁的理化特性进行表征。BCA 法、苯酚硫酸法以及福林酚法测定海参体壁溶出液蛋白、多糖以及 TCA 可溶性寡肽含量。结果表明：随着嫩化时间的延长、 Ca^{2+} 浓度的增加，海参体壁逐渐伸展、瘫软，色素溶解明显，体壁出现白斑，弹性降低； Ca^{2+} 的添加在一定程度上增加了海参体壁的硬度，且随着 Ca^{2+} 浓度的增加，硬度呈现先升高后降低

的趋势;VG 和 Cryo-SEM 结果表明高 Ca^{2+} 浓度会导致海参体壁模糊,大量细胞核聚集边缘,同时胶原纤维内部存在明显孔洞,伴随着胶原纤维细丝。上述研究结果为明确 Ca^{2+} 对胶原纤维结构的作用机制,提升低温嫩化海参品质的控制技术奠定了一定的理论基础。

关键词: 钙离子; 海参体壁; 低温嫩化

Effect of calcium ions on the structure of sea cucumber body wall under low temperature tenderization conditions

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Abstract: The main edible part of sea cucumber is the body wall, and collagen fibers (CFs) play an important role in the integrity of the tissue structure of the body wall. Low-temperature tenderization technology can improve the tenderness of products by reducing the stability of the body wall tissue structure. The addition of Ca^{2+} to meat products has been shown to improve product tenderness and regulate the level of chemical interactions. In order to further study the molecular mechanism of sea cucumber tenderization, the body wall of sea cucumber was treated with different concentrations of CaCl_2 solution under tenderization conditions (37 °C) to study its structural changes. Firstly, the body wall of fresh sea cucumber was incubated in 0, 2.5, 5, 10, 20 and 40 mM CaCl_2 solution and incubated at 37°C for 12 h, and the morphological changes of tissue blocks were observed. The body wall of fresh sea cucumber was experimented under the same conditions. TPA, VG staining and Cryo-SEM were used to characterize the physicochemical properties of sea cucumber body wall. BCA, phenol sulfuric acid and Lowry were used to determine the contents of protein, polysaccharide and TCA soluble oligopeptide in sea cucumber body wall dissolution. The results showed that with the extension of tenderization time and the increase of Ca^{2+} concentration, the body wall of sea cucumber gradually stretched and softened, the pigmentation dissolution was obvious, and the white spots and elasticity of the body wall decreased. The addition of Ca^{2+} increased the hardness of the body wall of sea cucumber to a certain extent, and with the increase of Ca^{2+} concentration, the hardness first increased and then decreased. The results of VG and Cryo-SEM showed that high Ca^{2+} concentration led to blurring of the body wall of sea cucumber, a large number of nuclei clustering at the edges, and obvious pores in the collagen fibers, accompanied by collagen fiber filaments. The above results lay a theoretical foundation for clarifying the mechanism of Ca^{2+} on the structure of collagen fibers and improving the control technology of low-temperature tenderized sea cucumbers.

Key words: calcium ions; sea cucumber body wall; low temperature tenderization

低温真空慢煮(Sous vide)加工对太平洋牡蛎风味及滋味变化影响机制

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摘要: 低温真空慢煮 (SV) 作为一种轻热加工技术, 在保持牡蛎原有风味及滋味品质方面具有较大应用潜力。本研究主要探讨了牡蛎在 SV 加工 (0-30min/75°C) 过程中风味及滋味的动态变化机制。结果表明, 牡蛎 SV 加工 10-15min 有助于提升其鲜味强度, 这可能是由于

单磷酸腺苷及谷氨酸含量的增加。然而,加工 20-30 min 则导致“青草味”显著损失,“蒸煮味”和“脂肪味”显著提升。感官评价结果显示,最佳的 SV 处理条件为 75°C, 15min。通过 GC-MS 结合 GC-IMS 分析发现,短链醛类物质如 (E)-2-戊烯醛、(E)-2-己烯醛和 (E, E)-2,4-己二烯醛的减少可能与“青草味”的损失相关,而 2,3-二乙基吡嗪和辛醛的生成则可能是产生“蒸煮味”和“脂肪味”的关键原因。脂质组学分析表明,主要通过甘油磷脂和鞘脂代谢合成的磷脂酰乙醇胺、溶血磷脂酰胆碱和鞘磷脂是醛类物质生成的重要前体。本研究为控制牡蛎在温和加工过程中的风味质量提供了理论依据。

关键词: 牡蛎; 低温真空慢煮; 风味; 滋味; 脂质组学

Effect of Sous-Vide Processing Duration on Flavor and Taste Variations of Oyster (*Crassostrea gigas*)

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Abstract: Sous-vide (SV), as a mild processing technique, exhibits some potential for keeping the original flavor of oyster. The dynamic changes mechanism of flavor and taste in oyster during SV processing (0-30 min/75 °C) were investigated. The results showed that SV processing for 10-15 min improved the umami of oysters, likely due to the increase in adenosine monophosphate and glutamate, while processing for 20-30 min resulted in a significant loss of “grassy” flavor and increase in “cooked” and “fatty” flavor. GC-MS and GC-IMS analysis showed that the loss of short-chain aldehydes, such as (E)-2-pentenal, (E)-2-hexenal and (E, E)-2,4-hexadienal may be related to the weakening of the “grassy” flavor, and the formation of 2,3-diethylpyrazine and octanal produced a “cooked” and “fatty” flavor. The analysis of lipidomics indicated that phosphatidylethanolamine, lysophosphatidylcholine and sphingomyelin, synthesized mainly through glycerophospholipid and sphingolipid metabolism, were key precursors for aldehyde formation. This study provides a theoretical basis for controlling the flavor quality of oyster during mild processing.

Key words: Oyster; Sous-vide; Flavor; Taste; Lipidomics

淀粉分子结构对淀粉基材料 3D 打印特性的影响机制研究

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摘要: 本工作聚焦于谷物食品中的重要组分——淀粉, 通过模拟 3D 打印挤出过程的不同阶段, 揭示了淀粉在打印过程中流变学性质与印刷特性之间的内在关系。借助计算流体动力学 (CFD) 技术, 科学且直观地模拟了淀粉在 3D 打印中的挤出行为, 并从淀粉链状结构和结晶结构的角度深入探讨了影响其挤出特性和支撑能力的关键因素。研究表明, 直链淀粉是淀粉基打印产品的主要支撑结构, 然而其较高的含量导致挤出困难, 造成打印过程中的挤出间

歇现象。虽然高直链淀粉形成的凝胶具有较强的剪切稀化能力，但其低保水性使打印表面粗糙，不利于打印结构的完整性。V型晶体结构的形成抑制了淀粉回生，增强了结合水量，导致支撑结构从骨架转变为片状结构。淀粉凝胶结构的变化进一步降低了材料的流动应力和储能模量，减少了“挤出膨胀”，从而提高了打印线宽的精度与整体打印性能。此外，淀粉短支链（DP 6-12）的增加削弱了分子链的短程有序性和氢键作用，进而对储能模量和屈服应力产生不利影响。该研究为淀粉流变学特性的优化与其3D打印性能的提升提供了重要的理论依据。

关键词：淀粉；3D打印；凝胶；分子结构

Study on the Mechanism of the Effect of Starch Molecular Structure on the 3D Printing Properties of Starch-Based Materials

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Abstract: This study focuses on starch, a key component in grain-based foods, and investigates the relationship between its rheological properties and printing characteristics during the 3D printing process by simulating different stages of extrusion. Using Computational Fluid Dynamics (CFD) technology, the extrusion behavior of starch in 3D printing was scientifically and intuitively simulated. The study further explores the key factors affecting extrusion properties and support capacity from the perspective of starch's chain structure and crystalline structure. The results reveal that amylose is the main support structure in starch-based printed products; however, a higher amylose content leads to extrusion difficulties, resulting in intermittent extrusion during printing. Although gels formed by high amylose exhibit strong shear-thinning behavior, their low water retention causes rough print surfaces, which negatively impacts the integrity of the printed structure. The formation of V-type crystalline structures inhibits starch retrogradation and increases bound water, causing the support structure to shift from a framework to a lamellar form. These changes in the gel structure further reduce the flow stress and storage modulus of starch-based gels, minimizing "extrusion swelling" and improving the precision of print line width and overall printing performance. Additionally, an increase in short starch chains (DP 6-12) weakens the short-range molecular order and hydrogen bonding, which adversely affects storage modulus and yield stress. This research provides important theoretical support for optimizing the rheological properties of starch and improving its 3D printing performance.

Key words: Starch; 3D printing; Gel; Molecular structure

淀粉膜的工业化制备与性能研究

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摘要：近年来，全球各地对塑料污染问题的关注度不断提升，越来越多的国家和地区开始出台禁塑政策。淀粉基薄膜因来源广泛、价格低廉及优异的降解性能，被认为是最有前途的生

物材料之一。本文通过研究辛烯基琥珀酸淀粉钠（OS 淀粉）在淀粉基材料非均相体系中的乳化机制，揭示淀粉基材料非均相体系性能演变规律，创新了 OS 淀粉定向改性理论体系。阐述了熔融挤出过程中淀粉与复合塑化剂、纳米增强剂多组分反应规律，创新性的提出了甘油-水复合塑化进程中存在的“反增塑”理论，阐明了一定比例的水和甘油对挤出吹制淀粉薄膜性能的协同增塑增强机制；阐述了挤出过程中淀粉与复合塑化剂、纳米增强剂多组分竞争性反应机制，解析了复合增强体系下淀粉基材料性能演变规律。

关键词：塑料污染；淀粉膜；挤压吹塑；性能

Study on industrial manufacture and properties of starch film

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Abstract: In recent years, with increasing attentions of environmental protection in the world, more and more countries and regions have announced a plastic ban. Starch-based films have been considered as one of the most promising biomaterials to replace petrochemical-based plastic materials, due to their excellent degradation performance and low cost. In this paper, the emulsification mechanism of octenyl succinic anhydride starch (OS starch) in the heterogeneous system of starch based materials was studied, innovating the theoretical system of directed modification of OS starch. We have investigated the synergistic plasticizing effect of water (W) and glycerol (G) on the physico-chemical and structural properties of starch-based films prepared by extrusion blowing. In addition, the effects of nano-ZnO and nano-SiO₂ nanoparticles on the properties of starch-based films prepared by extrusion blowing were also investigated in this study.

Key words: Plastic pollution; Starch film; Extrusion blowing; Property

短乳杆菌 YSJ-3 对小鼠生物钟紊乱的改善作用研究

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摘要：生物钟是机体为了适应昼夜更替而形成的一种内在节律性。随着社会竞争的加剧，越来越多的人受到生物钟紊乱困扰。伴随着肠-脑轴理论研究的深入，益生菌被证明可能通过分泌神经递质与大脑进行交流，从而调节生物钟紊乱。本研究筛选得到了一株高产褪黑素（MT）的短乳杆菌 YSJ-3 (*Levilactobacillus brevis* YSJ-3)，对其益生特性进行了评价，并

探究了其小鼠生物钟紊乱模型的改善作用。结果表明,短乳杆菌 YSJ-3 具有良好的益生特性,能够调节生物钟紊乱模型小鼠摄食量及体重,增加小鼠在旷场实验中的中央区域停留时间,提升小鼠在新物体识别实验中的学习能力,增加小鼠在明暗箱实验中的明箱停留时间及明箱移动距离,焦虑现象得到改善,预防由于生物钟紊乱导致的结肠炎症的发生;其作用机制与增加血清和结肠中的 5-HT、MT 含量,防止结肠局部淋巴细胞浸润,上调 5-HT_{1A}R 基因及生物钟基因 *Bmall*、下调 5-HT_{2A}R 基因及生物钟基因 *Per2*、*Rev-erba* 有关。本研究为进一步开发改善生物钟紊乱的益生菌制剂提供了理论依据。

关键词: 生物钟; 生物钟紊乱; 短乳杆菌; 褪黑素 (MT)

Study on the ameliorative effect of *Levilactobacillus brevis* YSJ-3 on biological clock disorders in mice

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Abstract: The biological clock is an intrinsic rhythmicity developed by the organism to adapt to the change of day and night. With increased social competition, more and more people are suffering from biological clock disorder. Along with deeper research into the gut-brain axis theory, probiotics have been shown to possibly regulate biological clock disorders by secreting neurotransmitters. In this study, we screened and obtained a high MT-producing strain of *Levilactobacillus brevis* YSJ-3 (YSJ-3), evaluated its probiotic properties, and explored its ameliorative effects on a mouse model of biological clock disorders. The results showed that YSJ-3 has good probiotic properties, which can regulate food intake and body weight in mice with biological clock disorders, increase the residence time in the central area in the open field experiment, improve the learning ability of the mice in the new object recognition experiment, increase the residence time and the distance of moving in the bright box in the light and dark box experiments, and improve the anxiety phenomenon significantly, and prevent the occurrence of colonic inflammation caused by the biological clock disorder. And preventing the occurrence of colon inflammation; The mechanism of action was associated with increase in serum and colonic levels of 5-HT and MT, prevention of local lymphocyte infiltration in the colon, up-regulation of the 5-HT_{1A}R gene and the bioburden gene *Bmall*, and down-regulation of the 5-HT_{2A}R gene and the bioburden genes *Per2* and *Rev-erba*. This study provides a theoretical basis for further development of probiotic preparations to improve biological clock disorders.

Key words: Biological clock; Biological clock disorder; *Levilactobacillus brevis*; Melatonin

对 *Wenyngzhuangia fucanilytica* 菌株中的 GH16 家族 β κ -卡拉胶酶底物识别和催化机制的结构研究

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摘要: 卡拉胶是海洋红藻中的一类线性硫酸化半乳聚糖, 在食品、药品、化妆品和材料工业中有着广泛应用。卡拉胶酶能够温和、高效、特异性地降解卡拉胶, 是制备低聚功能寡糖和研究多糖结构的重要工具。理解卡拉胶酶的底物识别和作用机制对于生物技术的应用具有重要意义。 $\beta\kappa$ -卡拉胶酶是水解主要杂化卡拉胶 furcellaran 的糖苷水解酶, 目前关于该类卡拉胶酶的结构基础仍不清楚。本文首次确定了来自 *Wenyngzhuangia fucanilytica* 菌株 GH16_13 亚家族 $\beta\kappa$ -卡拉胶酶 Cgbk16A_Wf 的晶体结构, 并阐明了该亚家族的结构特征。通过对其结合六糖配体的复合物晶体结构分析和分子对接分析, 明确了底物结合模式。结合口袋包含一个保守的催化基序和几个与底物识别相关的特定氨基酸残基。通过定点突变验证了残基 R88、E290 和 E184 是参与底物识别催化的重要位点。比较 $\beta\kappa$ -卡拉胶酶与 κ -卡拉胶酶, 发现它们不同的底物特异性源于亚位点-1 处的构象差异。这项研究有助于对卡拉胶酶识别机制的全面理解, 并为酶的改造和卡拉胶寡糖的制备提供了理论支持。

关键词: 卡拉胶; 卡拉胶酶; 晶体结构; 亚位点; 底物特异性

Structural insights into the substrate recognition and catalytic mechanism of a GH16 $\beta\kappa$ -Carrageenase from *Wenyngzhuangia fucanilytica*

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Abstract: Carrageenan, a type of linear sulfated galactan derived from marine red algae, is extensively utilized in the food, pharmaceutical, cosmetic, and materials industries. Carrageenases can degrade carrageenan in a gentle, efficient, and specific manner, making them essential tools for the production of functional oligosaccharides as well as the structural analysis of polysaccharides. Understanding the substrate specificity of carrageenases has long been of interest for biotechnology applications. So far, the structural basis of the $\beta\kappa$ -carrageenase that hydrolyzes furcellaran, a major hybrid carrageenan, remains unclear. Here, the crystal structure of Cgbk16A_Wf, as a representative of the $\beta\kappa$ -carrageenase from GH16_13, was determined, and the structural characteristics of this subfamily were elucidated for the first time. The substrate binding mode was clarified through structure analysis of the hexasaccharide-bound complex and molecular docking. The binding pocket involves a conserved catalytic motif and several specific residues associated with substrate recognition. Functions of residues R88, E290, and E184 were validated through site-directed mutagenesis. Comparing the $\beta\kappa$ -carrageenase with κ -carrageenase, we proposed that their different substrate specificities are partly due to the distinct conformations of subsite -1. This research offers a

comprehensive understanding of the recognition mechanism of carrageenases and provides valuable theoretical support for enzyme modification and carrageenan oligosaccharide preparation.

Key words: carrageenan; carrageenase; crystal structure; subsite; substrate specificity

多肽源糖尿病特医食品乳剂开发初探

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摘要: 本项目拟依据营养素对血糖和氧化应激的调节作用, 研发针对糖尿病患者的全营养配方食品。研究配方中主要营养成分抗氧化肽、药食同源的植物素、 α -亚麻酸和亚油酸、部分膳食纤维对降血糖、抗氧化应激功能调节作用, 优化全营养配方, 有针对性地解决血糖升高和氧化应激威胁。同时, 以探索糖尿病全营养配方食品乳剂的生产方法为切入点, 破解我国特医食品产业转型升级过程中的乳剂生产的技术难题, 通过开展关键共性技术研究, 实现稳定性乳剂生产的突破性进展。以期在营养支持的基础上, 实现个性化调节糖尿病患者的血糖水平、抗氧化应激功能, 为特医食品开发中开辟新思路。

关键词: 抗氧化肽; 血糖调节; 乳剂生产; 糖尿病; 全营养配方食品

The development of peptide-based medical food emulsions for diabetes

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Abstract: This project aims to develop a comprehensive nutritional formula specifically tailored for diabetic patients, based on the regulatory effects of key nutrients on blood glucose levels and oxidative stress. The study will focus on the primary components of the formula, including antioxidant peptides, bioactive compounds from medicinal and edible plants, alpha-linolenic acid, linoleic acid, and selected dietary fibers, evaluating their roles in regulating blood glucose and oxidative stress. The aim is to optimize the formulation to address the challenges posed by hyperglycemia and oxidative stress. Additionally, the project will explore the production methods for emulsions in diabetes-specific formula foods, with the goal of overcoming technical challenges in emulsion formulation amidst the transformation and advancement of China's medical food industry. Through research on key technologies, this project aims to achieve breakthroughs in the production of stable emulsions. Ultimately, the goal is to personalize the regulation of blood glucose and oxidative stress in diabetic patients through targeted nutritional interventions, offering new insights into the development of medical foods.

Key words: Antioxidant peptides; Blood glucose regulation; Emulsion production; Diabetes; Complete nutritional formula food

多源光谱传感技术在水产品质量安全检测中的应用

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摘要: 水产品富含蛋白质、脂肪和多种维生素和矿物质, 是人类饮食的重要组成部分。然而, 由于内外部环境因素的复杂性, 导致水产品的质量安全一直备受关注。近年来, 基于光谱学的快速、无损检测方法在食品领域受到了广泛关注。然而, 使用单一的光谱技术只能对被检测样品提供有限的化学信息。为了克服这一局限性, 基于多源光谱技术的数据融合策略已成为提高食品质量安全快速评价准确性的一种重要手段。本文将探讨低级、中级和高级等多种光谱数据融合策略的特点, 分析光谱数据融合技术, 包括不同光谱之间的融合、光谱与机器视觉的融合、光谱与电子鼻的融合, 以及光谱与核磁共振的融合技术对食品质量安全检测的适用性, 介绍多源光谱传感技术, 包括拉曼光谱、近红外光谱、激光诱导击穿光谱等, 在水产品质量安全检测中的应用, 展望所面临的挑战, 探讨机器学习方法在光谱特征提取及食品质量安全检测中的应用价值和未来的发展方向。

关键词: 水产品; 光谱; 质量安全; 无损检测; 机器学习

Application of multi-source spectral data fusion technology in the detection of quality and safety of aquatic products

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Abstract: Aquatic products, rich in proteins, fats, various vitamins, and minerals, constitute a vital part of human diets. However, due to the complexity of internal and external environmental factors, the quality and safety of aquatic products have always been of great concern. In recent years, rapid and non-destructive detection methods based on spectroscopy have garnered significant attention in the food industry. Nevertheless, the use of a single spectroscopic technique can only provide limited chemical information about the samples under investigation. To overcome this limitation, data fusion strategies based on multi-source spectroscopic techniques have emerged as an important means to enhance the accuracy of rapid food quality and safety evaluation. This report delves into the characteristics of low-level, mid-level, and high-level spectral data fusion strategies. It analyzes the applicability of spectral data fusion technologies, encompassing the fusion between different spectroscopic methods, the integration of spectroscopy with machine vision, electronic noses, and nuclear magnetic resonance in food quality and safety detection. Furthermore, it introduces the application of multi-source spectroscopic sensing technologies, such as

Raman spectroscopy, near-infrared spectroscopy, and laser-induced breakdown spectroscopy, in aquatic product quality and safety detection. The report anticipates the challenges faced and explores the value and future directions of machine learning methods in spectral feature extraction and food quality and safety detection.

Key words: aquatic products; spectrum; quality and safety; non-destructive testing; machine learning

二十碳五烯酸酰化虾青素通过调节肠道菌群-胆汁酸代谢途径改善慢性溃疡性结肠炎

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摘要: 大量研究显示二十碳五烯酸 (EPA) 可以显著改善溃疡性结肠炎 (UC), 但具体机制不明。二十碳五烯酸酰化虾青素 (EPA-AST) 是一种结构独特的鱼油, 前期未有研究探究其对 UC 的改善作用。本研究以 2% 葡聚糖硫酸钠构建慢性 UC 模型, EPA-AST 连续灌胃 3 周, 借助微生物组学与胆汁酸代谢组学技术, 探寻 EPA-AST 对 UC 的潜在改善作用机制。结果表明, EPA-AST 能有效地减轻肠黏膜机械屏障损伤, 同时抑制肠道炎症。16S rRNA 结果显示, EPA-AST 显著增加肠道菌群的 α 和 β 多样性。并且通过降低厚壁菌门和放线菌门的水平, 提高拟杆菌门、变形菌门以及肠杆菌科的水平, 进而调节 BSH 活性细菌的丰度。胆汁酸代谢数据表明, EPA-AST 通过提高次级胆汁酸的水平, 降低初级胆汁酸的水平, 调节粪便胆汁酸谱。此外, EPA-AST 可显著增加胆汁酸受体 TGR5 和 FXR 的表达。综上所述, EPA-AST 通过调节肠道菌群-胆汁酸代谢通路有效缓解 UC。此项研究不仅为利用 EPA 脂质和其他活性物质改善 UC 提供新思路, 也为食品产业高质量发展提供理论依据。

关键词: 二十碳五烯酸酰化虾青素; 溃疡性结肠炎; 肠道菌群; 胆汁酸代谢;

Eicosapentaenoic acid acylated astaxanthin ameliorates chronic ulcerative colitis by modulating the gut microbiota-bile acid metabolism pathway

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Abstract: Numerous studies have shown that eicosapentaenoic acid (EPA) can significantly improve ulcerative colitis (UC), but

the specific mechanism is unclear. Eicosapentaenoic acid acylated astaxanthin (EPA-AST) is a structurally unique fish oil that has not been studied for its improvement effect on UC. This study constructed a chronic UC model using 2% sodium dextran sulfate and gavaged EPA-AST continuously for 3 weeks. The potential improvement mechanism of EPA-AST on UC was explored using microbiome and bile acid metabolomics techniques. The results indicated that EPA-AST could effectively alleviate intestinal mucosal mechanical barrier damage and inhibit intestinal inflammation. The 16S rRNA results showed that EPA-AST significantly increased the α and β diversity of gut microbiota. Moreover, EPA-AST regulated bacteria with BSH activity, such as reducing the levels of *Firmicutes* and *Actinobacteria* and increasing the levels of *Bacteroidetes*, *Proteobacteria*, and *Enterobacteriaceae*. Bile acid metabolism data indicated that EPA-AST regulated the fecal bile acid spectrum by increasing the levels of secondary bile acids and decreasing the levels of primary bile acids. In addition, EPA-AST significantly increased the expression of bile acid receptors TGR5 and FXR. In summary, EPA-AST effectively alleviated UC by regulating gut microbiota and bile acid metabolism. This study not only provides new ideas for improving UC using EPA lipids and other active substances but also provides the theoretical basis for the high-quality development of the food industry.

Keywords: Eicosapentaenoic acid acylated astaxanthin; Ulcerative colitis; Gut microbiota; Bile acid metabolism;

菲律宾蛤仔多糖的结构表征与抗结直肠癌活性研究

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摘要: 生物活性多糖因其抗肿瘤活性好、无毒副作用已引起广泛关注。本研究为以菲律宾蛤仔多糖 (PRPF) 为研究对象, 探究 PRPF 主要活性组分 (PRPF 1-1) 的一级精细结构, 明确其对 AOM/DSS 诱导的结直肠原位癌 (CRC) 动物的抗 CRC 作用效果及机制。结果表明, PRPF 1-1 分子量为 443.661 kDa, 主要由葡萄糖构成, 1,4- α -D-Glcp 为主链, 在 6 号位形成分支, 侧链主要由 1,6- α -D-Glcp 组成, 具有高度分支且分支短的特点。体内外实验表明 PRPF 能够通过免疫调节间接发挥抗 CRC 活性。明显改善改善小鼠体征状态, 缓解结肠萎缩; 通过降低血清促炎因 (IL-1 β 、IL-6、IFN- γ 、TNF- α) 表达, 增加抑炎因子 (L-2、IL-10) 表达, 减少炎症; 增加紧密连接蛋白 Occudin 和黏附分子 E-cadherin 的表达, 修复受损肠粘膜屏障; 逆转肿瘤微环境中巨噬细胞 M2 型向 M1 型极化, 增强巨噬细胞抗癌活性等机制来达到抗 CRC。此外, 研究还发现其会增加肠道有益菌群的多样性和丰度。综上所述, PRPF 作为抗肿瘤试剂开发应用于功能性食品和药物具有巨大潜力, 也为海洋贝类高价值的利用奠定理论基础。

关键词: 菲律宾蛤仔; 多糖; 结直肠癌; 结构表征

Structural characterization and anti-colorectal cancer activity of *Ruditapes philippinarum* polysaccharides

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Abstract: Bioactive polysaccharides have garnered considerable attention due to their potent antitumor activity and lack of toxic side effects. This study focuses on polysaccharides derived from *Ruditapes philippinarum* (PRPF), investigating the primary fine structure of its main active component, PRPF 1-1, and assessing its anticancer effects and mechanisms in an azoxymethane/dextran sulfate sodium (AOM/DSS)-induced colorectal cancer (CRC) animal model. The results demonstrate that PRPF 1-1 has a molecular weight of 443.661 kDa, primarily composed of glucose, with a backbone of 1,4- α -D-Glcp and branching at the 6-position. The side chains consist mainly of 1,6- α -D-Glcp, exhibiting a highly branched and short branching structure. In vitro and in vivo experiments indicate that PRPF exerts its anticancer activity through immune modulation. Notably, PRPF significantly improves the clinical condition of mice, alleviates colon atrophy, reduces the expression of pro-inflammatory cytokines (IL-1 β , IL-6, IFN- γ , TNF- α), and increases anti-inflammatory cytokines (IL-2, IL-10). It also enhances the expression of tight junction protein Occudin and adhesion molecule E-cadherin, thereby repairing the damaged intestinal mucosal barrier. Furthermore, PRPF promotes the polarization of M2 macrophages to M1 macrophages in the tumor microenvironment, enhancing macrophage antitumor activity. Additionally, the study reveals that PRPF increases the diversity and abundance of beneficial gut microbiota. Collectively, these findings suggest that PRPF holds great potential as an antitumor agent for the development of functional foods and pharmaceuticals, while also establishing a theoretical foundation for the high-value utilization of marine bivalves.

Key words: *Ruditapes philippinarum*; Polysaccharides; Colorectal cancer; Structural characterization

风味蜕变与功能升级：发芽大豆的风味特征与蛋白质功能特性研究

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摘要: 本研究旨在深入剖析发芽大豆在风味及蛋白质功能特性上的显著变化, 为发芽大豆在食品工业中的应用提供科学依据。采用 GC-O-MS 等先进风味代谢组学技术, 探索了发芽大豆豆浆 (0 h、24 h、48 h、72 h) 中关键香味化合物形成的分子机制。特别是发芽 24 h 后制备的豆浆甜香味显著提升。这一过程中, 己醛、2-庚酮等 22 种香气物质的增加尤为显著, 这些变化得益于脂肪酸 β -氧化、脂氧合酶催化及糖酵解等代谢途径。同时, 在蛋白质功能特性方面, 发芽处理显著改变了大豆分离蛋白 (SPI) 的吸水性、吸油性及发泡与乳化性能。发芽 24 h 后, SPI 在中性至微酸性 pH 范围内的溶解度增加, 吸水能力达到顶峰后逐渐降低; 而吸油能力在发芽 48 h 后达到最强 (5.169 g/g)。此外, 发芽 SPI 的发泡能力及稳定性显著

提升, 其中发芽 24 h 的 SPI 表现出最佳的乳化能力, 能将乳液滴稳定至 2.80 μm 。值得注意的是, 发芽还增强了 SPI 的自支撑凝胶硬度, 归因于内源蛋白酶活性增加导致的蛋白轻度水解和空间结构变化, 利于形成更强的网络结构。这些研究结果表明, 可以利用发芽作为一种清洁标签工艺来改善大豆的风味和功能特性。

关键词: 大豆; 萌发; 风味组学; 代谢机制; 功能特性

Flavor metamorphosis and functional upgrading: flavor profile and protein functional properties of sprouted soybeans

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Abstract : The aim of this study was to deeply analyze the significant changes in flavor and protein functional properties of sprouted soybeans and to provide a scientific basis for the application of sprouted soybeans in the food industry. Advanced flavor metabolomics techniques, such as GC-O-MS, were used to explore the molecular mechanisms of the formation of key flavor compounds in soybean milk from germinated soybeans (0 h, 24 h, 48 h, and 72 h). In particular, the sweet flavor of soybean milk prepared after 24 h of germination was significantly enhanced. The increase of 22 aroma substances, including hexanal and 2-heptanone, was particularly significant in this process, and these changes were attributed to metabolic pathways such as fatty acid β -oxidation, lipoxygenase catalysis and glycolysis. Meanwhile, in terms of protein functional properties, germination treatment significantly altered the water absorption, oil absorption, and foaming and emulsifying properties of soybean isolate protein (SPI). After 24 h of germination, the solubility of SPI increased in the neutral to slightly acidic pH range, and the water-absorbing capacity peaked and then gradually decreased; while the oil-absorbing capacity reached its strongest (5.169 g/g) after 48 h of germination. In addition, the foaming ability and stability of germinated SPIs were significantly enhanced, with the SPIs germinated for 24 h showing the best emulsification ability, stabilizing the emulsion droplets up to 2.80 μm . Notably, germination also enhanced the self-supporting gel hardness of the SPIs, attributed to the mild hydrolysis of proteins and spatial structural changes resulting from the increased activity of endogenous proteases, which favored the formation of a stronger network structure. These findings suggest that germination can be utilized as a clean label process to improve flavor and functional properties of soybeans.

Key words : Soybean; Germination; Flavoromics; Metabolic mechanisms; Functional properties

负载香菜来源类外泌体纳米囊泡的水凝胶加速皮肤伤口愈合的研究

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摘要: 植物来源的类外泌体纳米囊泡(PDENs)因其抗氧化或抗炎特性, 在有效缓解皮肤伤口

的氧化应激和炎症方向具有应用潜力,有望成为加速伤口愈合进程的新策略。本研究从香菜中提取了类外泌体纳米囊泡(CDENs),发现其能够显著提高人永生化角质细胞(HaCaT)的迁移能力,并通过上调细胞内抗氧化酶的表达有效清除胞内活性氧(ROS),减轻氧化应激对伤口愈合的不利影响。基于此,本研究设计并制备了一种负载 CDENs 的海藻酸钠水凝胶,该水凝胶能稳定释放 CDENs。利用动物实验进一步验证其应用于伤口的愈合效果,结果表明 CDENs 水凝胶能激活 Nrf2 信号通路来调节伤口微环境的氧化平衡,在伤口修复炎症期上调巨噬细胞 M2 极化,在增殖期提高血管内皮生长因子表达,并在重塑期加速胶原蛋白沉积。综上所述,CDENs 水凝胶作为一种有效的促进伤口愈合敷料,为伤口管理提供了新思路。

关键词: 香菜; 类外泌体纳米囊泡; 水凝胶; 氧化应激; 伤口愈合

Coriander-derived exosome-like nanovesicles laden hydrogel accelerates skin wound healing

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Abstract: Plant-derived exosome-like nanovesicles (PDENs) have the potential to effectively relieve oxidative stress and inflammation in skin wounds due to their antioxidant or anti-inflammatory properties, and are expected to become a new strategy to accelerate the wound healing process. In this study, coriander-derived exosome-like nanovesicles (CDENs) were extracted, and it was found that they can significantly improve the migration of human immortalized keratinocytes (HaCaT), and effectively clear intracellular reactive oxygen species (ROS) by up-regulating the expression of intracellular antioxidant enzymes, so as to reduce the adverse effects of oxidative stress on wound healing. Based on this, this study designed and prepared a sodium alginate hydrogel loaded with CDENs, which can release CDENs stably. Animal experiments were performed to further verify the effect of CDENs on wound healing. The results showed that CDENs-hydrogel could activate the Nrf2 signaling pathway to regulate the oxidation balance of wound microenvironment, up-regulate macrophage M2 polarization during inflammation stage, increase vascular endothelial growth factor expression during proliferation stage, and accelerate collagen deposition during remodeling stage. In summary, CDENs-hydrogel, as an effective dressing to promote wound healing, provides a new idea for wound management.

Key words: coriander; exosome-like nanovesicles; hydrogel; oxidative stress; wound healing

改性山药淀粉的制备及其特性研究

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摘要: 山药淀粉的精准加工技术直接制约山药产业的发展, 本研究以“西施种子”山药为原料, 以提高抗性淀粉含量为主要目的, 分别制备了湿热山药淀粉 (RS₃)、柠檬酸山药淀粉酯 (RS₄)、山药淀粉-脂质复合物 (RS₅), 探究 3 种改性方式对山药淀粉结构及理化特性、功能及加工特性的影响规律。研究发现: 三种改性方式对山药淀粉特性影响差异显著, 湿热处理在提高抗性淀粉的同时能够保持良好的淀粉糊化和凝胶特性; 柠檬酸山药淀粉酯抗消化能力最强, 抗性淀粉含量高达 98%; 山药淀粉-脂质复合物的吸附和乳化特性提升最为显著。这为产品原料的选择、产品品质特性改善及新品种研发提供一些较为客观的、数据化的参考, 以达到根据终产品的目标性质, 反向选择用什么方式去处理淀粉的最终目的。

关键词: 山药淀粉; 抗性淀粉; 淀粉改性; 特性研究

Preparation and characterization of modified yam starch

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Abstract: The precise processing technology of yam starch directly restricts the development of yam industry. In this study, damp-heat yam starch (RS₃), citric acid yam starch ester (RS₄), and yam starch-lipid complex (RS₅) were prepared from "Xishi seed" yam as raw materials to improve the content of resistant starch. The effects of three modification methods on the structure, physicochemical properties, function, and processing characteristics of yam starch were investigated. The study found that the three modification methods affected the characteristics of yam starch significantly. Wet-heat treatment could maintain good gelatinization and gel properties while improving the resistant starch. Citric acid yam starch ester had the strongest anti-digestion ability, and the resistant starch content was up to 98%. The adsorption and emulsification properties of yam starch-lipid complexes were most significantly. This will provide some objective and data reference for the selection of raw materials, the improvement of product quality characteristics and the research and development of new varieties, so as to achieve the ultimate goal of reverse selection of how to treat starch according to the target nature of the final product.

Key words: Yam starch; Resistant starch; Starch modification; Study on characteristics

甘薯 α -葡萄糖苷酶抑制肽的制备及降低餐后血糖作用研究

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摘要: 废水是甘薯淀粉生产过程中的副产物, 富含蛋白质, 常被丢弃造成资源浪费和环境污染。本研究从甘薯淀粉生产废水中回收甘薯蛋白, 采用热高压辅助酶解蛋白制备甘薯肽 (Sweet potato peptides, SPP), 并通过单因素和响应面试验优化其制备工艺, 经超滤膜分离筛选 α -葡萄糖苷酶抑制活性最优组分, 鉴定序列并探究其稳定性和血糖调节作用。结果如下: 确定碱性蛋白酶为最佳水解酶。最优酶解条件为: 料液比 1:20 (w/v), 酶添加量 4%, 水解时间 3 h, 高压压力 200 MPa, 高压时间 6 min, 在此条件下多肽得率为 76.89%, α -葡萄糖苷酶抑制率为 70.93%。通过超滤法获得分子量小于 3 kDa 的组分 SPP-1, 其 α -葡萄糖苷酶抑制活性 (IC_{50} 值为 6.14 mg/mL) 显著高于其他组分 ($P < 0.05$), 并表现出良好的热稳定性、耐酸碱性和胃肠道消化稳定性。SPP-1 经 LC-MS/MS 鉴定得到肽段 1204 条, 通过分子对接筛选获得 3 条高活性的新肽段。动物实验结果表明, SPP-1 能够延缓餐后血糖上升, 其效果呈浓度依赖效应。本研究为甘薯废水综合利用及新型降血糖功能食品的开发提供了理论依据。

关键词: 多肽; 甘薯; α -葡萄糖苷酶抑制活性; 稳定性; 餐后血糖

Preparation of α -glucosidase inhibitory peptides from sweet potato and study on the effect of reducing postprandial blood glucose

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Abstract: Wastewater, a protein enriched byproduct of sweet potato starch production, is often discarded that leads to resource waste and environmental pollution. This study aimed to recycle sweet potato protein from wastewater and prepare sweet potato peptides (SPP) using thermal high-pressure-assisted enzymatic hydrolysis. The process was optimized through single-factor experiments and response surface methodology. After ultrafiltration, the fraction with the highest α -glucosidase inhibitory activity was selected for peptides sequence identification, stability evaluation and blood glucose regulative effect investigation. The results showed that alkaline protease was identified as the optimal enzyme for hydrolysis. The optimal hydrolysis conditions were as follows: 1:20 (w/v) for solid-liquid ratio, 4% for enzyme to substrate ratio, 3 hours for hydrolysis time, 200 MPa for pressure of HPP and 6 minutes for HPP time. The peptide yield was 76.89%, and the α -glucosidase inhibition rate was 70.93% under these conditions. The fraction SPP-1, with a molecular weight of less than 3 kDa, was obtained through ultrafiltration and exhibited significantly higher α -glucosidase inhibitory activity ($IC_{50} = 6.14$ mg/mL) compared to other fractions ($P < 0.05$).

SPP-1 also displayed good thermal stability, pH tolerance, and gastrointestinal digestion stability. A total of 1,204 peptides sequences were identified by LC-MS/MS from SPP-1, and three highly active novel peptides were screened out through molecular docking. Animal experiments further showed that SPP-1 could effectively delay postprandial blood glucose elevation in a dose-dependent manner. This study provides a theoretical basis for the comprehensive utilization of sweet potato wastewater and development of novel hypoglycemic functional foods.

Key words : Peptide; sweet potato; α -glucosidase inhibitory activity; stability; postprandial blood glucose

高品质卤蛋产品加工工艺研究与产品开发

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摘要: 本研究探讨了超高压处理对卤蛋感官性能及理化性质的影响, 结果表明, 超高压能够显著改善卤蛋的质构, 咀嚼性显著增强 ($P < 0.05$); 在光泽、滋味、香味方面都有一定改善; 蛋白、蛋黄的微观结构发生显著改变; 还能显著延长保质期。得到的最佳超高压条件为: 真空包装后超高压 400 MPa 保压 300 s, 再进行高温灭菌处理。经感官评价分析, 该条件下制得的卤蛋具有颜色分布均匀、色泽鲜亮、有弹性、咸度适中、有成熟卤蛋香气等特点, 感官质量整体评价较高。并详细介绍了最佳超高压处理条件下卤蛋产品的创新性及其生产工艺, 为超高压技术应用于卤蛋的生产开发提供了研究思路、基础与依据。

关键词: 超高压; 卤蛋; 感官性能; 理化性质

Research on processing technology and product development of high-quality marinated egg products

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Abstract: In this study, the effects of ultra-high pressure treatment on the sensory properties and physicochemical properties of marinated eggs were investigated. The results showed that ultra-high pressure could significantly improve the texture of marinated eggs and significantly enhance the chewiness ($P < 0.05$). There are some improvements in gloss, taste and aroma. The microstructure of protein and egg yolk changed significantly. It can also significantly prolong the shelf life. The optimum ultra-high pressure conditions were as follows: ultra-high pressure 400 MPa for 300 s after vacuum packaging, and then high temperature sterilization. The sensory evaluation analysis showed that the marinated eggs prepared under this condition had the characteristics of uniform color

distribution, bright color, elasticity, moderate saltiness, and mature marinated egg aroma, and the overall evaluation of sensory quality was high. The innovation and production process of marinated egg products under the optimum ultra-high pressure treatment conditions were introduced in detail, which provided research ideas, basis and basis for the application of ultra-high pressure technology in the production and development of marinated eggs.

Key words: ultra-high pressure; marinated eggs; sensory properties; physicochemical properties

高压均质引起的果胶特性变化对浑浊山楂汁稳定性的影响

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摘要: 研究了高压均质 (HPH) 对浑浊山楂汁稳定性, 营养成分, 感官属性以及水溶性果胶结构和理化性质的影响, 探明高压均质引起的内源性果胶特性变化对于浑浊山楂汁稳定的影响。结果表明, HPH 可以降低浑浊山楂汁样品的平均粒径和沉降指数 (IS), 提悬浮稳定性, 减少浑浊山楂汁在货架期内的颗粒沉降; 然而, 过度的 HPH 处理会导致果汁的营养丰富度和感官质量下降。果胶作为影响浑浊山楂汁稳定性的关键因素, 与未均质相比, HPH 使山楂果胶酯化度 (DE), 分子量 (Mw) 降低, 并引起果胶侧链的降解, 使得果胶的粘度增加, 乳化能力增强; 同样降低了果胶的平均粒径, 并且随着压力的增加, 呈现出和果汁粒径相同的降解增强趋势。这些关于溶液中果胶的结构及理化性质的发现不仅为高品质山楂浑浊汁生产提供理论基础, 也为高压均质技术在浑浊果汁的应用提供理论依据和技术支持。

关键词: 高压均质; 浑浊山楂汁; 山楂果胶

Effect of changes in pectin properties induced by high pressure homogenisation on the stability of turbid hawthorn juice

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Abstract: The effects of high pressure homogenisation (HPH) on the stability, nutrient composition, organoleptic properties, and structure and physicochemical properties of water-soluble pectin in turbid hawthorn juice were investigated, and the effects of endogenous pectin property changes induced by HPH on the stability of turbid hawthorn juice were investigated. The results showed that HPH could reduce the average particle size and sedimentation index (IS) of the turbid hawthorn juice samples, improve the suspension stability, and reduce the

particle settling of turbid hawthorn juice during the shelf-life; however, excessive HPH treatment could lead to a decrease in the nutrient richness and organoleptic quality of the juice. Pectin, as a key factor affecting the stability of turbid hawthorn juice, HPH reduced the degree of esterification (DE), molecular weight (Mw) of hawthorn pectin and caused degradation of the pectin side chains, resulting in increased viscosity and emulsification of the pectin, compared with unhomogenised pectin; it reduced the average particle size of the pectin and showed the same trend of enhanced degradation with increasing pressure as that of the juice particle size. These findings on the structure and physicochemical properties of pectin in solution not only provide a theoretical basis for the production of high-quality hawthorn turbid juice, but also provide a theoretical basis and technical support for the application of high-pressure homogenisation technology in turbid juice.

Keyword: High pressure homogenisation; Turbid hawthorn juice; Hawthorn pectin

植物源 3D 打印三文鱼肉样品构建及质构特征强化

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摘要: 植物基鱼类模拟物是解决传统水产养殖业效率低下和环境挑战的可持续解决方案。本研究利用 3D 打印和转谷氨酰胺酶(TGase)后处理技术构建了结构稳定的三文鱼片模拟物。优化含有玉米淀粉、亚麻籽油和豌豆蛋白的生物墨水, 用于构建结构稳定的肌节模拟物。亚麻籽油和豌豆蛋白肌膈生物墨水随后根据真实三文鱼片的宏观营养成分注入到 3D 打印的肌节模拟物中。对肌节和肌膈生物墨水的流变特性以及肌节和肌膈类似物的微观结构和化学成分进行了系统表征。在肌节和肌膈模拟物中加入 TGase 以实现糊-固转化。此外研究了生熟三文鱼片模拟物的质构特性。制备的三文鱼片模拟物在肌节模拟物中表现出类似鱼肉的纤维结构, 与真实三文鱼肉相似, 表明其在模拟更好的鱼肉质地方面具有巨大潜力。

关键词: 3D 食品打印; 转谷氨酰胺酶质构化; 三文鱼片模拟物

Construction of 3D printed salmon fillet simulants and enhancement of its post-printing texturization via transglutaminase

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Abstract: Plant-based fish analogues have been proposed as a sustainable solution to address the inefficiencies and environmental challenges of traditional aquaculture. In this study, structurally stable salmon fillet simulants were constructed using three-dimensional (3D) printing technology coupled with transglutaminase (TGase) post-treatment. The myomere bioinks containing corn starch, flaxseed oil, and pea protein were optimised for the construction of

structurally stable simulants. The flaxseed oil and pea protein myosepta bioinks were then injected into the 3D printed myomere analogues according to the macronutrients of real salmon fillets. The rheological properties of the myomere and myosepta bioinks, as well as the microstructure and chemical composition of the myomere and myosepta analogues, were systematically characterized. TGase was added to both myomere and myosepta simulants for paste-solid transformation. Moreover, the textural properties of the raw and cooked salmon fillet simulants were investigated. The prepared salmon fillet simulants exhibited fish muscle-like fibre structures in myomere analogues and good similarity to real salmon meat, demonstrating the great potential in simulating better fish meat texture.

Keywords: 3D food printing; Transglutaminase texturization; Salmon fillet simulants

谷氨酸抑制鲜切马铃薯褐变的作用及 StERF-BR1-like 的调控机制

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摘要: 酶促褐变是影响鲜切马铃薯品质和商品价值的主要问题, 安全褐变抑制剂的筛选及其抑制机制的探索是目前研究的热点。本研究发现, 采用浓度 15 g/L 的谷氨酸溶液处理马铃薯丝 4 分钟, 可将 4°C 贮藏的鲜切马铃薯丝货架期延长至 5 天。结果显示, 谷氨酸处理可以显著降低鲜切马铃薯丝的总酚、H₂O₂、O₂-含量, 提升 CAT、APX、SOD 和 GPX 活性, 同时, 组氨酸、丝氨酸等 10 种氨基酸含量显著上升。分子对接证明谷氨酸能与 PPO 的活性位点结合, 通过降低 pH 值和螯合 Cu²⁺ 来抑制多酚氧化酶 (PPO) 的活性。进一步通过转录组学分析发现, 在 Glu 处理组和对照组中, 存在大量的差异表达基因, 主要富集在谷胱甘肽代谢、类黄酮生物合成、苯丙氨酸代谢、苯丙素生物合成、淀粉和蔗糖代谢及植物激素信号转导途径, Glu 处理显著影响了它们的转录水平。通过 RT-qPCR 发现, StPPO2、StPPO3、StPPO7 和 StERF-BR1-like 的转录水平受到明显抑制。StERF-BR1-like 作为核蛋白, 可通过直接结合 StPPO2 启动子激活其转录。上述结果表明 Glu 可以通过调节上述途径抑制鲜切马铃薯的褐变, StERF-BR1-like 通过激活 StPPO2 的表达参与褐变抑制过程。

关键词: 鲜切马铃薯; 褐变; 谷氨酸; 转录组学分析; StERF-BR1-like

Transcriptomic analysis reveals that glutamic acid-regulated key factors inhibit browning in fresh-cut potatoes

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Abstract: Enzymatic browning is a major issue affecting the quality and commercial value of fresh-cut potatoes, and the screening of safe browning inhibitors and exploration of their inhibition mechanisms is currently a research hotspot. This study found that treating potato strips with a 15 g/L glutamic acid solution for 4 minutes can extend the shelf life of fresh-cut potato strips stored at 4°C to 5 days. Results showed that glutamic acid treatment

significantly reduced the total phenol, H₂O₂, and O₂·- content in fresh-cut potato strips while enhancing the activities of CAT, APX, SOD, and GPX. Additionally, the content of Histidine, serine, and other amino acids increased significantly. Molecular docking confirmed that glutamic acid can bind to the active site of PPO, inhibiting polyphenol oxidase (PPO) activity by lowering pH and chelating Cu²⁺. Further transcriptomic analysis revealed a large number of differentially expressed genes between the Glu treatment and control groups, mainly enriched in glutathione metabolism, flavonoid biosynthesis, phenylalanine metabolism, phenolic compound biosynthesis, starch and sucrose metabolism, and plant hormone signal transduction pathways, with Glu treatment significantly affecting their transcription levels. RT-qPCR analysis indicated that the transcription levels of StPPO2, StPPO3, StPPO7, and StERF-BR1-like were significantly inhibited. StERF-BR1-like, as a nuclear protein, can activate StPPO2 transcription by directly binding to its promoter. These results suggest that Glu can inhibit browning in fresh-cut potatoes by regulating the aforementioned pathways, with StERF-BR1-like participating in the browning inhibition process by activating StPPO2 expression.

Key words: Fresh-cut potatoes; browning; glutamic acid; transcriptomic analysis; StERF-BR1-like

光皮木瓜乳酸菌饮品发酵工艺及品质研究

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摘要: 本文以光皮木瓜为原料制备乳酸菌发酵饮品, 对发酵工艺优化并对发酵汁品质研究。首先对发酵菌株筛选, 探究了3种乳酸菌即鼠李糖乳杆菌、副干酪乳杆菌及植物乳杆菌单菌发酵和两菌混合发酵对光皮木瓜汁的影响, 其中副干酪乳杆菌产酸能力最强, 当其与另外两种乳酸菌混合发酵时产酸能力和活菌数均有提升。此外混菌发酵的光皮木瓜汁在风味组成上更加丰富, 其中以鼠李糖乳杆菌和副干酪乳杆菌的发酵风味最佳, 增加了3-羟基-2-丁酮、2-庚酮等奶香风味的成分。在此基础上探究了浸渍时间、发酵初始 pH 及发酵温度对发酵汁品质的影响, 当浸渍时间 8.5 h, 初始 pH5.5, 发酵温度 31℃时, 发酵汁感官品质最佳, 发酵 48 h 活菌数可达 8.3 lgCFU/mL。对发酵汁的品质研究发现, 随发酵的进行, 光皮木瓜汁由原来的果汁清香增加了酸甜的发酵香, 有机酸主要为乳酸和酒石酸; 发酵过程会伴随多酚类物质的利用, 发酵后光皮木瓜汁中的酚类以表儿茶素、绿原酸、儿茶素、原儿茶酸为主。

关键词: 光皮木瓜; 乳酸菌; 发酵饮品; 风味

Research on the fermentation technology and quality of lactic acid bacteria in *Chaenomeles sinensis* (Thouin) Koehne

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Abstract : The objective of this study was to investigate the fermentation conditions and quality of *Chaenomeles*

sinensis (Thouin) Koehne as a raw material for production of fermented juice by lactic acid bacteria. Three lactic acid bacteria strains (*Lacticaseibacillus rhamnosus*, *Lacticaseibacillus paracasei* and *Lactiplantibacillus plantarum*) were studied. The acid production capacity of *Lactobacillus paracei* was the best, while the mixture of *Lacticaseibacillus paracasei* and *Lacticaseibacillus rhamnosus* or *Lactiplantibacillus plantarum* showed higher acid production capacity and more viable counts. In addition, the flavor compounds of the mixture of *Lacticaseibacillus paracasei* and *Lacticaseibacillus rhamnosus* was more abundant, because of the production of 3-hydroxy-2-butanone, 2-heptanone and other fermentation flavor compounds. Three effects on the quality of fermented juice were investigated. When the impregnation time was 8.5 h, pH was 5.5 and the fermentation temperature was 31°C, the sensory quality of fermented juice was the best, and the viable cell counts reached above 8.3 lgCFU/mL. During the fermentation process, the sweet and sour fermentation flavor was increased compared with the original juice fragrance, and the organic acids were mainly lactic acid and tartaric acid. The fermentation process is accompanied by the utilization of polyphenols, and the phenolic compounds in the juice after fermentation are mainly epicatechin, chlorogenic acid, catechin and Protocatechuic acid.

Key words : *Chaenomeles sinensis* (Thouin) Koehne; Lactic acid bacteria; Fermented juice; Flavor volatiles

海参肠卵水解物通过调节肠道菌群及其代谢物干预并改善葡聚糖硫酸钠诱发的结肠炎症状

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摘要: 结肠炎是一种严重影响日常生活的炎症性疾病, 近来已引起广泛关注。然而, 海参肠卵水解物 (CFHs) 对结肠炎的影响尚未得到充分探讨。本研究利用葡聚糖硫酸钠诱导的结肠炎实验模型来评估海参肠卵水解物的治疗潜力。研究表明, 预防性服用 CFHs 能显著减轻小鼠结肠炎的相关病理表现, 包括体重减轻、结肠缩短和组织损伤。此外, CFHs 还能抑制结肠组织中促炎症细胞因子 IL-6、TNF- α 和 IL-1 β 以及 MPO 的分泌。宏基因组测序结果表明, CFHs 可以通过加强拟杆菌门和抑制疣微菌门来恢复失调肠道菌群的平衡, 从而对各种微生物功能产生影响。代谢组分析进一步显示, CFHs 对 DSS 诱导的代谢异常具有更有效的调节作用, 包括氨基酸生物合成、亚油酸代谢和多巴胺能突触。总之, CFHs 在缓解结肠炎方面表现出良好前景, 为开发和应用 CFHs 作为缓解结肠炎的功能性食品奠定了基础。

关键词: 结肠炎; 海参肠卵水解物; 肠道菌群及其代谢物

Sea cucumber intestines and ovum hydrolysates intervention ameliorates the symptoms of dextran sulfate sodium-induced colitis by modulating gut microbiota and its metabolites

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Abstract: Colitis, a troublesome inflammatory disease that significantly impacts daily life, has garnered considerable attention in recent times. However, the effects of sea cucumber intestines and ovum hydrolysates (CFHs) on colitis have not been fully explored. This study utilized a dextran sulfate sodium-induced experimental colitis model to assess the therapeutic potential of CFHs. The findings indicated that preventive administration of CFHs dramatically attenuated the pathological manifestations associated with colitis in mice, including weight loss, colon shortening, and tissue damage. Furthermore, CFHs suppressed the secretion of pro-inflammatory cytokines IL-6, TNF- α , and IL-1 β , as well as MPO in colon tissue. Metagenomic sequencing demonstrated that CFHs could restore balance to the dysregulated gut microbiota by reinforcing *Bacteroidota* and suppressing *Verrucomicrobia* populations, impacting various microbial functions. Metabolomic analyses further revealed that CFHs exhibited a more efficacious modulatory effect on DSS-induced metabolic abnormalities, including amino acid biosynthesis, linoleic acid metabolism, and dopaminergic synapses. In conclusion, CFHs showed promise in alleviating colitis, laying the groundwork for the development and application of CFHs as functional food for colitis relief.

Key words: Colitis; Sea cucumber intestines and ovum hydrolysates; Gut microbiota and its metabolites

海参卵水解物通过调节肠道菌群缓解小鼠结肠炎的研究

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摘要: 结肠炎仍然是临床上的一项重大挑战。本研究旨在阐明海参卵水解物 (SCH) 对小鼠葡聚糖硫酸钠 (DSS) 诱导的结肠炎模型中结肠炎症反应以及肠道菌群和代谢物变化的影响。研究表明, 口服 SCH 可减轻葡聚糖硫酸钠诱导的结肠炎的严重程度。脾脏指数的显著改善、结肠组织损伤严重程度的降低及血清促炎因子水平的下降表明, 口服 SCH 能有效缓解结肠炎小鼠的炎症症状。此外, 对肠道内容物进行的宏基因组分析结果表明, 在 SCH 的干预下, 有益微生物增加, 促炎症细菌减少。结肠组织的代谢组分析结果表明, 口服 SCH 后, 结肠炎小鼠体内的苯乙酸、2-羟基戊二酸和 L-天门冬氨酸等抗炎代谢物水平升高。总之, SCH 是一种有望治疗结肠炎的候选药物。

关键词: 海参卵水解物; 结肠炎; 微生物代谢

Sea cucumber ovum hydrolysates ameliorate colitis in mice by regulating intestinal flora

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Abstract: Inflammatory bowel disease continues to pose a significant challenge in clinical settings. This study aimed to elucidate the effects of sea cucumber ovum hydrolysates (SCH) on the colonic inflammatory response, as well as on alterations in the intestinal microbiota and metabolites in a mouse model of dextran sulfate sodium (DSS)-induced colitis. The findings suggested that oral administration of SCH might mitigate the severity of DSS-induced colitis. Notable improvements in the splenic index, a reduction in the severity of colonic tissue damage, and decreased levels of serum pro-inflammatory factors indicated that oral administration of SCH effectively alleviated symptoms and inflammation in colitis-affected mice. Furthermore, macrogenomic analysis of intestinal contents revealed an increase in beneficial microorganisms and a decrease in pro-inflammatory bacteria following SCH intervention. Metabolomic analysis of colonic tissues identified elevated levels of anti-inflammatory metabolites, such as Phenyllactate, 2-Hydroxyglutarate, and L-Aspartic acid, in colitis mice after oral administration of SCH. In conclusion, SCH represents a promising candidate for the treatment of colitis.

Key words: Sea cucumber ovum hydrolysates; Colitis; Microbial metabolism

耗尽吸引驱动微藻蛋白基乳液凝胶的构建及应用

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摘要: 随着全球人口的增长及蛋白质需求的增加, 迫切需要开发新的蛋白质资源。与传统农业和畜牧业相比, 微藻是一种具有吸引力的可持续蛋白质来源, 其优势包括可大规模扩展、低二氧化碳排放以及生产每单位蛋白质的土地和淡水资源需求显著减少。此外, 许多微藻富含蛋白质 (>40wt%), 且具有符合人类膳食需求的必需氨基酸 (EAA) 组成。然而, 微藻蛋白的开发及利用仍处于初始阶段, 因此挖掘其功能特性是重要的。本研究发现在高粘度藻泥体系中, 微藻释放的高分子多糖通过“耗尽”吸引 (Depletion attraction), 促使水溶性的色素蛋白复合颗粒吸附并稳定油-水界面, 也使形成的油滴聚集, 形成凝胶网络结构, 通过调整油水体积比, 产生结构可控的乳液凝胶, 具有优异的 3D 打印特性和良好的涂抹特性。这不仅为利用新蛋白资源设计和构建未来食品提供理论依据和技术支持, 对实现微藻蛋白可持续加工与应用具有现实的重要意义, 也为在高粘度食品体系中乳化提供新见解和新方法。

关键词: “耗尽”吸引; 微藻蛋白; 乳液凝胶; 油-水界面; 高粘度食品体系

Depletion attraction driven formation of microalgae protein-based emulsion gels and their applications

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Abstract: With the global population burgeoning and concomitant escalation in protein demands, the imperative to explore novel protein resources has become increasingly pronounced. Microalgae, in comparison to conventional agricultural and livestock practices, stand out as an enticing and sustainable reservoir of proteins, distinguished by attributes such as mass scalability, low CO₂ emissions, and significantly reduced land and freshwater use per unit protein. Numerous microalgae species boast protein contents exceeding 40wt%, coupled with EAA compositions harmonizing with human dietary requirements. Despite these promising attributes, the development and exploitation of microalgal proteins remain nascent, underscoring the imperative to delve into their functional characteristics. This study elucidates a mechanism wherein, within a high-viscosity algal slurry milieu, the liberation of high-molecular-weight polysaccharides from microalgae, driven by depletion attraction, induces the adsorption and stabilization of water-soluble pigment-protein composite particles at the oil-water interface. Concurrently, this process instigates the aggregation of oil droplets, giving rise to a gel-like network structure. Manipulation of the oil-to-water volume ratio yields a structurally controllable emulsion gel, demonstrating commendable 3D printing attributes and favorable spreading characteristics. These revelations not only furnish theoretical and technical underpinnings for the conceptualization and construction of future foods utilizing nascent protein resources but also bear pragmatic significance for the sustainable processing and application of microalgal proteins. Additionally, they contribute novel insights and methodologies to the domain of emulsification within high-viscosity food systems.

Key words: Depletion attraction; Microalgae protein; Emulsion gel; Oil-water interface; High-solids viscous food slurries

核酸是重要的营养物质——核酸的分解及吸收

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摘要: 核酸在生物学上的作用受到越来越多的重视, 特别是最近不断发现 RNA 具有基因调控及信息传递等多种新功能。另一方面, 包括单核苷酸在内的核酸类物质在食品工业中得到了越来越多的应用, 如婴配奶粉、特医食品、功能食品、鲜味剂等等。但在营养学上核酸类物质的作用长久被忽视, 造成食品中核酸类物质的应用与基础研究严重脱节, 食品中使用核酸类物质迫切需要科学研究给予理论支持。通过从核酸营养的角度进行研究, 最近我们获得

了一些非常惊奇的发现，如胃蛋白酶可以分解核酸，一些 DNA 酶可以分解 RNA，很多微生物能直接吸收大分子核酸等。这些结果表明食物中的核酸在被摄入后不但具有重要的基因调控功能，还是重要的宏量营养素。我们坚信，从营养学角度研究核酸类物质，将为其在食品工业中的应用提供理论支持，也为开发新的功能性食品提供充分的理论依据。

关键词：核酸；核酸酶；核酸代谢；功能食品；特医食品

Nucleic Acids Are Important Nutrients—Decomposition and Absorption of Nucleic Acids

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Abstract: The role of nucleic acids in biology is receiving increasing attention, especially with the recent discovery that RNA has multiple new functions such as gene regulation and information transmission. On the other hand, nucleic acid substances, including single nucleotides, have been increasingly used in the food industry, such as infant formula, specialty foods, functional foods, flavorings, and so on. However, the role of nucleic acid substances has long been overlooked in nutrition, resulting in a serious disconnect between the application of nucleic acid substances in food and basic research. The use of nucleic acid substances in food urgently requires scientific research to provide theoretical support. Through research from the perspective of nucleic acid nutrition, we have recently made some amazing discoveries, such as gastric protease can break down nucleic acids, some DNA enzymes can break down RNA, and many microorganisms can directly absorb large molecular nucleic acids. These results indicate that nucleic acids in food not only have important gene regulatory functions after ingestion, but also serve as important macronutrients. We firmly believe that studying nucleic acid substances from a nutritional perspective will provide theoretical support for their application in the food industry and provide sufficient theoretical basis for the development of new functional foods.

Key words: Nucleic acid; Nucleases; Nucleic acid metabolism; Functional food; Special Medical Food

红茶菌通过 Nrf2/HO-1/NQO-1 通路改善氧化应激缓解小鼠结肠炎

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摘要：溃疡性结肠炎（Ulcerative Colitis, UC）是一种慢性炎症性肠道疾病，其临床表现为特

久或持续性腹泻、腹痛、饱胀、便血、体重下降等。目前 UC 的确切发病机制尚不清楚，但氧化应激和免疫失调被认为是导致 UC 的危险因素。茶菌（Kombucha）是一种传统微生物发酵饮料，因其早期常使用红茶进行发酵，又名红茶菌，具有一定的抗氧化功效，但其是否具有缓解肠道炎症的作用尚未见报道。在本项研究中，我们比较了不同来源红茶菌对结肠炎小鼠的改善效果及其抗炎和抗氧化作用，并探讨了其相关机制。本研究基于葡聚糖硫酸钠（DSS）诱导小鼠溃疡性结肠炎模型，采用不同来源、不同剂量的红茶菌发酵液进行干预。实验结果表明，红茶菌能够显著降低疾病活动指数（DAI）评分，缓解小鼠体重减轻和结肠缩短，改善脾脏指数以及结肠病理损伤，且不同来源和不同干预剂量作用效果不同。进一步研究发现，红茶菌能够降低脂质氧化产物丙二醛（MDA）和髓过氧化物酶（MPO）的含量，提高超氧化物歧化酶（SOD）和谷胱甘肽（GSH）的含量，基于 qPCR 检测并结合 Western blot 检测相关蛋白的表达，结果表红茶菌能够通过 Nrf2/HO-1/NQO-1 通路改善氧化应激，进而缓解 DSS 造成的溃疡性结肠炎。

关键词：红茶菌；溃疡性结肠炎；氧化应激；作用机制

Kombucha tea alleviates ulcerative colitis by ameliorating oxidative stress through the Nrf2/HO-1/NQO-1 pathway

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Abstract: Ulcerative Colitis (UC) is a chronic inflammatory bowel disease characterized by persistent or continuous diarrhea, abdominal pain, fullness, blood in the stool, and weight loss. The exact pathogenesis of UC is currently unknown, but oxidative stress and immune dysregulation are considered risk factors for UC. Kombucha, a traditional microbial fermented beverage, also known as black tea bacteria because it was often fermented with black tea in its early days, has some antioxidant properties. However, whether it has a role in relieving intestinal inflammation has not been reported. In this study, we compared the ameliorative effects of different sources of Kombucha on mice with colitis and their anti-inflammatory and antioxidant effects and explored the mechanisms involved. The study was based on the dextran sodium sulfate (DSS)-induced ulcerative colitis model in mice, with the intervention of different sources and dosages of Kombucha. Experimental results indicated that Kombucha significantly decreased Disease Activity Index (DAI) scores, relieving weight loss and colon shortening in mice, while also enhancing splenic indices and reducing pathological damage to the colon. The effect varies depending on the source and the dosage of the intervention. Further research showed that Kombucha was able to reduce levels of the lipid oxidation products malondialdehyde (MDA) and myeloperoxidase (MPO) while increasing levels of superoxide dismutase (SOD) and glutathione (GSH). Using qPCR assay and Western blot, the results indicate that Kombucha can alleviate oxidative stress via the Nrf2/HO-1/NQO-1 pathway, which in turn alleviates ulcerative colitis caused by DSS.

Key words: Kombucha; Ulcerative colitis; Oxidative stress; Mechanism of action

基于 Zn-CuGaO₂@CMK-3 信号放大的高灵敏度电化学传感平台同时检测食品中的日落黄和柠檬黄

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摘要: 这项工作中, 成功开发了一种基于锌掺杂铜镓氧化物包有序介孔碳 CMK-3 (Zn-CuGaO₂@CMK-3)的高灵敏度电化学传感器, 用于信号放大, 同时检测食品中的日落黄(SY)和柠檬黄(TZ)。与 CuGaO₂@CMK-3 相比, 由于 Zn-CuGaO₂@CMK-3 载流子密度的提高, 电导率和催化性能都得到了提高, 有利于 SY 和 TZ 的电氧化。在最佳测试条件下, 所构建的 Zn-CuGaO₂@CMK-3/GCE 传感器具有较宽的线性浓度范围(0.25 ~ 100.00 μM), 可同时检测 SY 和 TZ。SY 和 TZ 的检出限分别为 0.044 μM 和 0.059 μM。在牛奶、白醋和饼干样品中进行添加回收实验, 回收率为 82.70%~114.80%。将该传感器成功应用于两种碳酸饮料中 SY 和 TZ 残留的检测, 结果与高效液相色谱法检测结果基本一致(P>0.05)。

关键词: 锌掺杂铜镓氧化物; 有序介孔碳; 电化学传感器; 日落黄; 柠檬黄

A highly sensitive electrochemical sensing platform based on Zn-CuGaO₂@CMK-3 signal amplification for simultaneous detection of the sunset yellow and tartrazine in foods

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Abstract : In this work, a highly sensitive electrochemical sensor based on Zn-doped copper gallium oxide@ordered mesoporous carbon (Zn-CuGaO₂@CMK-3) for signal amplification was successfully developed for the simultaneous detection of sunset yellow (SY) and tartrazine (TZ) in foods. Compared with CuGaO₂@CMK-3, Zn-CuGaO₂@CMK-3 offered enhanced conductivity and catalytic properties owing to the improved carrier density, which was beneficial to the electrooxidation of SY and TZ. Under the optimal testing conditions, the constructed Zn-CuGaO₂@CMK-3/GCE sensor offered a wide linear concentration range (0.25 to 100.00 μM) for the detection of both SY and TZ. The limits of detection for SY and TZ were 0.044 μM and 0.059 μM, respectively. Recovery experiments were performed in milk, white vinegar and biscuit samples, yielding satisfactory recoveries (82.70%-114.80%). Furthermore, the sensor was successfully applied to the determination of the SY and TZ residues in two kinds of carbonated drinks, and the results were nearly consistent with those detected by the high performance liquid chromatography (HPLC) method (P>0.05).

Key words : Zn-doped copper gallium oxide; Ordered mesoporous carbon; Electrochemical sensor; Sunset yellow; Tartrazine

基于 β -乳球蛋白发掘新型纤溶酶抑制剂增强 UHT 乳贮藏稳定性研究

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摘要: 纤溶酶引起的蛋白质水解显著影响了超高温 (UHT) 乳的稳定性。研究发现, β -乳球蛋白 (β -Lg) 能够抑制纤溶酶活性, 表明 β -Lg 中存在纤溶酶抑制剂的活性位点。本研究通过实验和计算模拟技术发掘源于 β -Lg 的纤溶酶抑制肽。结果表明, 随着 β -Lg 变性程度的增加, 其与纤溶酶的亲和力增强, 具有更高的纤溶酶活性抑制力。分子动力学模拟显示, 静电力和范德华力是 β -Lg/纤溶酶复合物中的主要结合力。变性的 β -Lg 增加了氢键的形成并降低了其与纤溶酶的结合能。研究发现 β -Lg 与纤溶酶的活性位点分别为 His624、Asp667 和 Ser762。基于这些结合位点, 从 β -Lg 中鉴定出了四种纤溶酶抑制肽: QTMKGLDI、EKTKIPAV、TDYKKYLL 和 CLVRTPEV。这些肽有效抑制了纤溶酶活性, 增强了 UHT 乳的稳定性。本研究为开发新型纤溶酶抑制剂以提高 UHT 乳的稳定性提供了新见解。

关键词: β -乳球蛋白; 纤溶酶; 活性肽; 分子动力学模拟; UHT 乳

Study on the Development of Novel Plasmin Inhibitors Based on β -Lactoglobulin to Enhance the Storage Stability of UHT Milk

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Abstract: Plasmin-induced protein hydrolysis significantly compromises the stability of ultra-high-temperature (UHT) milk. It has been reported that β -lactoglobulin (β -Lg) can inhibit plasmin activity, suggesting the presence of active sites for plasmin inhibition within β -Lg. In this study, plasmin inhibitory peptides derived from β -Lg were explored using experimental and computational simulation techniques. The results showed that as the degree of β -Lg denaturation increased, its affinity for plasmin was enhanced, leading to stronger inhibition of plasmin activity. Molecular dynamics simulations indicated that electrostatic and van der Waals forces were the primary binding forces in the β -Lg/plasmin complex. Denatured β -Lg increased hydrogen bonding and reduced its binding energy with plasmin. The study identified the active binding sites between β -Lg and plasmin as His624, Asp667, and Ser762. Based on these binding sites, four plasmin inhibitory peptides were identified from β -Lg: QTMKGLDI, EKTKIPAV, TDYKKYLL, and CLVRTPEV. These peptides effectively inhibited plasmin activity and enhanced the stability of UHT milk. This study provides new insights for the development of novel plasmin inhibitors to improve the stability of UHT milk.

Keywords: β -lactoglobulin; plasmin; bioactive peptides; molecular dynamics simulation; UHT milk

基于多聚结构域的紫菜多糖酶活性优化方法

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摘要: 紫菜是最具经济价值的红藻种类之一, 其主要生物活性多糖是紫菜多糖。高活性的酶对紫菜多糖的研究与开发具有重要意义。本研究从多糖结合蛋白中发现了一个二聚体结构域 (PKD), 具有潜在的诱导蛋白聚集功能。通过融合表达构建 PKD 结构域与紫菜多糖酶 Por16B_Wf 的融合酶 PKD-Por16B。HPSEC 法结果表明, PKD-Por16B 的表观分子量 (65.13 kDa) 为理论分子量 (46.02 kDa) 的 1.42 倍, 而单体 Por16B_Wf 的表观分子量 (25.90 kDa) 远小于其理论值 (34.60 kDa), 提示成功构建聚集体融合酶 PKD-Por16B, 且极可能为二聚酶。PKD-Por16B 的比酶活从 65.31 U/mg 显著提高到 325.69 U/mg, 同时酶稳定性也明显提升。此外, PKD-Por16B 与 Por16B_Wf 的水解模式一致, 提示其底物特异性或反应机制没有明显的变化。上述结果表明, 基于多聚结构域控制蛋白聚集的策略在提高酶活性方面具有一定的可行性, 操作简便且成本低廉。

关键词: 紫菜多糖酶; 酶活; 蛋白质工程

Enhancement of the activity of a porphyranase by fusing a polymerization-inducing domain

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Abstract: *Prophyra* is one of the most economically valuable species of red algae, with porphyran being its primary bioactive polysaccharide. Highly active enzymes play a significant role in the research and development of porphyran. In this study, a dimeric domain (PKD) with potential to induce protein aggregation, was identified within polysaccharide-binding proteins. By fusing it with porphyranase Por16B_Wf, a chimeric enzyme PKD-Por16B was constructed. HPSEC analysis revealed that the apparent molecular weight (65.13 kDa) of PKD-Por16B was 1.42 times its theoretical value (46.02 kDa), whereas the apparent molecular weight (25.90 kDa) of the monomeric Por16B_Wf was substantially smaller than its theoretical weight (34.60 kDa). It was indicated the successful construction of the aggregated fusion enzyme PKD-Por16B, likely existing as a dimer. The activity of PKD-Por16B was remarkably enhanced from 65.31 U/mg to 325.69 U/mg, accompanied by an improvement in enzymatic stability. Meanwhile, the hydrolysis pattern of PKD-Por16B remained unaltered in comparison to that of Por16B_Wf, indicating no significant deviation in its substrate specificity or reaction mechanism. These results suggest the feasibility of a strategy based on domain-induced aggregation to enhance enzyme activity, which is both easy and economical.

Key words: Porphyranase; Activity; Protein engineering

基于多维数据融合的农产品品质及成熟度智能预测

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摘要: 针对农产品品质检测步骤繁琐且只能进行抽样检测的现状, 利用机器视觉和光谱技术对农产品进行数据采集, 提取了样本的光谱信息和图像信息。结合化学计量学方法, 原始光谱 (Raw) 信息是使用一次性降维算法 (GA、CARS、SPA、UVE) 和组合降维和算法 (CARS-SPA、UVE-SPA) 提取, 并融合提取图像的灰度共生矩阵作为图像的纹理特征信息, 并将其与图像的颜色信息 (R、G、B、H、S、V、L、a、B), 建立图谱融合建立多维数据融合的农产品品质及成熟度智能预测模型, 并通过深度学习的方法对预测模型进行优化, 构建了农产品品质及成熟度的最优预测模型, 实现了农产品多品质及成熟度的准确、无损、快速预测。可为农产品品质及成熟度自动化在线检测提供可靠的技术支撑。

关键词: 光谱技术; 多维数据融合; 农产品品质及成熟度; 智能预测

Intelligent prediction of agricultural product quality and maturity based on multidimensional data fusion

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Abstract: In response to the current situation where the quality inspection steps for agricultural products are cumbersome and can only be sampled, machine vision and spectral technology were used to collect data on agricultural products, extracting spectral and image information from the samples. Combining chemometric methods, raw spectral information is extracted using one-time dimensionality reduction algorithms (GA, CARS, SPA, UVE) and combined dimensionality reduction algorithms (CARS-SPA, UVE-SPA), and the gray level co-occurrence matrix of the extracted image is fused as the texture feature information of the image, which is then combined with the color information of the image (R、G、B、H、S、V、L、a、B), Establishing an intelligent prediction model for agricultural product quality and maturity through graph fusion and multi-dimensional data fusion, and optimizing the prediction model through deep learning methods, the optimal prediction model for agricultural product quality and maturity was constructed, achieving accurate, non-destructive, and rapid prediction of multiple qualities and maturity of agricultural products. It can provide reliable technical support for automated online detection of agricultural product quality and maturity.

Key words: Spectral technology; Multidimensional data fusion; Quality and maturity of agricultural products; Intelligent prediction

基于海藻酸钙的益生菌载体研究

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摘要: 载体化技术是在加工、贮藏及胃肠道中保护益生菌的有效策略。作为益生菌主要产品形式, 冷冻干燥载体化菌粉已经实现优异的冷冻干燥存活和贮藏稳定性, 而胃肠道耐受性有限, 且市售菌粉普遍采用的多层包埋技术增加了制备复杂性。基于酸不溶碱溶的pH响应性, 海藻酸钙已被证明是在胃肠道中保护益生菌的理想壁材, 然而存在干燥过程中存活损失的挑战, 一直未被关注。本研究拟在明确海藻酸钙载体化益生菌冷冻干燥存活损失机制的基础上, 提出针对性的解决策略, 其中原位再培养形成生物膜状态益生菌是有效策略, 实现了益生菌从干燥至胃肠道全程稳态化的目标, 且优于目前商业化菌粉水平。此外, 该策略能够增加后生元抗氧化性, 阐明了其对益生菌功能性的积极影响。同时, 海藻酸钙基生物膜状态益生菌可以实现非干燥式应用。

关键词: 海藻酸钙; 益生菌; 载体化; 冷冻干燥; 生物膜

Research on the probiotic carriers based on calcium alginate

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Abstract: Carrier technology is an effective strategy for protecting probiotics during processing, storage, and gastrointestinal tract. As the main product form of probiotics, freeze-drying carrier-based probiotic powder has achieved excellent freeze-drying survival and storage stability. However, the gastrointestinal tolerance is limited, and the multi-layer encapsulation technology commonly used in commercial probiotic powder increases the preparation complexity. Based on the pH responsiveness of acid-insoluble and alkali-soluble, calcium alginate has been proven to be an ideal wall material for protecting probiotics during the gastrointestinal tract. However, there is a challenge of survival loss during the drying process, which has been unnoticed. This study aims to propose targeted strategies based on clarifying the mechanism of freeze-drying survival loss of probiotics loaded by calcium alginate. Among these, in situ re-culture to form biofilm-state probiotics is an effective strategy, achieving the goal of maintaining the full process stabilization of probiotics from drying to the gastrointestinal tract, surpassing the performance of current commercial probiotic powders. Besides, this strategy can increase the antioxidant activity of postbiotics, elucidating its positive effect on the functionality of probiotics. Meanwhile, calcium alginate-based probiotics in biofilm state can achieve non-drying applications.

Key words: Calcium alginate; Probiotics; Carrier; Freeze-drying; Biofilm

基于两亲性蛋白 BslA 修饰酯酶的自乳化生物催化系统在油脂水解中的应用

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摘要: 为了解决乳化剂在非均相酶促反应中对环境造成污染和应用局限性的问题, 本研究设计并建立了一种基于生物膜表面层蛋白 A(BslA)的自乳化体系。本文开发了基于两亲性蛋白 BslA 的自乳化催化体系, 并以虾青素为例, 研究了融合 BslA 的酯酶 Est3-14(BslA-Est3-14) 水解虾青素酯的能力。与 Tween-80、Span-20 和乙醇处理组相比, BslA-Est3-14 融合蛋白在减小乳液液滴大小和保持酶活性方面表现出优势, 其游离虾青素的产率分别提高了 52.3%、78.0%和 76.9%。在超声处理下, 测定了自乳化反应体系虾青素的产率为 184 $\mu\text{g}\cdot\text{mL}^{-1}$ 。该方法不仅解决了非均相酶促反应效率低的问题, 同时减少了对表面活性剂的需求, 最大限度降低了对环境的潜在影响。

关键词: 自乳化; 生物膜表面层蛋白 A; 酯酶; 乳液; 虾青素; 酶法水解

Self-emulsifying biocatalysis based on an amphipathic protein BslA-modified esterase functioning as a fine-tuned system for oil hydrolysis

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Abstract: To mitigate the environmental impact and application limitations associated with the use of emulsifiers in heterogeneous enzymatic reactions, a self-emulsifying system based on biofilm surface layer protein A (BslA) was designed and established in this study. In this paper, the self-emulsification system of the BslA-Est3-14 fusion protein, comprising the binding amphiphilic protein BslA and esterase Est3-14, was investigated with astaxanthin as a case study. The BslA-Est3-14 fusion protein was tested for the enzymatic hydrolysis of astaxanthin esters. The fusion protein and demonstrated competitive efficacy in reducing the size of the emulsion droplets and maintaining enzyme activity, increasing product yield of free astaxanthin by 52.3%, 78.0%, and 76.9% compared to the Tween-80, Span-20, and ethanol groups, respectively. With assistance of ultrasonic, the yield of astaxanthin in emulsion reaction system was determined to be 184 $\mu\text{g}\cdot\text{mL}^{-1}$. This method not only addresses the challenge of low enzymatic reaction efficiency of heterogeneous reactions but also reduces the need for surfactants, minimizing potential environmental impacts.

Key words: Self-emulsifying; Biofilm surface layer protein A; Esterase; Emulsion; Astaxanthin; Enzymatic hydrolysis

基于鲈鱼各成熟阶段品质变化对成熟度公式的改进及应用

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摘要: 采用感官评价及仪器分析, 首先对鲈鱼在 Medium, Medium Well, Well Done 三种成熟状态下风味及滋味等特性进行了研究。采用感官分析和仪器技术研究了热加工对鲈鱼肉风味的影响。建立了一个包含 26 个描述符的词汇库, 用于对生鲈鱼和蒸鲈鱼进行感官评价。选择 Check-all-that-apply 和 Free Choice Profiling 方法生成的 10 个气味属性作为特征描述符, 分别是“熟鱼香味、鲜味、粘牙、象牙白、甜味、油脂味、海水味、弹性、肉香味、褐色”。采用气相离子迁移谱法(GC-IMS)鉴定了 54 种挥发物。采用三重四级杆气相色谱-质谱联用法(GC-MS/MS)鉴定了 31 种游离脂肪酸。并通过游离氨基酸、核苷酸等滋味物质的检测、蛋白质及质构特性的变化。联合各指标与感官评价结果的关系, 筛选出相关性较强的指标(游离氨基酸、质构特性等)。将筛选出的各指标引入成熟度公式中, 对其进行改良与创新, 使其不再仅仅依托于单一的感官结果, 提高其科学性及可应用型。本研究为调控热加工水产品的品质变化及调控提供了理论依据。

关键词: 鲈鱼; 热加工; 感官词汇; 成熟度公式; 风味轮廓; 滋味特性

Improvement and application of maturity formulae based on quality changes at various maturity stages of perch

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Abstract : Using sensory evaluation and instrumental analysis, the flavor and taste characteristics of sea bass were firstly investigated in three maturation states: Medium, Medium Well and Well Done. Sensory analysis and instrumental techniques were used to investigate the effect of thermal processing on the flavor of sea bass meat. A vocabulary library containing a set of 26 descriptors was established for sensory evaluation of raw and steamed sea bass. Ten odor attributes generated by the Check-all-that-apply and Free Choice Profiling methods were selected as the characteristic descriptors, which were “cooked fish flavor, freshness, sticky teeth, ivory, sweetness, grease, seawater, elasticity, meaty flavor, and brown color”. Fifty-four volatiles were identified by gas phase ion mobility spectrometry (GC-IMS). Thirty-one free fatty acids were identified by triple quadrupole gas chromatography-mass spectrometry (GC-MS/MS). And through the detection of free amino acids, nucleotides and other flavor substances, protein and changes in textural properties. The relationship between each index and the sensory evaluation results

was combined, and the indexes with strong correlation (free amino acids, textural characteristics, etc.) were screened out. The screened indicators were introduced into the maturity formula, and the formula was improved and innovated, so that it was no longer only based on a single sensory result, and its scientificity and applicability were improved. This study provides a theoretical basis for regulating the quality change and regulation of thermally processed aquatic products.

Key words: Perch; Thermal processing; Sensory vocabulary; Maturity formula; Flavor profile; Taste characteristics

基于纳米材料光热效应的己烯雌酚快速检测方法研究

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摘要: 己烯雌酚具有促进动物生长, 促进动物蛋白质的合成代谢, 提高动物日增重和提高饲料转化率的作用, 曾被作为动物生长促进剂用于畜禽以及水产品养殖。然而, 己烯雌酚是一种雌激素干扰物, 可扰乱人体内的激素平衡, 严重时会导致癌症的发生。依赖大型仪器的己烯雌酚传统检测方法可以完成痕量检测, 但是也存在诸多弊端, 如检测周期长、成本高、方法复杂等。因此, 开发快速、简单、灵敏的己烯雌酚检测方法对于食品安全监管以及大型活动食品安全保障等具有重要意义。近年来, 光热传感检测方法因其操作简单、灵敏度高、可实现目标物多模态检测等优点, 被广泛应用于小分子(如农药、兽药等)和大分子(包括病原菌、癌细胞等)传感检测, 有望应用于己烯雌酚快速灵敏检测。光热纳米材料是上述检测方法的核心, 开发具有更好光热性能的光热纳米材料可以显著提高此类方法的检测性能。成功开发了黑磷杂化纳米金、紫磷纳米片、共价有机框架材料三种具有优异光热转换效率(31.1%~51.2%)的新型光热纳米材料, 并构建了己烯雌酚光热快速检测方法。结果表明, 方法最低检测限可达 $0.24 \mu\text{g}\cdot\text{L}^{-1}$, 并成功应用于水、牛奶、猪肉等实际样品检测。

关键词: 己烯雌酚; 光热纳米材料; 快速检测

Rapid diethylstilbestrol detection methods based on the photothermal effect of nanomaterials

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Abstract: Diethylstilbestrol has the function of promoting animal growth, enhancing the synthesis and metabolism of animal proteins, increasing animal weight and improving feed conversion ratio. It has been used as an animal growth promoter in breeding industry. However, diethylstilbestrol is an estrogen disruptor, which can disturb the

hormonal balance in the body, and can lead to cancer in severe cases. Traditional diethylstilbestrol detection methods that rely on instruments can achieve trace detection, but there are also many drawbacks, such as long detection cycles, high costs, and complex methods. Therefore, the development of fast, simple and sensitive diethylstilbestrol detection methods is of great significance for food safety supervision and large-scale event protection. In recent years, photothermal detection methods have been widely used in micromolecules (such as pesticides, veterinary drugs, etc.) and macromolecules (including pathogenic bacterium, cancer cells, etc.) sensing detection due to their advantages of simple operation, high sensitivity, and multimodal detection, and are expected to be applied to the rapid and sensitive detection of diethylstilbestrol. Photothermal nanomaterials are the core of the above detection methods, and the development of photothermal nanomaterials with better photothermal properties can significantly improve the detection performance of such methods. Three new photothermal nanomaterials with excellent photothermal conversion efficiency (31.1%~51.2%) were successfully developed, which were black phosphorus hybrid gold nano, violet phosphorus nanosheets and covalent organic framework. The results showed that the detection limit of the proposed photothermal methods can reach $0.24 \mu\text{g}\cdot\text{L}^{-1}$, and were successfully applied in water, milk and pork samples.

Key words: Diethylstilbestrol; photothermal nanomaterials; rapid detection

基于酿酒酵母的采前共培养方法改善螺旋藻 (*Arthrospira platensis*) 藻体的色泽和香气质量机制研究

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摘要: 螺旋藻因具有不佳的颜色和气味特征而限制其在食品中的广泛应用, 目前食品工业中通常采用采后加工方式来提高其在食品应用中的感官品质。本研究通过在螺旋藻采前暂养阶段以 10: 1000 的酵母/微藻生物量比例接种酿酒酵母, 同时补充 5 g/L 葡萄糖, 在 36 h 内通过混养来提高螺旋藻生物量和脂质的积累。结果表明: 通过酵母共培养的诱导使得藻体颜色从深蓝绿色变为浅绿色, 并赋予螺旋藻“花香”和“果香”等宜人香气。共培养后藻体的光合色素(叶绿素、类胡萝卜素和藻蓝蛋白)含量显著增加, 具体而言, 叶绿素 a 和类胡萝卜素的含量增加了 2 倍以上。挥发性风味化合物的鉴定结果显示, 酵母共培养可显著提高螺旋藻萜烯类和 C5-C9 醛类化合物的含量, 并脱除了藻体中具有“恶臭”气味的挥发性有机硫化物。酿酒酵母在共培养体系中产生了丰富的有机酸, 尤其是乙酸和乳酸。在验证实验中, 相较于乳酸, 乙酸显著提高了螺旋藻生物量、光合色素合成和香气化合物的挥发。总体而言, 采前酵母共培养是具有改善螺旋藻色泽外观和香气质量的有效方法。

关键词: 共培养; 螺旋藻; 酵母; 色泽; 风味

Improvement of color appearance and aroma quality of *Spirulina* (*Arthrospira platensis*) biomass through preharvest co-cultivation with yeast *Saccharomyces cerevisiae*

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Abstract: *Spirulina* is hindered from broad food applications by its undesirable color and odor, and postharvest technologies are usually employed to improve its sensory quality. In this study, *Saccharomyces cerevisiae* inoculation of a pre-harvest *Arthrospira platensis* culture with 5 g/L glucose supplementation enhanced microalgal growth and lipid accumulation at a yeast/microalgae biomass ratio of 10 : 1000 within 36 h of mixotrophic incubation. Yeast co-cultivation induced a microalgal color change from dark blue-green to light green and imparted the pleasant aromas of “floral” and “fruity” to *Spirulina*. The co-cultured microalgae had significantly increased levels of the photosynthetic pigments of chlorophylls, carotenoids, and phycobiliproteins, and specifically, the contents of chlorophyll a and carotenoids were more than 2-fold increased. Co-cultivation with yeast remarkably increased the microalgal levels of aromatic norisoprenoids and C5–C9 aldehydes and eliminated malodorous volatile organic sulfur compounds in *Spirulina*. Abundant organic acids especially acetic acid and lactic acid were produced by *S. cerevisiae* in the co-culture system, and in medium supplementation experiments, acetic acid, rather than lactic acid, significantly improved microalgal biomass yield, pigment biosynthesis, and volatile flavor profile. Overall, pre-harvest co-cultivation with yeast improved the color appearance and aroma quality of *Spirulina*, with acetate potentially acting as a central effector and mediator.

Key words: Co-cultivation; *Spirulina*; Yeast; Pigments; Volatile flavor profile.

基于受配体识别构建 ACE 抑制肽肠道靶向递送脂质体的研究

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摘要: 食源功能多肽因其良好的生物学功能已被广泛研究, 但由于胃肠道酶对其消化及其肠道内的不定向分布, 制约了生物活性肽的应用潜力。本项目以食源ACE抑制肽为研究对象, 通过构建基于受配体结合的多肽递送载体增强其生物功能。首先, 本研究以 β -葡聚糖修饰的DSPE-PEG为载体骨架, 利用微流控技术制备了尺寸(150 nm)和形态(球形)可控的靶向脂质体纳米颗粒, 并装载ACE抑制肽, 封装率达到80%。其次, 通过模拟胃肠消化实验考察了该递送系统对多肽抗胃肠消化酶的保护作用, 研究发现相比于裸露多肽, 载体包埋多肽具有良好的抗消化能力并且具有完整的多肽结构。通过测定ACE抑制肽的抑制活性发现, 封装后比裸露多肽ACE抑制活性提高了1.78倍。同时, 利用Dectin-1表达的鼠源M ϕ (RAW264.7)

细胞系研究载体的靶向结合能力,通过激光共聚焦显微镜染色发现,经 β -葡聚糖修饰的脂质体具有与RAW264.7细胞更强的结合能力,比未修饰脂质体约提高1.44倍。总之,本研究构建了可靶向肠道Dectin-1的经 β -葡聚糖修饰的脂质体纳米载体,为之后食源功能多肽的开发及工业应用提供了数据基础。

关键词: 肠道靶向, 纳米脂质体; ACE抑制肽; 微流控技术; 微褶皱细胞

Research on the construction of ACE inhibitory peptide intestinal targeted delivery liposomes based on ligand recognition

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Abstract: Functional peptides derived from food sources have been widely studied due to their excellent biological functions. However, the potential application of bioactive peptides is limited by their digestion by gastrointestinal enzymes and their non directional distribution in the intestine. This study focuses on the research of ACE inhibitory peptides from food sources, and enhances their biological functions by constructing peptide delivery carriers based on ligand binding. Firstly, in this study, DSPE-PEG modified with β -glucan was used as the carrier skeleton to prepare targeted liposome nanoparticles with controllable size (150 nm) and shape (spherical) using microfluidic technology. The nanoparticles were loaded with ACE inhibitory peptides and encapsulation efficiency reached 80%. Secondly, the protective effect of the delivery system on peptide anti gastrointestinal digestive enzymes was investigated through simulated gastrointestinal digestion experiments. The study found that compared to naked peptides, carrier embedded peptides have good anti digestive ability and complete peptide structure. By measuring the inhibitory activity of ACE inhibitory peptides, it was found that the encapsulated peptide showed a 1.78-fold increase in ACE inhibitory activity compared to the naked peptide. At the same time, the targeted binding ability of the vector was studied using the Dectin-1 expressed mouse M ϕ (RAW264.7) cell line. Through laser confocal microscopy staining, it was found that liposomes modified with β -glucan had stronger binding ability to RAW264.7 cells, which was about 1.44 times higher than unmodified liposomes. In summary, this study constructed a liposome nanocarrier modified with β -glucan that can target intestinal Dectin-1, providing a data foundation for the development and industrial application of food derived functional peptides in the future.

Keywords: intestinal targeting; nanoliposomes; ACE inhibitory peptides; microfluidic technology; microfold cells

基于虚拟筛选和分子对接的海湾扇贝副产物鲜味肽的滋味特征和鲜味机制研究

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摘要: 本研究旨在从海湾扇贝副产物中分离、纯化、鉴定和表征新的鲜味肽, 并进一步探讨呈鲜机制。利用 AP200-A 碱性蛋白酶和 FF106 风味蛋白酶对海湾扇贝副产物进行二步酶解, 利用超滤膜对扇贝副产物水解液中的鲜味肽进行分离纯化得到 <3kDa 和 >3kDa 组分, 感官评定发现 <3kDa 的组分鲜味程度最高。对 <3kDa 的组分经凝胶层析纯化并进一步优选出鲜味最佳组分。采用 LC-MS/MS 技术对筛选得到鲜味肽组分进行鉴定得到 65 个潜在鲜味肽, 通过虚拟筛选最终得到了三种鲜味肽, 分别为 HELPRY、WDGRDGAVD 和 AHELPRYG, 使用电子舌进行了检测并用分子对接技术探索鲜味的呈鲜机理。结果显示氢键和疏水相互作用是鲜味肽与鲜味受体 T1R1/T1R3 之间的主要结合力, 主要结合位点为 ASN-150、SER158、LYS-155、ASP-219、PRO-57 和 ARG-255。本实验对扇贝水产鲜味肽的制备和鉴定提供了理论参考, 同时也为扇贝副产物的综合利用提供了技术支撑。

关键词: 海湾扇贝; 鲜味肽; 分子对接; 呈味特性

Taste properties and mechanism of umami peptides from bay scallop (*Argopecten irradians*) based on virtual screening and molecular docking

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Abstract : This study aims to isolate, purify, identify, and characterize new umami peptides from byproducts of bay scallops, and further explore the mechanisms of umami presentation. Two-step enzymatic hydrolysis of bay scallop byproducts was performed using AP200-A alkaline protease and FF106 flavor protease, followed by ultrafiltration to separate and purify umami peptides from the hydrolysate into <3 kDa and >3 kDa fractions. Sensory evaluation revealed that the <3 kDa fraction exhibited the highest umami intensity. The <3 kDa fraction was further purified through gel chromatography, leading to the selection of the optimal umami components. LC-MS/MS technology was employed to identify the selected umami peptide components, resulting in 65 potential umami peptides. Through virtual screening, three umami peptides were ultimately obtained: HELPRY, WDGRDGAVD, and AHELPRYG. An electronic tongue was used for detection, and molecular docking techniques were applied to explore the mechanisms of umami presentation. Results indicated that hydrogen bonding and hydrophobic interactions are the primary binding forces between umami peptides and the umami receptors T1R1/T1R3, with key binding sites identified as ASN-150, SER158, LYS-155, ASP-219, PRO-57, and ARG-255. This experiment provides a theoretical reference for the preparation and identification of umami peptides from scallops, while also offering technical support for the comprehensive utilization of scallop byproducts.

Key words: Bay scallop; Umami peptides; Molecular docking; Sensory characteristics

基于益生菌和 HMB 的防治肌少症高活性产品制备研究

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摘要: 肌少症会引起老年人身体功能衰退, 影响健康老龄化, 目前没有有效的药物被批准用于肌少症防治。本研究首先建立 D-半乳糖诱导的肌少症体外模型, 通过对比 12 组益生菌和 HMB 不同干预组合的肌管直径, 发现 3 株益生菌和 HMB 均可改善肌肉衰减综合征且具有协同增效作用, 其中 *L. plantarum* NDF100S-2、*L. plantarum* HZZC-3 和 HMB 的复配效果最好。以菌株存活率为评定指标, 对冻干保护剂进行了筛选优化。乳清蛋白、脱脂乳粉和山梨醇配伍的复合保护剂可使 *L. plantarum* NDF100S-2 存活率达 (90.34±2.14) %; 明胶、脱脂乳粉和麦芽糊精组成的复合保护剂使得 *L. plantarum* HZZC-3 存活率达 (93.12±1.07) %; 最后将冻干菌粉与 HMB 复配完成产品制备。该产品经功能验证可改善由肌少症带来的肌管萎缩。本研究为从营养干预角度防治肌少症新型产品的研究和开发提供了理论依据。

关键词: 肌少症; 益生菌; HMB; 冻干保护剂; 工艺优化

Study on preparation of high active products for prevention and treatment of sarcopenia based on probiotics and HMB

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Abstract: Sarcopenia can cause physical function decline in the elderly and affect healthy aging. Currently, no effective drugs have been approved for the prevention and treatment of sarcopenia. This study first established an in vitro model of D-galactose-induced sarcopenia. By comparing the muscle tube diameter of 12 groups of different intervention combinations of probiotics and HMB, it was found that 3 strains of probiotics and HMB can improve muscle attenuation syndrome and have a synergistic effect. The combination effect of *L. plantarum* NDF100S-2, *L. plantarum* HZZC-3, and HMB was the best. The survival rate of strain was taken as the evaluation index, and the lyophilized protective agent was screened and optimized. The survival rate of *L. plantarum* NDF100S-2 was (90.34±2.14)% with the combination of whey protein, skim milk powder, and sorbitol. The survival rate of *L. plantarum* HZZC-3 was (93.12±1.07)% with the compound protective agent composed of gelatin, skim milk powder, and maltodextrin. Finally, the freeze-dried bacteria powder was combined with HMB to complete the product preparation. The product has been functionally proven to improve muscular tube atrophy caused by sarcopenia. This study provides a theoretical basis for the research and development of new products for the prevention and treatment of sarcopenia from the perspective of nutritional intervention.

Key words: Sarcopenia; probiotic; HMB; cryoprotectant; process optimization

具有过氧化物酶催化活性的 γ -环糊精还原铁(III)纳米颗粒的合成

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摘要: 食源性微生物是导致人类食源性疾病的主要原因, 因此探索新的抗菌策略势在必行。本研究成功合成了 Fe- γ -CD 作为一种用于牛奶和橙汁的食品抗菌剂。Fe- γ -CD 由 6/11 Fe(II) 和 5/11 Fe(III) 组成, 它可以催化过氧化氢进行类芬顿反应生成 \cdot OH。因此, Fe- γ -CD 具有特殊的过氧化物酶活性和广谱抗菌效果。Fe- γ -CD 不仅会破坏 ESBL-*E. coli* 的细胞壁结构, 还会导致蛋白质泄漏和遗传物质破坏, 最终导致其死亡。此外, Fe- γ -CD 抑制 MRSA 生物膜的形成, 导致其死亡。重要的是, Fe- γ -CD 对正常哺乳动物细胞没有毒性。这些发现表明, Fe- γ -CD 具有良好的抗菌性能, 是一种很有前景的食品抗菌剂。

关键词: 纳米酶, 类芬顿催化反应, 食源性微生物, 抗菌机制

Synthesis of γ -Cyclodextrin-Reduced Fe(III) Nanoparticles with Peroxidase-like Catalytic Activity for Bacteriostasis of Food

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Abstract: Foodborne pathogens are a primary cause of human foodborne illness, making it imperative to explore novel antibacterial strategies for their control. In this study, Fe- γ -CD was successfully synthesized as a food antibacterial agent for use in milk and orange juice. The Fe- γ -CD consists of 6/11 Fe(II) and 5/11 Fe(III), which catalyze a Fenton-like catalytic reaction with H₂O₂ to generate \cdot OH. Consequently, Fe- γ -CD exhibits exceptional peroxidase-like activity and broad-spectrum antibacterial efficacy. Fe- γ -CD not only disrupts the wall structure of ESBL-*E. coli* but also induces protein leakage and genetic destruction, ultimately leading to its death. Furthermore, Fe- γ -CD inhibits biofilm formation by MRSA and eradicates mature biofilms, resulting in MRSA's demise. Importantly, Fe- γ -CD demonstrates negligible cytotoxicity toward normal mammalian cells. These findings highlight that Fe- γ -CD has good antimicrobial properties as a promising food antimicrobial agent.

Key words: Fe- γ -CD nanoparticles, Fenton-like catalytic reaction, foodborne pathogens, antibacterial mechanism

抗基质干扰鼠伤寒沙门菌适配体的筛选和应用

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摘要: 适配体的结构和性能在实际应用中会受到样本基质的影响, 从而干扰适配体与其靶标之间的特异性结合。为了获得抗基质干扰的适配体, 利用指数富集的配体系统进化技术 (SELEX) 以鼠伤寒沙门菌为筛选靶标, 在筛选过程中引入四种典型食品基质作为负筛选靶标及筛选环境。成功获得了针对鼠伤寒沙门菌的高特异性候选适配体 (BB-34、BB-37、ROU-8、ROU-9、ROU-14、ROU-24、DAN-3、NAI-12 和 NAI-21)。根据这些候选适配体的二级结构、亲和性和特异性的表征结果, 选择猪肉基质中的 ROU-24 和结合缓冲液中的 BB-34 制备无标记荧光适配体传感器, 用于快速灵敏检测鼠伤寒沙门菌, 并验证其抗基质干扰的性能。基于 ROU-24 的适配体传感器与基于 BB-34 的适配体传感器相比, 具有更宽的线性范围和更好的特异性。同时, 基于 ROU-24 的适配体传感器在 17 个实际样品检测中的回收率(范围为 94.2%~110.7%)显著高于基于 BB-34 的适配体传感器。上述结果表明, 在 SELEX 筛选过程中引入食品基质作为负筛选靶标与筛选环境可以增强适配体与靶标的特异性结合以及抗基质干扰的性能。本研究筛选的抗基质干扰适配体及开发的无标记荧光核酸适配体传感器已在不同的食品中验证, 为抗基质干扰核酸适配体的特性研究和应用提供了理论和实践基础。

关键词: SELEX; 鼠伤寒沙门菌; 适配体; 无标记荧光适配体传感器; 基质干扰

Selection and application of highly specific *Salmonella typhimurium* aptamers against matrix interference

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Abstract: In practical applications, the structure and performance of aptamers can be influenced by the presence of sample matrices, which interferes with the specific binding between the aptamer and its target. In this work, to obtain aptamer chains resistant to matrix interference, four typical food matrices were introduced as negative selection targets and selection environments in the process of selecting aptamers for *Salmonella typhimurium* using the systematic evolution of ligands by exponential enrichment (SELEX) technology. As a result, some highly specific candidate aptamers for *Salmonella typhimurium* (BB-34, BB-37, ROU-8, ROU-9, ROU-14, ROU-24, DAN-3, NAI-12, and NAI-21) were successfully obtained. Based on the characterization results of secondary structure, affinity, and specificity of these candidate aptamers, ROU-24 selected in the pork matrix and BB-34 selected in the binding buffer were chosen to develop label-free fluorescence aptasensors for the sensitive and rapid detection of the *Salmonella typhimurium* and verify the performance against matrix interference. The ROU-24-based aptasensor demonstrated a larger linear range and better specificity compared to the BB-34-based aptasensor. Meanwhile, the recovery rate of the ROU-24-based aptasensor in real sample detection (ranging from 94.2% to 110.7%) was

significantly higher than that of the BB-34-based aptasensor. These results illustrated that the negative selection of food matrices induced in SELEX could enhance specific binding between the aptamer and its target and the performance against matrix interference. Overall, the label-free fluorescence aptasensors were developed and successfully validated in different foodstuffs, demonstrating a theoretical and practical basis for the study of aptamers against matrix interference.

Keywords: SELEX, *Salmonella typhimurium*, Aptamer, Label-free fluorescence aptasensor, Matrix interference

可溶性大豆多糖基“免撕同食”活性包装膜的构建与性能研究

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摘要:“民以食为天, 食以安为先。”塑料因质轻、价廉被广泛应用于食品包装中, 而塑料的不当管制引起的食品安全及环境污染问题日益严峻。因此, 安全环保的新型包装材料势在必行。豆渣是大豆加工过程的主要副产物, 可溶性大豆多糖 (SSPS) 是由豆渣经过脱脂、干燥等工艺制成, 具有良好的成膜特性。本研究针对大豆加工行业中豆渣纤维等副产物利用程度低、存在资源浪费、环境污染及 SSPS 基包装材料机械性能与阻隔性能不足等痛点问题。以羧基化纳米纤维素为增强单元, 设计并制造出具有优越机械性能与阻隔性能的 SSPS “免撕同食”包装膜, 用于脱水蔬菜的包装, 可有效抑制脱水蔬菜吸水; 以废弃柚子皮中提取的柚皮苷作为天然抗氧化成分, 制备兼具优良机械性能与抗氧化活性的可食包装膜, 用于猪油包装, 可有效延长产品货架期。“免撕同食”活性包装膜的创生, 不仅从源头上切断“白色污染”, 助力豆制品企业副产物高值化利用, 且符合“绿色可持续发展”理念, 助力“双碳战略”, 有望成为新一代绿色包装材料。

关键词: 可溶性大豆多糖; 免撕同食; 活性可食膜; 柚皮提取物; 货架期

Study on construction and properties of soluble soybean polysaccharide based “free-tear and edible” active packaging film

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Abstract: “Food is the priority of the people, and safety is the priority of food.” Plastic is widely used in food packaging because of its light weight and low price, and the problem of food safety and environmental pollution caused by improper control of plastic is becoming increasingly serious. Therefore, safe and environmentally friendly new packaging materials are imperative. Soybean

residue is the main by-product of soybean processing. Soluble soybean polysaccharide (SSPS) is made from soybean residue by degreasing and drying, and has good film forming properties. This study is aimed at the low utilization of soybean residue fiber and other byproducts, resource waste, environmental pollution, and insufficient mechanical and barrier properties of SSPS-based materials in soybean processing industry. Carboxylated nanocellulose was used as reinforcement unit to design and prepare SSPS-based “free-tear and edible” packaging film with superior mechanical properties and barrier properties. It was used in the packaging of dehydrated vegetables to effectively inhibit the water absorption of dehydrated vegetables. Naringin extracted from waste pomelo peel was used as a natural antioxidant component to prepare film with excellent mechanical properties and antioxidant activity to effectively extend the shelf life of lard. The creation of “free-tear and edible” active packaging materials not only cuts off “white pollution” from the source, helps soybean products high value utilization of by-products, and is in line with the concept of “green sustainable development”, helps the “double carbon strategy”. It is expected to become a new generation of green “free-tear and edible” packaging materials.

Key words: Soluble soybean polysaccharide; Free-tear and edible; Active edible film; Pomelo peel extract; Shelf life

可食用支架的制备及在细胞培养鱼肉中的应用研究

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摘要: 海洋食品是人类未来食品的基础, 但是海水养殖面临环境污染、资源紧张、动物福利等显著问题。细胞培育鱼肉是利用种子干细胞体外培养获得可食用肉类的一项新型技术, 具有可精确模拟天然肉类特征、节约资源等优势。然而现有细胞培养肉在干细胞规模化培养、食品组织化等领域严重依赖医学、生物学 3D 细胞培养支架, 在安全性和可食用等方面难以满足需求。本研究以豌豆球蛋白淀粉样纤维和甲壳素纳米晶为原料, 基于蛋白和多糖相互作用, 制得 Pickering 乳液, 进而采用离子交联技术制备了双层 Pickering 乳液凝胶, 从而构建了系列孔径均一的大孔 3D 细胞培养支架, 该支架的结构与孔隙特征可以通过调节乳液特性进行调控。进而该支架应用于大黄鱼肌肉干细胞的 3D 培养实验, 结果表明该支架具备出色的促进干细胞粘附、增殖和分化性能, 本研究为细胞培养鱼肉用高性能支架的创制提供了理论支撑和技术支持。

关键词: 3D 打印多孔支架、干细胞、双层乳液凝胶、细胞培养鱼肉类类似物、甲壳素纳米晶、豌豆蛋白淀粉样纤维

Preparation of edible scaffolds and their application in cell cultured fish meat

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Abstract: Marine food is the foundation of human future food, but marine aquaculture faces significant issues such as environmental pollution, resource scarcity, and animal welfare. Cell cultured fish meat is a novel technology that utilizes seed stem cells to obtain edible meat through in vitro cultivation. It has the advantages of accurately simulating the characteristics of natural meat and conserving resources. However, existing cell cultured meat heavily relies on medical and biological 3D cell culture scaffolds for large-scale stem cell cultivation, food organization, and other fields, making it difficult to meet the requirements in terms of safety and edibility. In this study, the pea globulin amyloid fiber and chitin nanocrystals were used as raw materials to prepare Pickering lotion based on the interaction of protein and polysaccharide, and then the double-layer Pickering lotion gel was prepared using the ion crosslinking technology, so as to build a series of macroporous 3D cell culture scaffolds with uniform pore size. The structure and pore characteristics of the scaffold can be adjusted by adjusting the characteristics of the lotion. Furthermore, the scaffold was applied to 3D culture experiments of muscle stem cells from large yellow croaker, and the results showed that the scaffold has excellent properties in promoting stem cell adhesion, proliferation, and differentiation. This study provides theoretical and technical support for the creation of high-performance scaffolds for cell culture of fish meat.

Key words: 3D-printable porous scaffolds, stem cells, bilayer emulgel, cell-cultured fish meat analogues, chitin nanocrystals, pea protein amyloid fibrils

莱茵衣藻源富羟脯氨酸肽的制备及口服生物利用度研究

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摘要: 莱茵衣藻(*Chlamydomonas reinhardtii*)作为一种可食用微藻, 其细胞壁独特, 由富含羟脯氨酸的糖蛋白 (HRGPs) 组成。本研究通过分离获得莱茵衣藻有性生殖产生的配子溶酶 (G-lysin) 作为工具酶来制备富羟脯氨酸肽 (CHRP), 该过程对 G-lysin 的分离提取条件进行优化, 结果表明, 单性别藻株缺氮胁迫 24 h, 在 25°C 下交配 30 min 产生的 G-lysin 活性最高; 相同质量的湿藻制备 CHRP, 肽含量与酶添加量呈正相关, 且在 30°C, 裂解 2 h, 会有更多的 CHRP 产生。利用纳滤技术纯化后, 溶液中 2-6 肽占总肽含量的 92.2%, 其中羟脯氨酸 (Hyp) 含量为 92 mg/g; 通过 Q Extractive 高分辨质谱并结合 PepOSX 软件分析, 结果显示含 Hyp 和脯氨酸(Pro)的占 83.1%, 其中 2、3 肽占 98.1%。本研究旨在为微藻源

富含羟脯氨酸生物活性肽的制备和研究奠定基础。

关键词：莱茵衣藻；有性生殖；配子溶酶；HRGPs；CHRP

Preparation and Oral Bioavailability Study of Hydroxyproline-Rich Peptides Derived from *Chlamydomonas reinhardtii*

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Abstract: *Chlamydomonas reinhardtii*, as an edible microalga, possesses a unique cell wall composed of hydroxyproline-rich glycoproteins (HRGPs). In this study, gamete lysin (G-lysin), produced during the sexual reproduction of *Chlamydomonas reinhardtii*, was isolated and used as a tool enzyme to prepare hydroxyproline-rich peptides (CHRP). The conditions for the isolation and extraction of G-lysin were optimized, revealing that G-lysin exhibited the highest activity when unisexual algal strains were subjected to nitrogen stress for 24 h and subsequently mated at 25°C for 30 min. For the preparation of CHRP from the same mass of wet algae, the peptide content was positively correlated with the amount of enzyme added, and a greater yield of CHRP was achieved after 2 h of lysis at 30°C. After purification by nanofiltration, di- to hexapeptides accounted for 92.2% of the total peptide content in the solution, with a hydroxyproline (Hyp) content of 92 mg/g. High-resolution mass spectrometry (Q Extractive) combined with PepOSX software analysis showed that peptides containing both Hyp and proline (Pro) made up 83.1%, of which di- and tripeptides comprised 98.1%. This study aimed to establish a foundation for the preparation and research of microalgae-derived bioactive peptides rich in hydroxyproline.

Key words: *Chlamydomonas reinhardtii*; Sexual reproduction; Gamete lysin; HRGPs; CHRP

两歧双歧杆菌 FL-228.1 维护肠道屏障功能缓解小鼠结肠炎的作用机制研究

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摘要: 溃疡性结肠炎 (Ulcerative colitis, UC) 是一种与肠道菌群失调和肠内稳态失衡密切相关的慢性非特异性炎症性肠病, 其发病机制尚不明确且无法有效治愈。研究表明, 益生菌在缓解 UC 过程中可通过调节肠道菌群的丰度和多样性, 调节免疫, 增强肠道屏障功能发挥作用。本文研究了两歧双歧杆菌 (*Bifidobacterium bifidum*) FL-228.1 对肠道屏障功能的改善作用和作用机制。通过构建 DSS 肠炎小鼠模型, 观察实验菌株干预对 DSS 诱导小鼠体重、

结肠长度、疾病活动指数、炎症因子、肠道上皮和黏液层的受损情况的影响,并进一步利用伪无菌小鼠研究 FL-228.1 的作用途径。结果表明:两歧双歧杆菌 FL-228.1 可以有效缓解 DSS 诱导产生的结肠炎症状,改善肠屏障功能,使肠通透性显著降低。除此之外,FL-228.1 上调了紧密连接蛋白并显著刺激 Muc2 蛋白的表达,并促进了 Muc2 的唾液酸化和岩藻糖基化修饰。通过观察结肠组织的染色切片还发现 FL-228.1 组小鼠结肠的绒毛和隐窝结构以及黏液层保留完整。同时,利用伪无菌小鼠模型发现 FL-228.1 通过调节肠道菌群发挥作用并提高了有益菌种 *Ligilactobacillus murinus* 和 *Alistipes finegoldii* 的相对丰度。因此,两歧双歧杆菌 FL-228.1 能通过调控肠道菌群来改善肠道屏障作用,以缓解 DSS 诱导的溃疡性结肠炎。

关键词: 两歧双歧杆菌; 溃疡性结肠炎; 肠道屏障; 黏蛋白; 肠道菌群

Study on the mechanism of *Bifidobacterium bifidum* FL-228.1 to maintain intestinal barrier function and relieve DSS-induced ulcerative colitis

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Abstract Ulcerative colitis is a chronic non-specific inflammatory bowel disease closely related to intestinal flora imbalance and intestinal homeostasis imbalance. The pathogenesis of ulcerative colitis is still unclear and there is no effective cure. Studies have shown that probiotics play a role in alleviating UC by regulating the abundance and diversity of intestinal flora, regulating immunity, and enhancing intestinal barrier function. In this paper, we studied the effect and mechanism of *Bifidobacterium bifidum* FL-228.1 on intestinal barrier function. By establishing a mouse model of DSS enteritis, the effects of experimental strain intervention on body weight, colon length, disease activity index, inflammatory factors, intestinal epithelium and mucous layer damage of DSS induced mice were observed, and the pathway of action of FL-228.1 was further studied using pseudo-sterile mice. The results showed that FL-228.1 could effectively relieve the symptoms of colitis induced by DSS, improve intestinal barrier function, and significantly reduce intestinal permeability. In addition, FL-228.1 upregulated the tight-junction protein and significantly stimulated the expression of Muc2 protein, and promoted the sialylation and fucosylation of Muc2. It was also found that the colonic villi and crypt structure and mucous layer were intact in the FL-228.1 group. Meanwhile, FL-228.1 was found to regulate intestinal flora in a pseudo-sterile mouse model and increase the relative abundance of beneficial strains *Ligilactobacillus murinus* and *Alistipes finegoldii*. Therefore, *Bifidobacterium bifidum* FL-228.1 can improve the intestinal barrier effect by regulating the intestinal flora to alleviate DSS induced ulcerative colitis.

Key words *Bifidobacterium bifidum*; Ulcerative colitis; Intestinal barrier; Mucin; Gut microbiota

灵芝固态发酵小麦果皮过程中酶活性及营养物质组成的变化

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摘要: 小麦果皮富含阿拉伯木聚糖和酚类物质, 可预防高脂饮食导致的各种慢性疾病, 但由于口感差, 目前主要用于动物饲料。为提高小麦果皮的利用价值, 选用灵芝对其进行固态发酵, 测定发酵过程中酶活性以及木质纤维素基质、戊聚糖、总酚和总黄酮等含量的变化。研究发现, 发酵 6 d 时灵芝菌丝已经完全渗透小麦果皮培养基内部, 但菌丝纤弱, 菌丝量较少, 灵芝菌分泌的纤维素酶、半纤维素酶、漆酶等酶活性最高点出现在第 6 d 或者 6 d 后。由于菌丝的穿透作用以及酶的降解作用, 小麦果皮中半纤维素和木质素先略微增加后持续减少, 而纤维素含量持续下降, 相应的, 木质纤维素等的降解产物, 如戊聚糖、还原糖等呈先增加后下降趋势, 6 d 时含量最高, 并且发酵 6 d 时发酵基质可溶性固形物含量最高, 但是持水能力明显下降。此外, 发酵基质水提物的抗氧化能力以及总酚和总黄酮含量随发酵的进行先减少后增加。综上, 灵芝固态发酵能够改变小麦果皮的营养组成, 适宜的发酵时间为 6 d。

关键词: 小麦果皮; 灵芝菌; 固态发酵; 酶活性; 营养成分

Changes in enzyme activity and nutrition composition during solid-state fermentation of wheat pericarp by *Ganoderma lucidum*

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Abstract: Wheat pericarp is rich in arabinoxylan and phenolic substances, which can help to prevent various chronic diseases associated with a high-fat diet. However, due to the poor taste, it is primarily used for animal feed. Solid-state fermentation of wheat pericarp was conducted using *Ganoderma lucidum* to enhance the utilization value. This study assessed changes in enzyme activity and content of lignocellulosic matrix, pentosan, total phenol, and total flavonoids during fermentation. The study revealed that at 6 d of fermentation, the *Ganoderma lucidum* hyphae had completely penetrated the inner part of the wheat pericarp medium, however, the hyphae were weak and spare. The highest enzyme activities of cellulase, hemicellulase, laccase, and other enzymes secreted by *Ganoderma lucidum* appeared on the 6th day or later. Due to the penetration of *Ganoderma lucidum* hyphae and the degradation effect of enzymes, the hemicellulose and lignin in wheat pericarp initially increased slightly before continuously decreasing, while the cellulose content consistently decreased. Correspondingly, the degradation products of lignocellulose, such as pentosan and reducing sugar, exhibited a trend of increasing and then decreasing, with the highest content at 6 d. Besides, on the 6th d of fermentation, the soluble solid content of the substrate was the highest, but the water retention capacity decreased significantly. In addition, the antioxidant capacity and total phenol and flavonoid content of the

fermentation matrix extract, decreased initially and then increased during fermentation. In summary, solid-state fermentation with *Ganoderma lucidum* can change the nutritional composition of the wheat pericarp with optimal fermentation time of 6 days.

Key words: wheat pericarp; *Ganoderma lucidum*; solid-state fermentation; enzymatic activity; nutritional composition

罗非鱼肾保护肽的制备及其作用机理研究

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摘要: 本研究聚焦罗非鱼皮肾保护肽(TSP)的制备工艺优化及对腺嘌呤诱导的小鼠慢性肾损伤的保护作用。首先建 GA-BP 神经网络算法预测模型,使用 69 组样本进行 7 次迭代(MSE 为 0.005287, R=0.98317); 使用 18 组样本进行验证分析 R=0.98787, 说明该模型可良好预测不同工艺参数下酶解结果。对最优条件下制备的 TSP 进行功能验证。体外功效验证显示, 5mg/ml 的 TSP 的 DPPH、ABTS、羟基自由基清除率、24h 和 48h 肾小球系膜细胞抑制率分别达到了 66.26%、69.42%、40.24%、32.8%和 37.07%。体内实验结果表明, TSP 能改善腺嘌呤引起的小鼠慢性肾损伤症状, 高剂量组相比正常组小鼠尿酸、肌酐、尿素氮含量下调(21.06%、32.70%、66.23%), 超氧化物歧化酶(SOD)含量上调(30.11%); 肾脏中炎症因子 IL-1 β 、IL-6 和 TNF- α 含量下调(17.89%、16.90%、16.87%); 通过组织病理学分析发现 TSP 可以改善模型小鼠肾脏组织细胞增生和纤维化。综上所述制备的 TSP 具有改善慢性肾损伤的作用。

关键词: 肾保护肽; GA-BP 神经网络; 氧化应激; 炎症; 纤维化

Preparation of renoprotective peptide from tilapia and its mechanism of action

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Abstract: The present study aimed to optimise the preparation process of tilapia skin renoprotective peptide(TSP)and to investigate its protective effect against adenine-induced chronic kidney injury in mice. GA-BP neural network algorithm was initially constructed to predict the model with seven iterations using 69 groups of samples (MSE of 0.005287, R= 0.98317). The validation analysis, which used 18 groups of samples with R=0.98787,

indicated that the model could effectively predict the results of the enzymatic hydrolysis under different process parameters. The functional validation of TSP, prepared under optimal conditions, is presented herewith. The in vitro efficacy validation demonstrated that TSP exhibited DPPH, ABTS, hydroxyl radical scavenging, and 24 and 48 hour glomerular thylakoid cell inhibition at a concentration of 5 mg/ml, reaching 66.26%, 69.42%, 40.24%, 32.8%, and 37.07%, respectively. The results of the in vivo experiments demonstrated that TSP was effective in alleviating the symptoms of adenine-induced chronic kidney injury in mice. This was evidenced by a reduction in uric acid, creatinine, and urea nitrogen levels in the high-dose group compared to the normal group (21.06%, 32.70%, and 66.23%, respectively). Additionally, there was an increase in superoxide dismutase (SOD) content (30.11%); and down-regulation of the contents of the inflammatory factors IL-1 β , IL-6, and TNF- α in the kidneys (17.89%, 16.90%, 16.87%); by histopathological analysis, it was found that TSP could ameliorate the proliferation and fibrosis of renal tissue cells in model mice. In conclusion, the prepared TSP has the effect of improving chronic kidney injury.

Key words: Renoprotective peptide ; GA-BP neural network; Oxidative stress; Inflammation; Fibrosis

马铃薯蛋白改性及其功能性载体开发应用

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摘要: 马铃薯蛋白是一种天然、高营养、非致敏蛋白, 独特的分子结构和丰富的功能特性使其成为活性物质和营养物质的理想载体。采用物理、化学、生物及多种复合方法进行改性可以有效提高马铃薯蛋白的功能特性, 同时有利于构建马铃薯蛋白基多糖/多酚等复合物、微胶囊、复合膜、水凝胶、抗菌与营养递送纳米乳液等多种功能性载体。通过从纳米到宏观的各种尺度上组装生物聚合物来设计功能性载体, 可有效提高负载功能性成分的稳定性、生物活性以及生物利用度, 为马铃薯蛋白高值化加工和食品功能因子的高效利用提供了重要参考。

关键词: 马铃薯蛋白; 改性; 功能性载体; 高值化利用

Modification of potato protein and its development as functional carriers

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Abstract: Potato protein is a kind of natural, high nutrient, non-allergenic protein. Its unique molecular structure and rich functional properties make it an ideal carrier for active substances and nutrients. Modification by physical,

chemical, biological and multiple composite methods can effectively improve the functional properties of potato proteins, and is conducive to the construction of potato protein-based polysaccharide/polyphenol complexes, microcapsules, composite membranes, hydrogels, antibacterial and nutrient delivery nanoemulsions and other functional carriers. The stability, bioactivity and bioavailability of the delivered functional components can be effectively improved by assembling biopolymers at various scales from nano to macro to design functional carriers, providing an important reference for the high-value processing of potato protein and the efficient utilization of food functional factors.

Key words: Potato protein; Modification; Functional carrier; High-value utilization

母乳化乳脂肪球重构及其对认知作用机制研究

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摘要: 随着高端婴儿配方奶粉的发展, 婴配奶粉功能成分及结构特征的母乳化, 已成为该产业创新发展的研发导向及产业升级关键点。乳脂肪球 (MFG) 在母乳中的结构和功能成分对于婴幼儿的智力发育具有重要作用。然而, 幼儿配方奶粉中 MFG 在磷脂组成和结构特性方面与母乳的差异, 制约了配方奶粉的母乳化进程。本研究旨在从“组成”到“结构”两方面模拟母乳制备三层膜 MFG, 并基于配方奶喂养幼鼠模型探究母乳化 MFG 对幼鼠神经发育和认知功能的作用机制。结果显示, 与配方奶喂养组相比, 母乳化 MFG 显著改善了幼鼠的认知行为测试, 增加了海马体中神经元和星形胶质细胞的比例。此外, 母乳化 MFG 显著提高了幼鼠血清中鞘磷脂水平, 调节了海马体脂质组成和蛋白质表达。相关性分析表明, 海马体组蛋白脱乙酰酶和硫酸肝素 6-O-磺基转移酶与海马体 SM 42:2;O2 显著相关。综上, 本研究明确了母乳化 MFG 在改善幼鼠认知功能中的潜在作用机制, 为高端婴幼儿配方奶粉的功能性开发和产业化提供了科学依据。

关键词: 乳脂肪球; 三层膜结构; 认知; 鞘磷脂;

From composition to structure: Reconstruction of the humanized milk fat globule and its mechanism of action on cognitive function

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Abstract: As premium infant formulas continue to develop, replicating the functional components and structural characteristics of breast milk has become a central focus of innovation and advancement in the industry. The structure

and functional components of milk fat globules (MFGs) in breast milk are crucial for infant cognitive development. However, the differences in phospholipid composition and structural characteristics between MFGs in infant formula and those in breast milk have impeded the progress of optimizing formula milk. This study aims to simulate breast milk by preparing three-layer MFGs, focusing on both compositional and structural aspects, and to investigate the mechanisms by which these humanized MFGs influence neural development and cognitive function in formula-fed rat pups. The results demonstrated that, compared to the formula-fed group, humanized MFGs significantly improved cognitive behavior tests and increased the proportion of neurons and astrocytes in the hippocampus. Furthermore, humanized MFGs notably elevated serum sphingomyelin levels, modulated hippocampal lipid composition, and altered protein expression. Correlation analysis revealed significant associations between hippocampal histone deacetylase, heparan sulfate 6-O-sulfotransferase, and hippocampal SM 42:2;O2. In conclusion, this study clarifies the potential mechanisms by which humanized MFGs enhance cognitive function in rat pups, providing scientific evidence to support the functional development and industrial production of high-end infant formula.

Key words: milk fat globules; three-layer membrane structure; cognition; sphingomyelin

纳米塑料残留的检测、毒理及消除方法研究

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摘要: 废弃塑料在各种自然条件共同作用下最终会以微米级或纳米级塑料微粒分散于种养殖环境及水体中, 进而通过食物链进入人体, 目前已报道从各种动植物体内检测到微塑料残留, 并已证实会对动植物及人类健康产生危害。目前纳米塑料研究领域尚存在的以下问题: 用于开展研究的纳米塑料多为商品化塑料微球, 其物理化学性质与天然形成的纳米塑料差异显著, 势必会导致研究结果的不准确性; 纳米塑料的表征检测涉及到化学本质、物理尺寸、颗粒数量等多个参数, 目前检测方法大多针对个别参数建立, 难以满足多参数同时检测的现实需求; 纳米塑料的毒理学研究开展较多, 但在分子机制方面仍不够深入; 尚缺乏针对各类种养殖环境及水体中纳米塑料消除的有效方法。针对上述问题, 本团队开展了以下研究工作: 模拟自然条件作用制备纳米塑料标准品及其参数表征; 纳米塑料多参数同时检测方法的建立; 纳米塑料引起血管内皮损伤、凝血功能障碍及肠道炎症、菌群失调的机理研究; 纳米塑料在可食植物中的转运及抑制; 界面水蒸发消除饮用水中纳米塑料等。

关键词: 纳米塑料; 微塑料; 检测; 毒理; 消除

Study on the detection, toxicology and elimination methods of nanoplastics

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Abstract: Under the combined action of various natural conditions, waste plastics disperse in the breeding environment and water with micro- or nano- plastic particles, and then enter human body through the food chain. Microplastic residues have been reported from all kinds of animals and plants, and have been confirmed to cause harm to health. At present, the following problems still remain: most of the nanoplastics used for research are commercial plastics, and their physical and chemical properties are different from the naturally formed ones, leading to the inaccuracy of results. Their characterization and detection involves many parameters including chemical composition, physical size, particle number. Most of the detection methods are established for individual parameters, which is difficult to meet the needs of simultaneous detection. Many studies are about nanoplastic toxicology, but their molecular mechanism is not deep enough. There is still a lack of effective methods to eliminate nanoplastics in breeding environments and water. To solve the above problems, our team carried out the following researches: preparation of nanoplastic standards in simulated natural conditions and parameters characterization; The establishment of multi-parameter simultaneous detection method for nanoplastics; Study on the mechanism of vascular endothelial injury, coagulation dysfunction, intestinal inflammation and microbial imbalance caused by nanoplastics; Transportation and inhibition of nanoplastics in edible plants; Elimination of nanoplastics in drinking water by interfacial water evaporation.

Key words: Nanoplastics; Microplastics; Detection; Toxicology; Elimination

沙棘提取物抑制鲜切马铃薯褐变的技术和机理研究

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摘要: 沙棘是中国传统的药食同源植物, 含有丰富的生物活性成分, 对人体健康有益。该研究探讨了沙棘叶和果实提取物对鲜切马铃薯褐变的影响, 结果表明, 相比于果实提取物, 沙棘叶提取物 1: 20 (w/v 水) 具有更好的抑制褐变作用。通过 UPLC-MS 分析发现沙棘叶提取物主要由儿茶素、金丝桃素、没食子酸、异鼠李素和绿原酸等物质组成, 具有很强的 DPPH 和 ABTS 自由基清除能力。进一步酶促动力学研究发现, 沙棘叶提取物能竞争性抑制多酚氧化酶 (polyphenol oxidase, PPO) 活性, IC₅₀ 值为 0.7 mg/mL。同时, 也降低了鲜切马铃薯过氧化物酶 (peroxidase, POD) 和苯丙氨酸解氨酶 (phenylalanine ammonia-lyase, PAL) 活性,

减少了总酚含量,从而抑制鲜切马铃薯的褐变。分子对接发现,与异鼠李素相比,没食子酸对 PPO 的结合能力更强,沙棘叶提取物中活性成分的复配实验证明了它们之间具有协同抗褐变作用。此外,覆盆子水提取液及氧化白藜芦醇等活性成分也有明显抑制鲜切果蔬褐变的作用。因此,植物提取物及活性成分可以作为鲜切果蔬潜在的、安全的褐变抑制剂。

关键词: 沙棘叶提取物; 鲜切马铃薯; 褐变; 分子对接; PPO

Inhibition Technology and Mechanism of Seabuckthorn

Extract on Browning of Fresh-cut potatoes

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Abstract: Seabuckthorn is a traditional medicinal and edible plant, which is rich in bioactive ingredients and beneficial to human health. The study investigated the effect of seabuckthorn leaf and fruit extracts on browning of fresh-cut potatoes. The results showed that seabuckthorn leaf extracts 1:20 (w/v water) had better browning inhibition effect compared to fruit extracts. Seabuckthorn leaf extracts were mainly composed of catechin, hypericin, gallic acid, isorhamnetin and chlorogenic acid by UPLC-MS analysis, which possessed strong DPPH and ABTS radical scavenging abilities. Further enzyme kinetics revealed that seabuckthorn leaf extracts competitively inhibited the activity of polyphenol oxidase (PPO) enzyme, and the IC₅₀ was 0.7 mg/mL. Meanwhile, the browning of fresh-cut potatoes was inhibited by reducing the activities of peroxidase (POD) and phenylalanine ammonia-lyase (PAL), decreasing the total phenolic content as well. The molecular docking revealed that gallic acid had a stronger binding capacity for PPO compared to isorhamnetin. And complexation experiments of active ingredients in seabuckthorn leaf extracts demonstrated synergistic anti-browning effects among them. In addition, active ingredients such as raspberry water extract and oxyresveratrol had significant inhibitory effects on browning of fresh-cut fruit and vegetables. Thus, plant extracts and active ingredients could be used as a potential and safety anti-browning agent of fresh-cut fruit and vegetables.

Key words: Seabuckthorn leaf extracts; Fresh-cut potatoes; Browning; Molecular docking; PPO

食品中有机小分子污染物的高效富集及 SERS 检测

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摘要: 食品中有机小分子污染物包括农药残留、兽药残留、违禁精神药物、工业添加剂等,是导致食品安全问题的一类主要因素。增强基底是表面增强拉曼散射分析的关键,金属有机

框架 (MOFs) 是一种比表面积大、孔结构可调、易于功能化的新型多孔晶体材料, 对有机小分子具有优异的富集分离性能。MOFs 与等离子体金属 (金、银、铜等) 的复合材料即可作为 SERS 增强基底快速识别目标分子, 又可高效富集目标分子, 显著提高检测信号。本报告介绍了课题组在该领域的一系列相关工作, 总结了基于 MOF-等离子体金属复合材料 (MOF-PMPs) 作为 SERS 基底在食品中有机小分子化学传感中的优势和局限性, 以及在未来应用面临的挑战和机遇。

关键词: 有机小分子; 食品; 表面增强拉曼光谱; 金属有机框架; 检测

Efficient Enrichment and SERS Detection of Organic Small Molecule Contaminants in Food

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Abstract: Organic small molecule contaminants in food, including pesticide residues, veterinary drug residues, prohibited psychotropic substances, industrial additives, etc., are a major factor leading to food safety issues. Enhanced substrate is the key to surface enhanced Raman scattering analysis. Metal organic frameworks (MOFs) are a new type of porous crystal material with large specific surface area, adjustable pore structure, and easy functionalization, which have excellent enrichment and separation performance for organic small molecules. The composite material of MOFs and plasma metals (gold, silver, copper, etc.) not only can serve as a SERS enhanced substrate for rapid recognition of target molecules, but also can efficiently enrich target molecules as well as significantly improving detection signals. This report introduces a series of related works of the research group in this field, summarizes the advantages and limitations of using MOF-plasma metal composites (MOF-PMPs) as SERS substrates for chemical sensing of organic small molecule contaminants in food, as well as the challenges and opportunities faced in future applications.

Key words: Organic small molecule; Foods; Surface enhanced Raman scattering; Metal organic framework; Detection

食源性致病菌现场快速检测技术的创建及应用

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摘要: 基于核酸水平的食源性致病菌病原检测成本低、速度快、灵敏度高, 是目前针对食源性致病菌的主流检测方法, 但现有核酸检测方法仍无法满足现场快速检测的需求。本报告以具有食源性致病菌细菌病原的精准靶向识别和快速检测这一关键问题为导向, 重点解决以下

关键问题。一、核酸富集提取技术,利用方便易携带的纸基、多孔弹性凝胶等作为介质材料,通过对其表面丰富的硅氧基、羟基等基团改性,接枝聚乙烯亚胺、壳聚糖等超支化配基,形成丰富表面活性位点,构建核酸快速提取技术;二、核酸等温扩增与可视化检测技术,利用可以扩增过程中产生的溶液体系的变化,开发可视化的核酸快速检测方法,实现细菌病原的现场快速检测;三、纸基微流控技术的开发,构建无需修饰的具有微流体聚集效应的纸基微流控芯片结合酶固定化技术构建纸基检测平台;四、开发致病性识别和快速检测体系,利用胞嘧啶脱氨酶高效催化脱氨反应构建对于甲基化位点的识别检测方法,构建致病性快速检测体系。未来有望有效串联病原核酸提取、扩增、可视化读取各个环节集成一体化核酸快速检测平台。

关键词: 食源性致病菌; 核酸检测; 核酸富集; 核酸可视化; 纸基微流控

Construction and application of on-site and rapid detection platform for foodborne pathogens

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Abstract: Nucleic acid-based method is low-cost, rapid, and highly sensitive, making it the mainstream method for detecting foodborne pathogens. However, existing nucleic acid detection techniques fail to meet the demand for on-site testing. This report addresses the critical issues of accurate targeting and rapid detection of foodborne bacterial pathogens, focusing on following key aspects. (1) Nucleic Acid Enrichment Technology: Paper materials or porous elastic hydrogel with siloxyl and hydroxyl groups were modified with hyperbranched ligands like polyethyleneimine and chitosan to create abundant active sites for rapid nucleic acid enrichment. (2) Isothermal Amplification and Visual Detection Technology: By leveraging the changes in the solution system during amplification, visual nucleic acid rapid detection methods to achieve on-site rapid identification of bacterial pathogens was achieved. (3) Paper-Based Microfluidic Technology: Paper-based microfluidic chips that exhibits a microfluidic aggregation effect was achieved. (4) Development of Pathogenic Recognition and Rapid Detection Systems: Cytosine deaminase was employed to efficiently catalyze deamination reactions, enabling the detection of methylation sites, thereby establishing a rapid detection system for pathogenicity. In the future, we anticipate the effective integration of nucleic acid extraction, amplification, and visual readout into a comprehensive rapid detection platform for pathogens.

Key words: Foodborne pathogens; Nucleic acid detection; Nucleic acid enrichment; Visual detection; Paper-Based Microfluidic

双网络结冷胶/果胶复合冷冻凝胶构建以及对 Pb²⁺的高效吸附

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摘要: 本研究以结冷胶 (GG) 和两种果胶 (AP1、AP2) 为材料, 采用渗透离子交联和冷冻干燥方法制备了一种 GG/AP 共混冷冻凝胶, 旨在吸附重金属离子 Pb²⁺。通过质构、流变、挤压和溶胀实验证明, GG 和 AP 形成的双交联网络结构大大提高了冷冻凝胶的强度, 并在 GG/AP 的比例为 1:4 时达到最大强度。SEM、BET 和 EDS 都证明了冷冻凝胶交联网络的形成和多孔结构的生成, 具有高比表面积和孔隙率。同时, GG/AP2 冷冻凝胶在不同条件下都具有良好的 Pb²⁺ 吸附能力, 最大吸附量达 93.56 mg/g。吸附前后的 XPS 分析证实, 吸附主要是通过含氧官能团螯合 Pb²⁺ 来实现。结果表明, 具有高比表面积和结构增强的混合低温凝胶是一种经济、可持续的吸附剂。这项研究为高效、环保地去除水资源中的 Pb²⁺ 提供了一种可行的替代方法。

关键词: 冷冻凝胶; 结冷胶; 果胶; 吸附能力

Construction of double network gellan gum/pectin composite cryogel and high efficiency adsorption of Pb²⁺

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Abstract: This study utilized gellan gum (GG) and pectin (AP1, AP2) as materials, employing ion cross-linking and freeze-drying method to prepare a hybrid GG/AP cryogel, aiming for Pb²⁺ adsorption. Through texture, rheology, extrusion and swelling experiments, it was demonstrated that the double crosslinked network structure formed by GG and AP greatly enhanced the strength of the cryogel and reached the maximum at a GG/AP ratio of 1:4. The formation of cryogel crosslinked networks and the generation of porous structures were demonstrated by SEM, BET, and EDS. Meanwhile, the GG/AP2 cryogel had a good Pb²⁺ adsorption capacity under different conditions, and the maximum adsorption amount was up to 93.56 mg/g. XPS analysis before and after adsorption confirmed that the adsorption is mainly through chelation of Pb²⁺ with oxygen-containing functional groups. The results showed that hybrid cryogels with high specific surface area and structural enhancement are an economical and sustainable adsorbent. This work provides a promising alternative for the efficient and environmentally friendly removal of Pb²⁺ from water resources.

Key words : Cryogel; Gellan gum; Pectin; Adsorption capacity

饲料中添加白藜芦醇对肉牛肌纤维类型及肉品质的影响

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摘要: 本研究通过动物试验探究了饲料中添加白藜芦醇对肉牛肌纤维类型和肉品质的影响。肉牛被随机分为两组, 对照组饲喂标准混合日粮, 处理组添加白藜芦醇(5 g/头/天), 饲喂 120 d 后进行商业化屠宰。屠宰后 24h 取两组牛的背最长肌、腰大肌和半腱肌进行指标测定。结果表明, 饲料添加白藜芦醇增加了 *MyHCI* 基因表达和肌肉中 I 型纤维的比例。成熟 21 d 各肌肉的蒸煮损失和 Warner-Bratzler 剪切力均有所降低。随着 I 型纤维比例的增加, 初始肉色更深, 但肉色稳定性有所提高, 处理组样品的 a^* 值在成熟初期较低, 但在成熟后期较高。本研究表明白藜芦醇在肉牛嫩度和肉色稳定性方面具有一定的应用价值。

关键词: 白藜芦醇; 牛肉; 肌纤维; 嫩度; 肉色稳定性

Effect of dietary resveratrol supplementation on muscle fiber types and meat quality in beef cattle

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Abstract: In order to investigate the effect of dietary resveratrol supplementation on muscle fiber types and meat quality in beef cattle, a feeding experiment was undertaken. *Longissimus lumborum*, *Psoas major* and *Semitendinosus* muscles were collected 24 h post-mortem from two groups of cattle, which were fed with a total mixed ration (Control - CON) or supplemented with resveratrol (5 g/animal/day, RES) for 120 d before slaughter. The results showed that dietary resveratrol increased the gene expression of *MyHCI* and enhanced the proportion of type I fibers in three muscles. The cooking loss and Warner-Bratzler shear force of all muscles during aging for 21 days were decreased. However, the increased proportion of type I fibers resulted in a darker initial color, but did improve color stability, as the a^* value of RES samples was lower initially but higher in the later stage of aging. This study indicates the supplementation potential of resveratrol for beef cattle for tenderness and color stability.

Key words: resveratrol; beef; muscle fiber; tenderness; color stability

随机型 ι -卡拉胶酶的基因挖掘、克隆表达及性质研究

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摘要: 卡拉胶寡糖在功能性食品、医药、化妆品、农业等领域中具有广阔的应用前景。随机型卡拉胶酶是制备不同分子量卡拉胶及一系列卡拉胶寡糖的理想工具。虽然连续型 ι -卡拉胶酶已被广泛研究, 但是随机型 ι -卡拉胶酶尚未见报道。本研究通过 AlphaFold2 鉴定了一种缺失盖子结构的 GH82 家族蛋白 Cg82Mf, 并对其进行克隆表达。水解模式分析结果表明, Cg82Mf 是第一个针对 ι -卡拉胶的随机型内切酶, 可实现不同聚合度 ι -卡拉胶寡糖的制备。与其他已表征的 ι -卡拉胶酶相比, Cg82Mf 表现出最高的底物亲和力 ($K_m = 0.18 \mu\text{M}$)。值得注意的是, Cg82Mf 能水解 κ -卡拉胶, 表明该酶的亚位点能容受 κ -卡拉胶二糖。新颖的水解模式和切割特异性揭示了 GH82 家族内的作用方式多样性。本研究为 ι -卡拉胶及其寡糖的进一步应用奠定了基础。

关键词: 卡拉胶; ι -卡拉胶酶; GH82; ι -卡拉胶寡糖

Gene mining, expression and characterization of a random endo-acting ι -carrageenase

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Abstract: Carrageenan oligosaccharides have considerable potential for application in the fields of functional food, medicine, cosmetics, and agriculture. Random endo-acting carrageenases are promising tools for the preparation of different molecular weight carrageenan and a series of carrageenan oligosaccharides. Although the processive ι -carrageenases have been widely investigated, the random ι -carrageenase has not been reported. In this study, a GH82 family protein Cg82Mf, which was identified by AlphaFold2 as lacking a lid structure on the catalytic groove, was cloned and expressed. The analysis of hydrolysis pattern proved that Cg82Mf was the first random endo-acting enzyme against ι -carrageenan, and was capable of preparing ι -carrageenan oligosaccharides with various degrees of polymerization. Cg82Mf exhibited higher substrate affinity among all characterized ι -carrageenases ($K_m = 0.18 \mu\text{M}$). Remarkably, Cg82Mf could also hydrolyze κ -carrageenan, that is, the subsites of the enzyme could tolerate κ -carrageenan disaccharide. The novel hydrolysis pattern and cleavage specificity shed light on the presence of diversity of action mode within the GH82 family. The acquiring of the novel enzyme would facilitate the future application of ι -carrageenan and its oligosaccharides.

Keywords: carrageenan; ι -carrageenase; GH82; ι -carrageenan oligosaccharide

羧基纤维素纳米晶稳定牛至精油皮克林乳液活化果胶基薄膜

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摘要: 果胶薄膜脆性高、易吸湿、生物活性低, 这些缺点都限制了其发展。针对这些局限性, 制备了羧基纤维素纳米晶稳定牛至精油皮克林乳液 (COPE) 来活化果胶膜。COPE 具有良好的相容性, 可以均匀地分散在果胶基质中, 从而促进 COPE 与果胶分子之间紧密缠结和氢键结合。与纯果胶薄膜相比, 果胶-COPE 复合薄膜具有更高的拉伸强度 (16.03 MPa)、断裂伸长率 (25.27%)、水接触角 (88.02°) 和更低的水蒸气渗透率 ($1.40 \times 10^{-10} \text{ g/m}\cdot\text{s}\cdot\text{Pa}$)。重要的是, COPE 赋予果胶膜独特的抗紫外线 (复合膜几乎完全阻挡 UVC (275-200 nm) 和 UVB (320-275 nm) 区域的光, 以及 UVA (400-320 nm) 区域的大部分光) 能力、抗氧化和抗菌性能, 使其在用于包装樱桃时能够显著延长保质期并保持樱桃的品质。总之, COPE 为增强果胶基薄膜的生物活性、机械性能和疏水性能提供了新的策略, 经 COPE 活化的果胶基复合膜作为潜在的石化塑料替代品, 可为食品保鲜/包装提供更多机会。

关键词: 多糖基薄膜; 改性纤维素; 抗菌; 活性包装

Pectin-based film activated with carboxylated cellulose nanocrystals-stabilized oregano essential oil Pickering emulsion

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Abstract: The high brittleness, susceptibility to moisture absorption and low biological activity of pectin films limit their development. To address these limitations, carboxylated cellulose nanocrystals-stabilized oregano essential oil Pickering emulsion (COPE) was prepared to activate pectin films. COPE has good compatibility, and it can be uniformly dispersed in pectin matrix, which promotes the stable formation of composite films characterized by tight entanglement and hydrogen bonding between COPE and pectin molecules. Compared with pure pectin film, pectin-COPE composite film shows higher tensile strength (16.03 MPa), elongation at break (25.27%), water contact angle (88.02°) and lower water vapor permeability ($1.40 \times 10^{-10} \text{ g/m}\cdot\text{s}\cdot\text{Pa}$). Importantly, COPE endows pectin film with unique anti-ultraviolet (composite film almost completely blocks light in the UVC (275-200 nm) and UVB (320-275 nm) regions, as well as most light in the UVA (400-320 nm) region), antioxidation (DPPH radical scavenging capacity and T-AOC were maximized by 4.53% and 2.72%, respectively) and antibacterial properties (a clear ring of inhibition appears around the composite film), allowing it to significantly extend the shelf life and maintain the quality of cherries when used for packaging. In conclusion, COPE offers novel strategies to enhance the bioactive, mechanical, and hydrophobic properties of pectin-based films, and the pectin-based composite films activated by COPE can provide more opportunities for food preservation/packaging as potential petrochemical plastic substitutes.

Keywords: Polysaccharide-based films; Modified cellulose; Antibacterial; Active packaging

通过大蒜多糖和酪蛋白的共热交联增强乳化行为和包封稳定性，形成强效递送乳液

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摘要: 本研究利用大蒜多糖对酪蛋白进行糖苷化改性, 得到不同接枝度的糖基复合物, 制备出高性能乳液。本研究利用荧光光谱、傅里叶红外光谱 (FT-IR)、紫外光谱 (CD)、X 射线衍射 (XRD) 等方法对接枝物的二级结构进行分析, 有效分析了结构变化引起的乳化特性变化。此外, 基于优化后的接枝物的乳液特性开展了姜黄素活性物质的后续包封, 获得了具有优越流变性能和稳定性的良好乳液。包封体系的制备以主导接枝物产生的乳液的完全解析为基础, 为后续包封其他与姜黄素类似的不稳定活性物质提供了积极的借鉴。

关键词: 大蒜多糖; 酪蛋白; 糖基化; 结构表征; 乳液

Enhancing Emulsification Behavior and Encapsulation Stability through Co-Thermal Cross-Linking of Garlic Polysaccharide and Casein for Potent Delivery Emulsion

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Abstract: In the current research, we use garlic polysaccharides for glycosylation modification of casein and obtain sugar base compounds with different degrees of grafting to prepare a high-performance emulsion. In this study, fluorescence spectroscopy, Fourier infrared spectroscopy (FT-IR), ultraviolet spectroscopy (CD), X-ray diffraction (XRD), and other methods were used to analyze the secondary structure of the graft, and the changes in emulsification characteristics caused by structural changes were effectively analyzed. In addition, the subsequent encapsulation of curcumin activity was carried out based on the optimized emulsion characteristics of the graft, which is a good emulsion with superior rheological properties and stability. The preparation of the loading system was based on the complete resolution of the emulsion produced by the dominant graft, thus providing a positive reference for the subsequent encapsulation of other labile active substances similar to curcumin.

Keywords: Garlic polysaccharide, casein, glycosylation; structural characterization; emulsion.

透明质酸虾青素自组装纳米粒子通过调节肠道屏障、肠道菌群和炎症反应来改善溃疡性结肠炎

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摘要: 虾青素 (AST) 具有显著的抗氧化和抗炎特性。然而, 其稳定性差和溶解性低限制了其生物利用度。本研究中, 我们将 AST 与透明质酸 (HA) 共轭形成共价复合物, 并在水相体系中自组装形成 HA-AST 纳米粒子。HA-AST 呈球形, 粒径约为 172.6 ± 2.1 nm, zeta 电位为 -16.6 ± 0.8 mV, 显著提高了 AST 的稳定性和分散性。HA-AST 纳米粒子中 AST 的封装率和载药量分别为 72.7% 和 44.8%。HA-AST 在改善 UC 小鼠的结肠炎症状方面表现出显著效果, 包括抑制 ROS 的产生、促进 ZO-1 和 occludin 的表达、降低促炎因子 TNF- α 和 IL-1 β 的水平。同时, HA-AST 通过提高厚壁菌门与拟杆菌门的比值, 增加 *Paraclostridium*、*Paeniclostridium* 和 *[Eubacterium]_fissicatena* 群的丰度, 减少由 DSS 结肠炎引起的 *[Eubacterium]_brachy* 群的种群, 从而重塑肠道微生物群落结构。因此, 透明质酸-虾青素递送系统能够抑制氧化应激, 阻止炎症因子的表达, 修复结肠屏障, 并调节肠道微生物群落, 具有治疗 DSS 诱导的溃疡性结肠炎的潜力。

关键词: 透明质酸; 虾青素; 肠道微生物群; 肠道屏障; 结肠炎。

Hyaluronic acid-astaxanthin self-assembly nanoparticle ameliorates colitis by modulation of dysregulated intestinal barrier, microbiome and inflammatory response in ulcer colitis

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Abstract: Astaxanthin (AST) exhibits excellent antioxidant and anti-inflammatory abilities. However, the poor stability and solubility restrict its bioavailability. Herein, AST was conjugated with hyaluronic acid (HA) to form covalent complexes, which was self-assembled in aqueous phase to form HA-AST nano micelle. HA-AST was spherical with the particle size of around 172.6 ± 2.1 nm. The nano micelle enhanced the stability and dispersity of AST, and its zeta potential was -16.6 ± 0.8 mV. Encapsulation rate and Loading capacity of AST in HA-AST nano micelle were 72.7% and 44.8%, respectively. HA-AST ameliorated the colitis symptoms of UC mice in the aspects of inhibiting ROS production, promoting ZO-1 and occludin expression, decreasing pro-inflammatory cytokine TNF- α and IL-1 β level. At the same time, HA-AST reshaped intestinal microbiota by enhancing the ratio of Firmicutes to Bacteroidota, increasing the abundance of *Paraclostridium*, *Paeniclostridium*, and

[*Eubacterium*]*_fissicatena_group*, and reducing the population of [*Eubacterium*]*_brachy_group* that caused by DSS colitis. Therefore, the hyaluronic acid-astaxanthin delivery system inhibited oxidative stress, prevented the expression of inflammatory cytokines, restored colon barrier, and modulated intestinal microbiota, and it had the potential to apply in treatment of DSS-induced ulcerative colitis.

Keywords: hyaluronic acid; astaxanthin; intestinal microbiota; intestinal barrier; colitis

微拟球藻油脂提取精制

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摘要: 微拟球藻中富含多不饱和脂肪酸, 是生产二十碳五烯酸最具潜力的藻类之一。但常见的藻油提取方法对 EPA 损耗大、产率低, 且提取的藻油中杂质和色素含量高, 会在很大程度上影响藻油的质量与外观。因此, 研究藻油的提取、富集工艺对藻油的工业化应用具有十分重要的意义。本研究主要以得到质量高且富含 EPA 的藻油为目的, 建立了对微拟球藻油脂的提取以及对藻油中 EPA 富集纯化的工艺。主要研究内容和结果如下: (1) 采用亚临界提取技术以不同有机溶剂体系对微拟球藻进行提取, 以油脂提取得率和 EPA 纯度为指标, 确定最佳溶剂体系, 优化溶剂比例。随后对提取次数、料液比、提取时间、提取温度进行探究, 并对工艺条件进行正交优化。(2) 对提取得到的微拟球藻油脂进行乙酯化, 采用分子蒸馏对藻油中的 EPA 进行富集, 以藻油中 EPA 纯度为指标对蒸发温度、冷却温度、刮板转速、真空度进行探究, 优化了分子蒸馏的工艺条件。

关键词: 微拟球藻; EPA; 亚临界提取; 分子蒸馏

Extraction and refining of *Nannochloropsis* sp oil

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Abstract: *Nannochloropsis* sp. is rich in polyunsaturated fatty acids and is considered one of the most promising algae for the production of eicosapentaenoic acid (EPA). However, conventional algal oil extraction methods often result in significant EPA loss, low yields, and high levels of impurities and pigments in the extracted oil, which negatively impacts both the quality and appearance of the algal oil. Therefore, it is of great significance to study the extraction, refining and enrichment process of algal oil. This study mainly discusses the extraction, refining process and the process of EPA enrichment purification in algal oil to obtain high-quality and EPA-rich algal oil. The main research components and findings are as follows: (1) Subcritical extraction technology was employed to extract *Nannochloropsis* sp. using various organic solvent systems. The optimal solvent system was determined based on

oil extraction yield and EPA purity, followed by the optimization of the solvent ratio. Subsequently, extraction times, solid-liquid ratios, extraction durations, and extraction temperatures were systematically investigated and orthogonally optimized. (2) Ethyl esterification was performed on the extracted micropseudococcus oil, and EPA was enriched through molecular distillation. The parameters of evaporation temperature, cooling temperature, scraping speed, and vacuum degree were examined in relation to the purity of EPA in the algal oil, leading to the optimization of the molecular distillation conditions.

Key words : *Nannochloropsis sp.*; EPA; Subcritical extraction; Molecular distillation

细胞培育鱼肉高品质种子细胞创制及应用

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摘要: 细胞培育鱼肉是应对传统海水养殖/捕捞系列问题, 满足未来水产品需求, 实现海洋新资源探索的新途径。海水鱼种子干细胞低成本高效规模化培养与分化是细胞培育鱼肉产业化的基础。团队针对细胞培育鱼肉产业化关键种子细胞、血清替代物、细胞培养支架、细胞培养放大与强化技术等开展科研攻关。在海水鱼干细胞方面, 构建海水鱼种子肌肉/脂肪干细胞分离、培养与驯化技术, 开发大黄鱼、褐点石斑鱼、三文鱼等肌肉/脂肪干细胞系; 完成部分海水鱼干细胞永生生化、悬浮培养、共培养等驯化, 创制海水鱼干细胞库; 开发适宜于海水鱼干细胞低成本高效扩增用血清替代物, 实现代表性海水鱼干细胞>30代传代, 且兼具成肌分化能力; 开发可食用细胞培养支架, 剖析细胞培养支架结构与界面特征对细胞行为的调控机制, 解决细胞在可食用支架表面高效黏附与“桥移”的问题, 并创制支架定向裂解和规模化增殖细胞无损收集体系; 结合生物反应器构建干细胞规模化培养与强化技术, 经过16天培养, 海水鱼肌肉干细胞扩增499倍, 细胞密度 6.35×10^5 个/mL; 脂肪干细胞扩增461倍, 细胞密度 5.77×10^5 个/mL。该研究为高效稳定的海细胞培养鱼肉类体系化生产提供了基础和技术支撑。

关键词: 细胞培育鱼肉; 种子细胞; 驯化; 规模化培养

The preparation and application of high-quality seed cells for the cultivation of fish meat in vitro

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Abstract Cell-cultured fish meat is regarded as a novel approach to address the traditional challenges of aquaculture within the context of our country's large population, to meet the future demand for aquatic products, and to explore new marine resources. The industrialisation of cell-cultured fish meat is contingent upon the establishment of a

robust foundation in the low-cost, efficient, and large-scale cultivation and differentiation of marine fish seed stem cells. Our team has conducted scientific research and development on key aspects of the industrialization of cell cultured fish meat, including seed cells, serum substitutes, cell culture scaffolds, and cell culture amplification technologies. In the field of marine fish stem cells, we have developed techniques for the isolation, culture, and domestication of marine fish seed muscle/fat stem cells, and established muscle/ adipose-derived stem cell lines for various species, including *Larimichthys crocea*, *Epinephelus fuscoguttatus*, and *Salmo salar*. We also achieved the immortalization, suspension culture, and co-culture of some marine fish stem cells, and creating a marine fish stem cell bank. Besides, a serum substitutes suitable for the low-cost, efficient amplification of marine fish stem cells was developed, which enable marine fish stem cells to be passaged for over 30 generations while retaining myogenic differentiation capabilities. In order to establish the 3D seed cell culture system, the regulatory mechanisms of scaffold structure and interfacial characteristics on cell behavior were investigated, and a series of edible cell cultured scaffolds were fabricated. Meanwhile, the issue of efficient cell adhesion and "bridging" on edible scaffold surfaces was addressed, and a novel system for the directed and non-destructive collection of cells was established. In conjugation with the bioreactor, we devised stem cell amplification and enhancement technologies, resulting in a 499-fold expansion of marine fish muscle stem cells and 461-fold expansion of adipose-derived stem cells within 16 days, with the highest cell density reaching 6.35×10^5 cells/mL and 5.77×10^5 cells/mL, respectively. This research provides a foundation and technical support for the efficient and stable production of marine cell-cultured fish meat systems.

Key words Cell cultured fish meat; Stem cell; Domestication; Scalable cultivation of cell

虾青素微藻马达的构建及其对葡聚糖硫酸钠诱导的慢性结肠炎的影响

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摘要: 虾青素 (AST) 具有显著的抗氧化和抗炎活性, 但其易于氧化且不稳定。本研究利用壳聚糖 (CS) 稳定虾青素, 并通过共价交联合成了 CS-AST 复合物。在水相体系中, 形成的 CS-AST 纳米粒子, 水合粒径为 142.6 nm, zeta 电位为 +38.5 mV。由于正负电荷之间的物理吸附作用, CS@AST 纳米粒子有效地包覆在莱茵衣藻上, 从而获得虾青素微藻马达 (CS-AST@CR)。葡聚糖硫酸钠 (DSS) 诱导的慢性结肠炎小鼠模型表明, CS-AST@CR 能明显改善小鼠慢性结肠炎的症状, 如小鼠体重、结肠长度和脾脏指数。CS-AST@CR 抑制了炎症因子 TNF- α 、IL-1 β 和相关蛋白 NLRP3 的过度分泌, 促进了抗炎细胞因子 IL-10 的产生。免疫组化分析表明, CS-AST@CR 可通过增强 ZO-1 和 occludin 的表达来保护肠道屏障。CS-AST@CR 还能通过激活 Nrf2/HO-1 通路抑制结肠的氧化应激反应。此外, CS-AST@CR 还能恢复肠道微生物群的结构, 如提高拟杆菌/厚壁菌的比例, 增加有益菌 *Lachnospiraceae* 和 *Oscillospiraceae* 的数量。总之, CS-AST@CR 对慢性结肠炎有明显的缓解作用, 有望开发成治疗结肠炎的功能性食品和药物。

关键词: CS-AST@CR; 慢性结肠炎; Nrf2/HO-1; 炎症反应; 肠道屏障; 肠道菌群

Construction of astaxanthin-loaded microalgae motor and its effect on dextran sulfate sodium-induced chronic colitis

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Abstract: Astaxanthin (AST) has significant antioxidant and anti-inflammatory activities, but it is prone to oxidation and unstable. In this study, chitosan (CS) was used to stabilize AST, and CS-AST complex was synthesized by covalent crosslinking. In an aqueous system, CS-AST nanoparticles were formed, and the hydrated particle size was 142.6 nm with a zeta potential of +38.5 mV. As the physical adsorption between positive and negative charges, CS@AST nanoparticles were effectively coated on the microalgae (*Chlamydomonas reinhardtii*) to obtain astaxanthin microalgae motor (CS-AST@CR). Dextran sulfate sodium (DSS)-induce chronic colitis mouse model indicated that CS-AST@CR significantly ameliorated the symptoms of mice chronic colitis as indicated by mice body weight, colon length and spleen index. CS-AST@CR suppressed the overproduction of inflammatory related proteins TNF- α , IL-1 β , and NLRP3, and promoted the secretion of anti-inflammatory cytokine IL-10. Immunohistochemical analysis revealed that CS-AST@CR could protect intestinal barrier by enhancing the expression of ZO-1 and occludin. CS-AST@CR also inhibited colon oxidative response via activating Nrf2/HO-1 pathway. In addition, CS-AST@CR restored the structure of intestinal microbiota such as increasing the ratio of Bacteroidetes/Firmicutes and enhancing the beneficial bacteria *Lachnospiraceae* and *Oscillospiraceae* abundance. In sum, CS-AST@CR exhibited significant relieving effects on chronic colitis, and it had the potential to be developed as functional foods and drugs for colitis treatment.

Key words: CS-AST@CR; chronic colitis; Nrf2/HO-1; inflammatory response; intestinal barrier; gut microbiota

虾蟹新鲜度的酶传感分析研究

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摘要: 水产品由于营养物质丰富受到消费者的广泛青睐。然而, 高蛋白、含水量高的肌肉组织也为微生物的生长和繁殖提供了良好的条件, 因此水产品极易腐败变质。新鲜度对评价水产品质量至关重要, 保障水产资源的新鲜度是对其进行高质量开发利用的先决条件。次黄嘌呤(Hx)是衡量新鲜度的指标之一, 其在生物体死亡后因ATP合成停止而逐渐增加, 因此可视为水产品早期阶段的新鲜度评价指标。本研究以虾蟹作为水产品代表, 开发了一种将

黄嘌呤氧化酶 (XOD) 与纳米酶 (AuNPs) 相结合的比色型酶生物传感器, 用于 Hx 的检测。其中, XOD 可催化 Hx 氧化生成 H_2O_2 , AuNPs 可进一步催化 H_2O_2 对 3,3',5,5'-四甲基联苯胺 (TMB) 的氧化作用, 产生 TMB 的蓝色氧化产物 (oxTMB), 用于比色定量。在最佳条件下, 该传感器对 Hx 的线性检测范围为 18.8-300 μM , 检出限为 4.47 μM , 其灵敏度较高, 且对 Hx 有较高选择性; 该传感器可用于鹰爪虾与三疣梭子蟹的实际样品检测, 回收率为 80.34%-116.3%; 可为次黄嘌呤的检测及虾蟹新鲜度监控提供新的思路, 并为水产资源开发利用行业中水产品新鲜度监控提供良好的参考基础。

关键词: 水产品鲜度; 次黄嘌呤; 酶传感器; 纳米酶

Enzyme-based biosensing analysis of freshness of shrimps and crabs

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Abstract: Aquatic products are widely favored by consumers because of their rich nutrients. However, the high protein and water content of muscle tissue also provides good conditions for the growth and reproduction of microorganisms, thus making aquatic products highly susceptible to spoilage. Freshness is an important indicator to evaluate the quality of aquatic products, ensuring the freshness of aquatic resources is critical for their high-quality exploitation. Hypoxanthine (Hx) is one of the indicators of freshness, which increases gradually after the death of the organism due to the cessation of ATP synthesis, and can therefore be considered as an indicator of freshness of aquatic products at an early stage. In this work, a colorimetric enzyme-based biosensor combining xanthine oxidase (XOD) and nanozymes (AuNPs) was developed for the detection of Hx, using shrimps and crabs as a representative of aquatic products. Among them, XOD can catalyze the oxidation of Hx to form H_2O_2 . AuNPs can further catalyze the oxidation of 3,3',5,5'-tetramethylbenzidine (TMB) by H_2O_2 , producing the blue oxidation product of TMB (oxTMB) for colorimetric quantification. Under the optimal conditions, the linear detection range of Hx is 18.8-300 μM , and the limit of detection is 4.47 μM , showing high sensitivity and high selectivity for Hx. The biosensor can be used for the actual sample detection of *Trachypena longipes* and *Portunus trituberculatus* with the recovery rates of 80.34%-116.3%. It can provide good reference for the detection of Hx and freshness monitoring of shrimps and crabs, and also provide good reference for freshness monitoring of other aquatic products.

Key words: Aquatic products freshness; Hypoxanthine; Enzyme-based biosensor; Nanozyme

新型 β -*N*-乙酰氨基葡萄糖苷酶的挖掘及在乳糖-*N*-三糖制备中的应用

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摘要: 本研究通过生物信息学分析筛选得到一个可高效合成 LNT II 的 β -*N*-乙酰氨基葡萄糖苷酶(Fshex)。通过大肠杆菌异源表达, 测定其酶学性质并用于 LNT II 的制备。其分子量为 78 kDa, 最适反应温度为 45 °C, 最适反应 pH 为 6.0。在稳定性方面, Fshex 在 40 °C 下孵育 24 h 可保持 95% 以上的活性, 在 4 °C 下可保存数月, 具有良好的稳定性。在制备 LNT II 方面, 以高浓度甲壳二糖为供体, 利用 Fshex 的转糖基活性将 GlcNAc 转移到乳糖受体的非还原端, 成功实现 LNT II 的制备, 转化率达到 22.17%。为了进一步提升转化率, 本研究将 Fshex 与甲壳二糖、乳糖和恶唑啉进行分子对接, 通过相互作用力分析、氨基酸性质对比等, 选取活性口袋内部非高度保守的 6 个氨基酸, 进行丙氨酸扫描定点突变, 成功将转化率提升至 34.9%, 是目前的领先水平。

关键词: *N*-乙酰氨基葡萄糖苷酶; 乳糖-*N*-三糖; 定点突变; 甲壳二糖; 甲壳素

Mining of a novel β -*N*-acetylglucosaminidase and its application in the preparation of lactose-*N*-triosaccharide

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Abstract: In this study, a β -D-acetylglucosaminidase Fshex was screened through bioinformatic analysis, which could efficiently synthesize LNT II. After the heterologous expression in *Escherichia coli*, the enzymatic properties were characterized and used for the preparation of LNT II. Its molecular weight was 78 kDa, with the optimal reaction temperature and pH of 45 °C and 6.0, respectively. Fshex showed good stability, maintaining more than 95% activity after being incubated at 40 °C for 24 h and 4 °C for several months. In the preparation of LNT II, GlcNAc was transferred to the non-reducing end of lactose with high concentration of *N*-acetylchitobiose as the donor, and the conversion rate reached 22.17%. In order to further improve the conversion rate, we analyzed the interaction force analysis, amino acid properties comparison between Fshex and several ligands (*N*-acetylchitobiose, lactose and oxazoline) in molecular docking, performing six site-specific mutations on Fshex. The conversion rate was successfully increased to 34.9%, which was the highest level up date.

Key words: *N*-acetylglucosaminidase; Lactose-*N*-triose; Site-specific mutation; Chitobiose; chitin

一种短时且低 5-HMF 含量的黑蒜加工技术的表征

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摘要: 黑蒜是一种经过深加工的蒜制品, 在亚洲各国广受欢迎。传统黑蒜的生产通常需要 60 至 90 天, 生产效率低, 并可能产生有害物质 5-羟甲基糠醛(5-HMF)。本研究中, 我们采用了一种新型生产工艺, 可以在仅 8.6 小时内生产出黑蒜 (SBG), 并显著降低 5-HMF 的含量。通过比较分析研究了 SBG 与市售黑蒜 (CBG) 在颜色、理化性质、特征成分、体外抗氧化能力及挥发性化合物等方面的质量差异。结果表明, SBG 与 CBG 在颜色上无显著差异。SBG 的蛋白质、还原糖和多酚含量较高。5-HMF、大蒜素和 S-丙烯基半胱氨酸(SAC)被选为黑蒜的特征成分。与 CBG 相比, SBG 中 5-HMF 的含量仅为 5.6%, SAC 的含量为 CBG 的 2.3 倍, 较新鲜大蒜高出 11.3 倍, 而在 SBG 样品中未检测到大蒜素。对比相同浓度的黑蒜提取物, SBG 的抗氧化能力均强于 CBG。CBG 与 SBG 的主要风味化合物有差异, 相比之下, SBG 的香气轮廓表现出更令人愉悦的气味, 并减少了辛辣味。

关键词: 抗氧化能力; 大蒜素; 褐变度; 关键风味化合物; S-烯丙基-L-半胱氨酸

Characterization of a short-term processing technology of black garlic with low 5-HMF content

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Abstract : Black garlic, a deep-processed product of garlic, is widely favored in various Asian countries. Traditional black garlic production typically takes 60 to 90 days, resulting in low production efficiency and the formation of potentially harmful levels of 5-hydroxymethylfurfural (5-HMF). In this study, we implemented a novel production process capable of producing short-term black garlic (SBG) with significantly reduced levels of 5-HMF within just 8.6 hours. A comparative analysis was conducted to investigate the quality disparities between SBG and commercially black garlic (CBG), encompassing assessments on color, physicochemical properties, characteristic components, in vitro antioxidant capacity, and volatile compounds. The results indicated that there were no significant differences in color between SBG and CBG. SBG exhibited higher levels of protein, reducing sugar, and polyphenols. 5-HMF, allicin, and S-allyl-L-cysteine (SAC) were selected as characteristic ingredients of black garlic. The

concentration of 5-HMF in SBG was only 5.6% compared to CBG. SAC content in SBG was 2.3 times higher than in CBG and 11.3 times higher than in fresh garlic, while allicin was not detected in SBG samples. When comparing black garlic extracts at the same concentration, the antioxidant capacity of SBG was found to be stronger than that of CBG. The key flavor compounds between CBG and SBG are differences. In comparison, the aroma profile of SBG exhibits a more pleasant scent with reduced pungency.

Key words : Antioxidant capacity; Allicin; Browning degree; Key flavor compounds; S-allyl-L-cysteine

一种内切-1,3-岩藻聚糖酶的乳酸菌表达及性质

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摘要: 岩藻聚糖是一种具有良好应用潜力的多糖, 具备多种生理活性。内切-1,3-岩藻聚糖酶是岩藻寡糖制备的关键工具。然而, 作用方式清晰的食物工业用岩藻聚糖酶的缺乏阻碍了该类酶的应用。本研究旨在获得来源于 GH174 家族的食物工业用内切-1,3-岩藻聚糖酶 Fun174Sb, 并探究其作用方式。利用乳酸菌表达系统实现了一种内切-1,3-岩藻聚糖酶 Fun174Sb 的异源表达。结果显示, Fun174Sb 对于来源于土耳其刺参的岩藻聚糖(Ht-FUC)具有降解能力, 酶活性为 1.90 U/mg。该酶在 35~50 °C、pH 7.5~8.5 条件下显示出较高的活性, 且具有良好的温度稳定性及 pH 稳定性。通过超高效凝胶排阻色谱串联质谱以及核磁共振技术阐明了 Fun174Sb 的酶解产物中主要寡糖的结构, 从而推断出 Fun174Sb 切割 Ht-FUC 的 Fucp2(OSO₃⁻)与 Fucp2,4(OSO₃⁻)之间的 α -1,3-糖苷键。研究表明, 乳酸菌表达的 Fun174Sb 具有良好的生化性质以及清晰的作用方式。本研究为作用方式清晰的食物级岩藻聚糖的应用奠定基础。

关键词: 岩藻聚糖酶; 乳酸菌; 刺参; 克隆表达; 生化性质; 作用方式

Expression and properties of an endo-1,3- fucoidanase in *Lactobacillus*

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Abstract : Fucoidan is a marine polysaccharide with diverse physiological activities. Endo-1,3-fucoidanase is a favorable tool for the preparation of fucooligosaccharides. Nevertheless, the lack of food-grade fucoidanase with clear cleavage sites has hindered its application. This study aimed to obtain a food-grade endo-1,3-fucoidanase from GH174 family (Fun174Sb) and to investigate its cleavage site. The study demonstrated that the food-grade expression of Fun174Sb could be achieved through the *Lactobacillus* NICE system. Fun174Sb exhibits significant

endo-acting hydrolysis activity towards fucoidan from *Holothuria tubulosa* (Ht-FUC), with an enzymatic activity of 1.90 U/mg. Fun174Sb showed significant activity within a temperature range of 35-50 °C and a pH range of 7.5-8.5, and it possessed good temperature and pH stability. Furthermore, the structure of the dominant oligosaccharide in the enzymatic product was analyzed using ultra performance size exclusion chromatography-mass spectrum (UPSEC-MS) and nuclear magnetic resonance (NMR). It could be inferred that Fun174Sb cleaves the α -1,3-glycosidic bond between Fucp2(OSO₃⁻) and Fucp2,4(OSO₃⁻) in Ht-FUC. The study showed that Fun174Sb expressed in *Lactobacillus* exhibited favorable biochemical properties and a clear mode of action. It laid the foundation for the application of food-grade fucoidanase.

Key words : fucoidanase; *Lactobacillus*; sea cucumber; cloning and expression; biochemical properties; action mode

一种新的聚甘露糖醛酸偏好性褐藻胶裂解酶的发现和特性：一个新的多糖裂解酶家族的第一个成员

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摘要: 褐藻胶是一种重要的海洋胶体多糖, 其寡糖具有多种生物学功能。褐藻胶裂解酶能特异性降解褐藻胶, 是研究和开发褐藻胶的理想工具。本研究中, 发现一个新的催化结构域, 此结构域与已知拥有功能的结构域没有显著的序列相似性, 被验证出为随机型内切褐藻胶裂解酶。将异源表达的蛋白, 命名为 Aly44A。作用方式分析表明, Aly44A 优先降解 polyM。其最小底物和最小产物分别为不饱和三糖和二糖。基于 Aly44A 及其同源序列的新颖性, 提出了一个新的多糖裂解酶家族 (PL44)。新的褐藻胶裂解酶和多糖裂解酶家族的发现为褐藻胶裂解酶的基因挖掘和获取提供了新的途径, 也将促进褐藻胶及其寡糖的利用。

关键词: 褐藻胶裂解酶; 多糖裂解酶; PolyM 偏好性; 作用方式; PL 44

Discovery and characterization of a novel poly-mannuronate preferred alginate lyase: The first member of a new polysaccharide lyase family

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Abstract: Alginate is one of the most important marine colloidal polysaccharides, and its oligosaccharides have been proven to possess diverse biological functions. Alginate lyases could specifically degrade alginate and therefore serve as desirable tools for

the research and development of alginate. In this report, a novel catalytic domain, which demonstrated no significant sequence similarity with all previously defined functional domains, was verified to exhibit a random endo-acting lyase activity to alginate. The action pattern analysis revealed that the heterologously expressed protein, named Aly44A, preferred to degrade polyM. Its minimum substrates and the minimum products were identified as unsaturated alginate trisaccharides and disaccharides, respectively. Based on the sequence novelty of Aly44A and its homologs, a new polysaccharide lyase family (PL44) was proposed. The discovery of the novel enzyme and polysaccharide lyase family provided a new entrance for the gene-mining and acquiring of alginate lyases, and would facilitate to the utilization of alginate and its oligosaccharides.

Key words : Alginate lyase; Polysaccharide lyase; PolyM-preferred; Action pattern; PL44

一种紫菜多糖结合蛋白的获取、研究与应用

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摘要: 紫菜多糖是紫菜的主要组成物质及营养功效成分, 在紫菜结构与品质的形成中发挥着关键作用, 已被证实具有抗衰老、抗氧化、免疫调节等显著生理功能。多糖结合蛋白是多糖研究的关键工具, 可服务于多糖的可视化分析、特异性检测、高通量分析等场景; 然而, 当前紫菜多糖结合蛋白稀缺。本研究以碳水化合物结合结构域 (Carbohydrate-binding module, CBM) 为切入点, 运用拓扑结构预测策略挖掘得到一个潜在的紫菜多糖结合蛋白基因, 以异源过量表达技术高效获取表达蛋白, 命名为 FvCBM99。以微阵列、微孔板、生物膜干涉等技术系统考察了该蛋白的结合特性, 发现该蛋白能够特异性结合紫菜多糖特征性结构单元。基于该蛋白序列的新颖性及明确的结合功能, 构建了一个全新的 CBM 家族—CBM99。进一步以 X-射线衍射技术以 1.75 Å 的分辨率成功解析了 FvCBM99 的晶体结构。定点突变分析表明芳香族氨基酸及带正电的极性氨基酸在 FvCBM99 对紫菜多糖的结合过程中发挥着关键作用。将该蛋白与绿色荧光蛋白进行融合表达, 并以荧光融合蛋白作为探针, 成功实现了紫菜中紫菜多糖的原位可视化观察。上述研究为紫菜多糖的未来研究与开发提供了良好工具。

关键词: 紫菜多糖; 多糖结合蛋白; 碳水化合物结合结构域; 晶体结构; 原位可视化

Discovery, characterization, and application of a porphyrin-binding protein

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Abstract: Porphyrin are the main constituents and nutritional components of *Porphyra*, playing a key role in the

formation of the structure and quality of *Porphyra*. Various bioactivities of porphyran were confirmed, including antiaging, antioxidant, and immunomodulatory. Polysaccharide-binding proteins are key tools for polysaccharide investigations, and could serve in the visualization, specific detection, and high-throughput analysis of polysaccharides. Nevertheless, porphyran-binding protein is currently scarce. In this report, taking the carbohydrate-binding module as the entry point, based on a structural prediction strategy, a potential porphyran-binding protein gene was explored. The expressed protein (named FvCBM99) was efficiently obtained by heterologous overexpression techniques, and further characterized by microarray, microtiter plate, and bio-layer interferometry assays. The results demonstrated that FvCBM99 could specifically bind to the characteristic structural units of porphyran. The sequence novelty and well-defined function of FvCBM99 reveal a new CBM family, CBM99. The structure of FvCBM99 was resolved at a 1.75 Å resolution by the X-ray crystallography. Site-directed mutagenesis assays confirmed that aromatic and positively charged polar residues are crucial for the ligand binding of FvCBM99. The protein was fused with a green fluorescent protein, and the *in situ* visualization of porphyran in *Porphyra* was realized employing the fluorescent fusion proteins as the probe. This study provides a promising tool for future studies and development of porphyran.

Key words: Porphyran; polysaccharide-binding protein; carbohydrate-binding module; crystal structure; *in situ* visualization

用于吞咽困难食品的 3D 打印蛋白质/多糖墨水：纤维素纳米晶体的影响

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摘要: 吞咽困难饮食需求量因人口老龄化问题而日益增长。3D 食品打印提供了一种具有前景的解决方案, 通过创新技术塑造食物的形状、风味、质地和营养成分, 显著改善吞咽困难患者的用餐体验。本研究选用了两种常用蛋白质: 明胶 (GB) 和乳清蛋白分离物 (WPI), 以及常见于吞咽困难饮食中的多糖黄原胶 (XG), 开发了含有纤维素纳米晶体 (CNCs) 的食品墨水。在 GB/XG 配方中加入 1.0 wt% 的 CNCs, WPI/XG 配方中加入 1.5 wt% 的 CNCs, 可以显著增强墨水的粘度、屈服应力和自支撑性。此外, CNCs 的加入大幅提升了 GB/XG 复合凝胶的热稳定性, 即使在 50°C 下也能保留约 90% 的形状保真度。根据国际吞咽困难饮食标准化倡议指南, 将 GB/XG/1.5CNC 样品维持在 4°C 下, 可使其从未被批准的类别转变为 5

级吞咽困难饮食。本研究不仅为 3D 打印吞咽困难食品的流变学特性和加工技术提供了宝贵见解，也为开发视觉吸引力强、营养丰富的订制餐食开辟了新途径。

关键词：3D 食品打印；蛋白质/多糖食品油墨；纤维素纳米晶体；流变学性质；吞咽困难饮食

3D printed protein / polysaccharide food simulant for dysphagia diet: impact of cellulose nanocrystals

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Abstract: The aging population is driving an increasing demand for dysphagia diets. Three-dimensional (3D) food printing offers a promising solution by employing innovative techniques to shape, flavor, enrich nutrition, and enhance texture, thereby greatly improving the dining experience for dysphagic individuals. In this study, we utilized two widely used proteins, gelatin B (GB) and whey protein isolate (WPI), along with xanthan gum (XG), a common polysaccharide found in dysphagic diets, to develop water-based food inks incorporating cellulose nanocrystals (CNCs). The inclusion of 1.0 wt% CNCs in GB/XG and 1.5 wt% in WPI/XG formulations led to notable enhancements in ink viscosity, yield stress, and self-supporting properties. Furthermore, the incorporation of CNCs substantially improved the thermal stability of GB/XG composite gels, preserving approximately 90% of the original cross-sectional area even at 50°C. Following the guidelines of the International Dysphagia Diet Standardisation Initiative (IDDSI), maintaining the temperature of GB/XG/1.5CNC samples at 4°C facilitated their transition from an unapproved classification to Level 5 minced and moist dysphagic diet formulations. This study not only offers insights into the rheological properties and processing techniques required for 3D printing of dysphagia-friendly foods but also opens avenues for creating visually appealing and nutritious meals tailored to the specific needs of dysphagic patients.

Key words: 3D food printing; Protein/polysaccharide food inks; Cellulose nanocrystals; Rheological properties; Dysphagia diet

油菜素内酯抑制纳米塑料在食源性植物中的积累及毒性研究

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摘要: 食物源植物种植过程中堆肥、塑料覆盖物和土壤改良剂的应用导致纳米塑料被释放到土壤, 被根系吸收并转移到可食用部分, 会对人类健康构成威胁。尽管纳米塑料引起的植物毒性越来越受到关注, 但如何抑制植物对纳米塑料的吸收并减少其导致的不良影响尚不清楚。本研究以广泛食用的十种食源性植物为研究对象, 考察了纳米塑料在植物可食部位(番茄果实、辣椒果实、生菜叶、芹菜茎、香菜茎、茼蒿茎、苦苣茎、葱茎、菠菜茎、菜心茎)的积累。结果表明, 不同植物对纳米塑料的吸收具有相似规律——被植物根系吸收, 并通过维管束向可食部位转运。研究还以番茄为对象, 考察了外源施加油菜素内酯对纳米塑料积累的抑制及其诱导的植物损伤的缓解。结果表明, 50 nM 油菜素内酯能够显著抑制番茄果实中纳米塑料的积累, 并缓解了纳米塑料诱导的植物毒性, 促进植株生长, 增加鲜重和株高, 缓解氧化损伤。

关键词: 纳米塑料; 番茄; 油菜素内酯; 毒性

Inhibition of accumulation and toxicity of nanoplastics in edible plants by brassinosteroids

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Abstract: The application of compost, plastic mulch and soil amendments during the cultivation of food-derived plants leads to the release of nanoplastics into the soil. The nanoplastics might be taken up by roots and transferred to edible parts, posing a threat to human health. Although the phytotoxicity caused by nanoplastics has attracted much attention, how to inhibit the absorption of nanoplastics by plants and reduce the subsequent adverse effects remains unclear. In this study, the accumulation of nanoplastics in edible parts of plants (tomato fruit, chilli fruit, lettuce leaves, celery stem, coriander stem, tarragon stem, endive stem, scallion stem, spinach stem, cabbage stem) was investigated. The results showed that the absorption of nanoplastics by different plants had similar laws—they could be absorbed by plant roots and transported to edible parts through vascular bundles. The effects of exogenous brassinosteroids on inhibiting the accumulation of nanoplastics and alleviating phytotoxicity induced by nanoplastics were investigated in tomato. The results showed that the application of 50 nM brassinosteroids significantly inhibited the accumulation of nanoplastics in tomato fruits and alleviated the phytotoxicity, promoted plant growth, increased fresh weight and plant height, and alleviated oxidative damage.

Key words: Nanoplastics; Tomato; Brassinosteroids; Toxicity

鱿鱼羽状壳胰蛋白酶水解物和壳聚糖微胶囊的合成、表征及初步分析

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摘要:为探究鱿鱼羽状壳(SP)的组成,对其基本成分和氨基酸组成进行了分析。结果表明,SP含有64.41%的蛋白质和26.03%的甲壳素。Met含量最高,浓度为13.67 g/100 g。SP的蛋白酶水解物由低分子量肽组成,具有优异的生物活性。为了提高稳定性和生物利用度,采用超声波乳化技术,将SP胰蛋白酶水解物(SPTH)和SP β -壳聚糖(SPC)制成了微胶囊。最佳制备条件为使用浓度为2%的SPC、浓度为4 mg/mL的SPTH、SPTH/SPC的芯壁比(v/v)为1:3,超声处理20分钟。在此条件下,微胶囊对SPTH的负载能力为58.95%。通过傅里叶变换红外光谱(FTIR)、X射线衍射(XRD)、差式扫描量热仪(DSC)和扫描电镜(SEM)等分析,证实了SPTH在SPC复合物中成功包封形成SPC-SPTH微胶囊,且表现出良好的热稳定性、小粒径和高包封率。体外消化研究表明,在模拟胃液中的释放率为15.61%,在肠液中的释放率为69.32%,实现了在肠道中的定向释放。与游离的SPTH消化物相比,消化产物显示出更高的抗氧化活性,这表明微胶囊化技术有效地保留了SPTH的生物活性。本研究提高了SPTH的生物利用度,为生物利用度和稳定性较低天然化合物提供了一种前景广阔的给药系统。

关键词:微胶囊; 鱿鱼羽状壳胰蛋白酶水解物; β -壳聚糖; 结构表征; 抗氧化活性

Synthesis, characterization, and preliminary analysis of squid pen trypsin hydrolysates and chitosan microcapsules

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Abstract: To understand the composition of squid pen (SP), the basic composition and amino acid composition were analyzed. SP was found to contain 64.41% protein and 26.03% chitin. Met was the most abundant amino acid in SP, with a concentration of 13.67 g/100 g. Protease hydrolysates of SP consist of low molecular weight peptides that exhibit excellent biological activity. To enhance the stability and bioavailability, microcapsules were developed using ultrasonic emulsification techniques with SP trypsin hydrolysates (SPTH) and SP β -chitosan (SPC). The optimal preparation conditions involved using a 2% concentration of SPC, a 4 mg/mL concentration of SPTH, a core-to-wall ratio (v/v) of 1:3 for SPTH/SPC, and subjecting the mixture to ultrasonic treatment for 20 min. These microcapsules had a loading capacity of 58.95% for SPTH under these conditions. The successful encapsulation of SPTH in the SPC complex to form SPC-SPTH microcapsules was confirmed through FTIR, XRD, DSC, and SEM,

exhibiting good thermal stability, small particle size, and high encapsulation efficiency. In vitro digestion studies demonstrated release rates of 15.61% in simulated gastric fluid and 69.32% in intestinal fluids, achieving targeted release in the intestines. The digested products displayed superior antioxidant activity compared to free SPTH digests, indicating that microencapsulation effectively preserves the bioactivity of SPTH. This study enhances the bioavailability of SPTH and offers a promising delivery system for natural compounds with low bioavailability and stability.

Key words: Microcapsules; squid pen trypsin hydrolysates; β -chitosan; structural characterization; antioxidant activity

增强酸奶坚果风味乳酸乳球菌的筛选及关键香气化合物的确定与发酵工艺的优化

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摘要: 目前酸奶风味同质化的问题突出, 根本原因在于缺乏特色发酵菌株, 乳酸乳球菌作为辅助菌株可以赋予酸奶独特的风味。本研究将 28 株不同乳酸乳球菌分别与嗜热链球菌、保加利亚乳杆菌复配制备酸奶, 基于香气分型结果筛选出坚果香型乳酸乳球菌 YN18-6.2, 采用固相微萃取-气相色谱-质谱联用共鉴定出 47 种挥发性化合物。正交偏最小二乘筛选得到 7 种差异化合物, 其中 3-甲基丁醛、异戊醇、2-苯乙醇对坚果香型贡献度较大, 其香气活度值均大于 1; 指纹图谱直观反映出坚果香型酸奶中 3-甲基丁醛含量明显高于对照组, 香气添加实验明确了主要关键香气化合物为 3-甲基丁醛; 全基因组结果表明与 3-甲基丁醛合成有关的基因为 *kdcA*、*pta*、*ack*、*pdhD*; 单因素实验确定在温度 32°C、加糖量 6%、接种量 2.5%、菌种配比(乳酸乳球菌:嗜热链球菌:保加利亚乳杆菌) 100: 10: 1 等条件下坚果味酸奶感官接受度最高, 此条件下 3-甲基丁醛浓度范围为 0.275-0.620 mg/kg。该研究将为坚果风味乳酸乳球菌的高效靶向筛选提供依据。

关键词: 乳酸乳球菌; 坚果味; 3-甲基丁醛; 关键基因; 发酵工艺

Screening of *Lactococcus lactis* for enhancing yogurt nutty flavor, identification of key aroma compounds and optimization of fermentation process

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Abstract : At present, the problem of homogenization of yogurt flavor is prominent. The fundamental reason is the lack of characteristic fermentation strains. *Lactococcus lactis* can give yogurt a unique flavor as an auxiliary strain. In this study, 28 different strains of *Lactococcus lactis* were compounded with *Streptococcus thermophilus* and

Lactobacillus bulgaricus to prepare yogurt. Based on the aroma typing results, the nut-flavored *Lactococcus lactis* YN18-6.2 was screened out, and a total of 47 volatile compounds were identified by solid phase microextraction-gas chromatography-mass spectrometry. Orthogonal partial least squares screening obtained 7 differential compounds, among which 3-methylbutanal, isopentanol, and 2-phenylethanol contributed the most to the nutty flavor, and their aroma activity values were all greater than 1; the fingerprint spectrum intuitively reflected that the content of 3-methylbutanal in the nutty flavor yogurt was significantly higher than that in the control group, and the aroma addition experiment confirmed that the main key aroma compound was 3-methylbutanal; the whole genome results showed that the genes related to the synthesis of 3-methylbutanal were *kdcA*, *pta*, *ack*, and *pdhD*; the single factor experiment determined that the sensory acceptance of nutty flavor yogurt was the highest under the conditions of temperature 32°C, sugar addition 6%, inoculation amount 2.5%, and strain ratio (*Lactococcus lactis*: *Streptococcus thermophilus*: *Lactobacillus bulgaricus*) 100:10:1, and the concentration range of 3-methylbutanal under this condition was 0.275-0.620 mg/kg. This study will provide a basis for the efficient targeted screening of nut-flavored *Lactococcus lactis*.

Key words : *Lactococcus lactis*; Nutty flavor; 3-methylbutyraldehyde; Key genes; fermentation process

榛果食养与健康：从传统中医记载到现代科学实证

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摘要: 榛果在传统中医药中被视为优良的食材, 具补脾胃、明目健行、润肺止咳、滋阴补血和益气力等功效。现代营养科学也证实, 榛果中的特异性组分有助于提高免疫力、调节血脂和血压、预防肿瘤等。文章系统总结了传统中医对榛果食疗效用的记载, 将传统中医与现代科学研究进行对比和融合, 探讨榛果的食养价值, 并结合榛果的实践应用, 以为榛果食养提供新的视角。

关键词: 榛果; 食养; 传统中医药; 现代营养科学;

Hazelnut nutrition and health: from traditional Chinese medicine records to modern scientific evidence

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Abstract: Hazelnuts have been traditionally regarded as a superior food ingredient in Traditional Chinese Medicine,

with documented benefits such as nourishing the spleen and stomach, improving vision and mobility, moistening the lungs and relieving cough, nourishing yin and replenishing blood, and enhancing energy and strength. Modern nutritional science has also confirmed that specific components in hazelnuts contribute to immune system enhancement, regulation of blood lipids and blood pressure, and prevention of tumors. This article systematically summarizes the Traditional Chinese Medicine records on the dietary therapeutic effects of hazelnuts, compares and integrates traditional Chinese medicine with modern scientific research, explores the dietary and nourishing value of hazelnuts, and combines practical applications of hazelnuts to provide new perspectives on their dietary nourishment.

Keywords: hazelnut; food nutrition; traditional Chinese medicine; modern nutritional science

植物内源性褐变抑制剂筛选及褐变抑制机制研究

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摘要: 熊果酸 (Ursolic acid, UA) 作为一种具有抗氧化特性的五环三萜类物质, 常见于夏枯草、枇杷、沙棘等天然植物中。实验室前期筛选到植物内源性褐变抑制剂 UA 可显著抑制苹果浆液与鲜切苹果褐变, 在此基础上对 UA 抑制褐变的机制进行了进一步研究, 结果表明, UA 处理可显著抑制鲜切苹果多酚氧化酶 (PPO) 活性、提高抗氧化能力、活性氧清除能力, 且具有较好的抑菌及广谱褐变抑制效果, 进一步通过非靶向代谢组学技术探讨了外源 UA 处理对鲜切苹果代谢物的影响并筛选到一种新型植物内源性褐变抑制剂-乌头酸。乌头酸 ($C_6H_6O_6$) 是一种不饱和三羧酸, 是三羧酸循环 (TCA) 中柠檬酸循环的中间产物, 广泛存在于生物体内, 具有较好的食用安全性。通过外源乌头酸处理鲜切苹果和马铃薯, 结果表明: 6% 乌头酸处理 5 min 可显著抑制鲜切苹果褐变, 4 °C 贮藏可达 12 d; 6% 乌头酸处理 1 min 可显著抑制鲜切马铃薯丝褐变, 4 °C 贮藏可达 7 d; 此外乌头酸也具有良好的抑菌效果, 能显著抑制鲜切果蔬表面的微生物增长。本研究为植物内源性褐变抑制剂的开发与应用开辟了新方向并奠定了理论基础。

关键词: 植物内源性物质; 褐变抑制剂; 熊果酸; 乌头酸; 鲜切果蔬

Screening of Endogenous Browning Inhibitors in Plants and the Mechanism of Browning Inhibition

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Abstract : Ursolic acid (UA), a pentacyclic triterpenoid with antioxidant properties, common in *prunella vulgaris*, loquat, and sea-buckthorn. Early studies found that UA could inhibit the browning of apple slurry and fresh-cut apple. The study of mechanism showed that UA can inhibit the activity of PPO, improve the antioxidant ability, reactive oxygen scavenging ability, antimicrobial ability and has broad spectrum browning inhibition effect. Further by untargeted metabolomics technology to explore the influence of UA on fresh-cut apple metabolites and find a new plant endogenous browning inhibitor - aconitic acid. Aconitic acid (C₆H₆O₆) is an unsaturated tricarboxylic acid, the intermediate product of citric acid cycle in tricarboxylic acid cycle (TCA). It is widely found in organisms and safe. By treating fresh-cut apples and potatoes, the results showed that treatment with 6 % aconitic acid for 5 min could inhibit the browning of fresh-cut apples, extending storage time to 12 d at 4 °C. Treatment with 6 % aconitic acid for 1 min could inhibit the browning of fresh-cut potatoes, extending storage time to 7 d at 4 °C. In addition, it can inhibit the microorganism on the surface of fresh-cut fruits and vegetables. This study showed a new direction and established a theoretical foundation for the development and application of endogenous browning inhibitors.

Key words : endogenous substance in plants; browning inhibitor; ursolic acid; aconitic acid; fresh-cut fruits and vegetables

植物乳植杆菌 CXG4 生物转化亚硒酸盐机制研究

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摘要: 微生物富硒技术是新兴硒产业中最具发展前景的技术之一。生物富集法以无机硒 (Se(IV)) 为原料, 生产出高营养、低毒性的有机硒和纳米硒。本研究筛选获得了植物乳植杆菌 (*Lactiplantibacillus plantarum*) CXG-4, 该菌株能有效地将 Se(IV) 转化为有机硒和硒纳米粒子 (SeNPs)。优化培养条件后, 植物乳植杆菌 CXG-4 的硒富集率和硒含量分别达到 64.11 ± 0.90% 和 1873.54 ± 13.59 μg/g。XPS、XDR 和 FTIR 分析表明植物乳植杆菌 CXG-4 中的有机硒主要以蛋白质结合形式存在, SeNPs 是亚硒酸盐的主要还原产物 (95.02%)。透射电镜和扫描电镜分析结果表明, SeNPs 的直径在 35 - 240 nm 之间, 分布在细胞外。此外, 全基因组分析表明, 植物乳植杆菌 CXG-4 具有多个与硒还原相关的基因, 如硫氧还蛋白家族蛋白基

因和短链脱氢酶还原酶家族氧化还原酶基因。转录组学和 RT-qPCR 进一步验证了植物乳植杆菌 CXG-4 可以通过上调编码硫氧还蛋白和氧化还原酶的 *trxA*、*adhE*、*mtlA* 和 *msrA* 等相关基因表达降低 Se(IV)。本研究为乳酸菌对 Se(IV)的生物转化机制提供了新见解,对开发新一代硒营养补充剂具有重要参考意义。

关键词: 微生物富硒; 植物乳植杆菌; 生物转化; 亚硒酸盐还原; 转录组学

Biotransformation mechanisms of selenite by *Lactiplantibacillus plantarum* CXG4

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Abstract : Selenium enrichment by microorganism is one of the most promising technologies in the emerging selenium industry. This biological enrichment method uses inorganic selenium (Se(IV)) as raw material to produce organic selenium and nano-selenium with high nutrition and low toxicity. *Lactiplantibacillus plantarum* (*L. plantarum*) CXG-4 was selected from lactic acid bacteria. It can effectively transform Se(IV) to organic selenium and selenium nanoparticles (SeNPs). After optimal culture conditions, selenium enrichment rate and selenium content of *L. plantarum* CXG-4 reached $64.11 \pm 0.90\%$ and $1873.54 \pm 13.59 \mu\text{g/g}$, respectively. XPS, XDR and FTIR analysis showed that organic selenium in *L. plantarum* CXG-4 was mainly in the form of protein binding, and SeNPs was the main reduction product of selenite (95.02%). Meanwhile, the results of TEM and SEM showed that the diameters of SeNPs were ranged from 35 - 240 nm, and distributed outside the cell. Furthermore, whole-genome analysis showed *L. plantarum* CXG-4 had a variety of genes related to Se(IV) reduction, such as thioredoxin family protein genes and some short-chain dehydrogenase reductase family oxidoreductases genes. Notably, the transcriptome and RT-qPCR was further validated that *L. plantarum* CXG-4 can reduced Se(IV) through upregulating the related genes expression of the thioredoxin and oxidoreductases containing *trxA*, *adhE*, *mtlA* and *msrA*. This study provides new insights into the transformation of Se(IV) by lactic acid bacteria, which is important for the development of a new generation of selenium nutritional supplements.

Key words : Microbial selenium-rich, *Lactiplantibacillus plantarum*, Biotransformation, Selenite reduction, Transcriptome analysis

栉孔扇贝高 F 值寡肽的制备及对小鼠急性酒精性肝损伤的保护作用

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摘要: 本研究以栉孔扇贝副产物为原料, 制备高 F 值寡肽, 并通过构建酒精性肝损伤小鼠模型评估其解酒护肝效果。结果显示, 高 F 值寡肽组能显著缩短小鼠醒酒时间及降低血清中天门冬氨酸氨基转移酶(AST)、丙氨酸氨基转移酶(ALT)的酶活力, 显著提高乙醇脱氢酶(ADH)、乙醛脱氢酶(ALDH)等酒精代谢相关酶活力, 提升小鼠肝脏中谷胱甘肽过氧化酶(GSH-Px)、超氧化物歧化酶(SOD)、过氧化氢酶(CAT)活力, 改善小鼠的肝脏损伤。在小鼠解酒防醉以及改善急性酒精性肝脏组织损伤能力方面, 高 F 值寡肽组的效果与阳性对照组相当, 且效果优于氨基酸组。该寡肽有望作为天然解酒护肝健康食品的开发原料。

关键词: 栉孔扇贝加工副产物; 高 F 值寡肽; 复配氨基酸; 酒精性肝损伤

Preparation of the high Fischer ratio oligopeptide from *Chlamys farreri* scallop and its protection function to acute alcoholic liver injury of mice

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Abstract : In the present study, high F-value oligopeptides were prepared from the by-products of Pecten scallop, and their effects on detoxification and hepatoprotection were evaluated by constructing a mouse model of alcoholic liver injury. The results showed that the high F-value oligopeptide group could significantly shorten the waking-up time and reduce the enzyme activities of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) in serum, significantly increase the activities of alcohol metabolism enzymes, such as ethanol dehydrogenase (ADH) and acetaldehyde dehydrogenase (ALDH), and increase the activities of glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), peroxidase, and oxidant enzyme (PX) in the livers of mice. (GSH-Px), superoxide dismutase (SOD) and catalase (CAT) in the liver of mice, and improve the liver injury of mice. The effect of the high F-value oligopeptide group was comparable to that of the positive control group and better than that of the amino acid group in terms of its ability to detoxify and prevent alcohol intoxication as well as to ameliorate acute alcoholic liver tissue injury in mice. The oligopeptide is expected to be used as a raw material for the development of natural alcohol- and liver-protecting health food.

Key words: *Chlamys farreri* scallop processing by-products; high F value oligopeptides; compound amino acid; alcoholic liver injury

重组 ACE 抑制肽 LYPVK 的异源表达与理性设计及其潜在的降血压机制

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摘要: 酶解是制备活性肽普遍使用的方法, 但所制备的活性肽纯度低、得率低, 限制了其作用机制的进一步解析。本研究提出了能够有效制备 ACE 抑制肽的生物工程方法, 并探究重组 ACE 抑制肽 LYPVK 潜在降血压作用机制。将 ACE 抑制肽 LYPVK 的编码基因序列重复串联, 并在大肠杆菌中异源表达及纯化。通过高效液相色谱、氨基酸组成分析验证纯化的串联 ACE 抑制肽序列的分子量为 13.4 kDa。进一步去除组氨酸标签, 并使用胰蛋白酶定向酶切获得重组 ACE 抑制肽 LYPVK, 质谱分析其分子量为 618.4 Da。LYPVK 抑制 ACE 活性的 IC₅₀ 值为 10.6 ± 0.86 μg/mL, 能够耐受高温及胃肠道环境, 且作用模式为非竞争性抑制。LYPVK 与 ACE 分子模拟对接显示, 氢键及疏水作用是主要相互作用力, 并基于对接结果对 LYPVK 进行序列优化, 获得 6 个新型 ACE 抑制肽序列, 其中 YWLKP 活性提升, IC₅₀ 值为 8.5 ± 0.24 μg/mL。进一步通过网络药理学分析 LYPVK 的潜在降血压机制, 除 ACE 外, ALB、SRC、PPARG 和 MMP9 也是 LYPVK 的潜在作用靶点。综上所述, 本研究为活性肽的高纯度及高得率制备提供了一种有效的生物工程方法, 为其作用机制的解析储备了技术手段。

关键词: 重组 ACE 抑制肽; 串联表达; 抑制特性; 降血压作用机制

Heterologous expression, rational design of a recombinant ACE inhibitory peptide LYPVK, and its potential antihypertensive action mechanism

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Abstract: Enzymatic hydrolysis approach is commonly employed for the preparation of active peptides, while the limited purity and yield of prepared peptides hinder further development of their action mechanisms. This study presents the biotechnological approach for the efficient production of the recombinant angiotensin converting enzyme (ACE) inhibitory peptide LYPVK. The DNA encoding sequence was designed to form a twenty-copy in tandem, which was expressed in *Escherichia coli* BL21 (DE3). The expressed peptide with molecular weight of 618.4 Da was verified by high performance liquid chromatography (HPLC), amino acid composition, and liquid chromatography-mass spectrometry (LC-MS) analysis. Subsequently, the ACE inhibitory peptide LYPVK was generated following trypsin-mediated cleavage of the purified tandem repeat protein. LYPVK exhibited an IC₅₀ value of 10.6 ± 0.86 μg/mL, demonstrating a non-competitive mode of action and resistance to gastrointestinal enzyme hydrolysis and heat conditions. Total six novel peptides were obtained by rational design of the sequences of LYPVK, among which YWLKP exhibited the strongest activity against ACE. Molecular docking results showed

that LYPVK interacted with ACE through conventional hydrogen bonds and the hydrophobic interactions. Except for ACE, ALB, SRC, PPARG, and MMP9 are also identified as potential key targets for its antihypertensive activity by network pharmacological analysis. This study provides a promising biotechnological approach for the preparation of active peptides with high purity and yield.

Key words: Recombinant ACE inhibitory peptide, Tandem expression, Inhibitory properties, Antihypertensive mechanism

自然发酵、发酵剂发酵与未发酵多谷物煎饼的风味物质分析

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摘要: 利用电子鼻、电子舌和气相色谱-离子迁移谱法 (GC-IMS) 对 4 种不同加工类型煎饼 (未发酵煎饼、自然发酵煎饼、LAB-7 发酵剂发酵煎饼和 LAB-16 发酵剂发酵煎饼) 中挥发性风味物质进行比较分析, 旨在揭示其关键风味化合物。

结果表明: 电子鼻、电子舌指纹图谱可以较好区分 4 种煎饼样品, 其挥发性化合物之间差异明显; 在此基础上, 利用 GC-IMS 法共鉴定出 57 种挥发性风味化合物, 主要包括醛类、醇类、酮类、酯类、烃类及芳香类化合物。未发酵煎饼中关键风味化合物为 2-丙酮、1-己醛, 自然发酵煎饼中关键风味化合物为乙酸、乙酸丙酯, LAB-7 与 LAB-16 煎饼样品中关键风味化合物均为 3-羟基-2-丁酮、2-丙酮, 但含量略有不同。综合分析可知, 未发酵煎饼的挥发性物质含量远低于 3 种发酵煎饼; 2 种发酵剂发酵煎饼与自然发酵煎饼的挥发性物质种类及含量相似, 其中 LAB-16 与自然发酵煎饼的相似度更高。

关键词: 煎饼; 挥发性风味物质; 电子鼻; 电子舌; 气相色谱-离子迁移谱法

Analysis of flavor compounds in natural-fermented, starter-culture-fermented and unfermented multi-grain pancakes

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Abstract: The volatile flavor compounds in four different types of pancakes (unfermented pancakes, naturally fermented pancakes, LAB-7 fermentation pancakes and LAB-16 fermentation fermented pancakes) were compared and analyzed by electronic nose, electronic tongue and GC-IMS, aiming to reveal their key flavor compounds. The

results showed that the fingerprints of electronic nose and electronic tongue could clearly distinguish the 4 kinds of scallion pancakes well, with obvious differences in their volatile compounds. On this basis, a total of 57 volatile aroma compounds were identified by GC-IMS, mainly including aldehydes, alcohols, ketones, esters, hydrocarbons, and aromatic compounds. The key flavor compounds in the unfermented scallion pancakes were 2-pentanone and 1-hexanal, while those in the naturally fermented scallion pancakes were acetic acid and ethyl acetate. The key flavor compounds in the LAB-7 and LAB-16 scallion pancakes were 3-hydroxy-2-butanone and 2-pentanone, but with slightly different contents. Overall, the volatile substances in the unfermented scallion pancakes were significantly less than those in the 3 fermented scallion pancakes. The volatile substances in the 2 fermented scallion pancakes and the naturally fermented scallion pancakes were similar in type and content, with the similarity between the LAB-16 and the naturally fermented scallion pancakes being higher.

Key words: pancakes; volatile compounds; electronic nose; electronic tongue; GC-I

