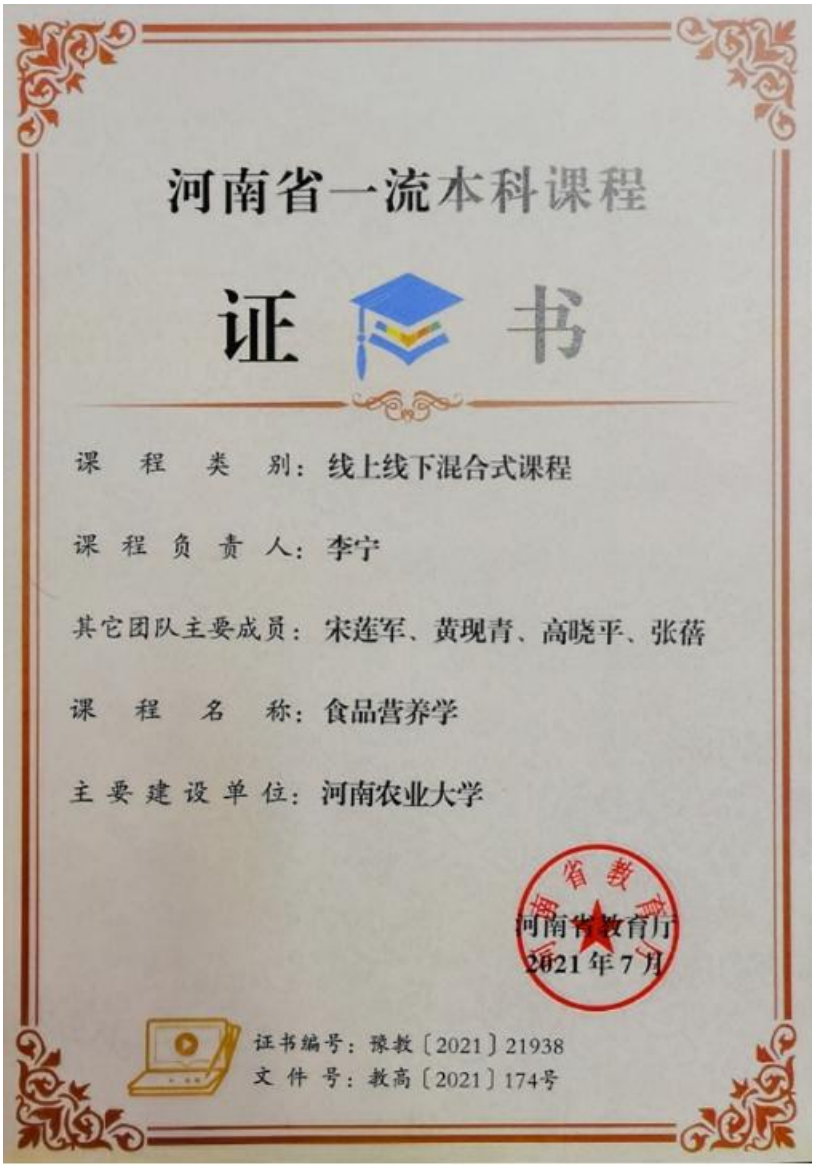
（一）教师所获成果

（1）2022 年，河南省第三批一流本科课程：食品营养学，河南省教育厅，李宁，主持

（2）2021 年，河南省第二批一流本科课程：食品营养学（混合课程），河南省教育厅，李宁，主持



（3）2023.05，国家级一流本科课程：食品分析与检验，宋莲军，主持

国家级一流本科课程

证书

★ ★ ★ ★ ★

课程类别：线上线下混合式一流课程

课程名称：食品分析与检验

课程负责人：宋莲军

课程团队其他主要成员：黄现青、赵秋艳、崔文明、乔明武

主要建设单位：河南农业大学

中华人民共和国教育部

2023年5月

证书编号：2023241151

（4）2021 年，河南省精品在线开放课程：食品营养学，河南省教育厅，李宁，主持

河南省教育厅关于2021年度河南省本科高等学校精品在线开放课程立项建设名单的公示

2021-11-23 18:19 【浏览字号：大 中 小】 来源：教育厅办公室

各本科高校：

根据教育厅办公室《关于做好2021年河南省本科高等学校精品在线开放课程建设工作的通知》（教办高〔2021〕245号）安排，经高校申报、资格审查、网络评审、会议评审，拟立项建设郑州大学《化工热力学》等400门省级精品在线开放课程，现将评审结果予以公示（见附件）。

自公布之日起7日内，任何单位和个人对评选结果持有异议，可以书面形式向我厅高教处提出。单位提出的异议，须在异议材料上加盖本单位公章，并写明联系人工作单位、通讯地址和电话。个人提出的异议，须在异议材料上签署真实姓名，并写明本人工作单位、通讯地址和电话。不符合上述要求的异议，不予受理。

联系人：刘克桥

电话：0371—69691868

地址：郑州市正光路11号

邮编：450018

附件：2021年度河南省本科高等学校精品在线开放课程拟立项建设名单

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52	河南大学	马克思主义基本原理	陈卫华	晏传英，杨莉，苏会芝，宋保林，殷华成，符征	哲学
53	河南农业大学	卷烟产品设计	付博	付博，陈红丽，武云杰，田斌强，王欢欢，来洪涛，于建军	工学
54	河南农业大学	食品营养学	李宁	宋莲军，黄现青，高晓平，赵秋雁，沈玥，张蓓，徐丽娜	工学
55	河南农业大学	农业与农村法治概论	徐铁博	杨红朝，张帅梁，赵菊敏，毋晓蕾，陈丹	法学
56	河南农业大学	植物化学	白润娥	闫凤鸣，王红卫，雷彩燕，刘艳艳，韩卫丽，游秀峰，李永辉，刘延峰	农学
57	河南农业大学	兽医寄生虫学	张龙现	宁长申，李俊强，李晓迎，王荣军，菅复春，张素梅，张	农学

（5）2020 年，河南省本科教育线上教学优秀课程：食品毒理学，河南省教育厅，高晓平，主持

河 南 省
本科教育线上教学优秀课程
证 书

为传递抗击疫情正能量，进一步激发教师参与课程改革的热情，促进课堂教学与信息化的深度融合，切实提高教学效率、提升教学质量，省教育厅从疫情防控期间开展线上教学的课程中评选出了一批本科教育优秀课程，特颁此证书。

课 程 名 称：食品毒理学

课 程 负 责 人：高晓平

团队其他主要成员：黄现青 李 宁 沈 玥 毛烨烜

所 在 高 校：河南农业大学

评 奖 等 级：二等奖

河南省教育厅

二〇年五月

文件号：教高〔2020〕265号　　证书编号：豫教〔2020〕13837号

34	生命科学学院	食品微生物学	杨鑫	林晖 李亚楠 胡廷如 吴坤	一等奖
35	食品科学技术学院	数据统计分析软件应用	赵莉君	余小领 赵改名 黄现青 李梦等	一等奖
36	食品科学技术学院	食品毒理学	高晓平	黄现青 李 宁 沈 玥 毛烨烜	一等奖
37	食品科学技术学院	食品安全控制学	张秋会	黄现青 朱瑶迪 崔文明 索标	一等奖
38	资源与环境学院	土地利用规划学	梁湛超	蔚霖 冯新伟 王秀丽 郭宇龙	一等奖
39	资源与环境学院	经济地理学	黄珺嫦	张亚丽 汪松 朱嘉伟 蔚霖	一等奖
40	文法学院	婚姻家庭法学概论	韩宁	代莉 张帅梁 程春丽 申娜	一等奖
41	文法学院	农村法制概论	徐铁博	张帅梁 杨红朝 男晓蕾 陈丹	一等奖

(6) 2020 年，河南省一流本科课程——食品毒理学，高晓平，主持

附 件

首批认定河南省一流本科课程名单

序号	学校名称	课程名称	课程负责人	课程团队主要成员	课程类别
1	郑州大学	化工设备设计基础	魏新利	刘 宏、方书起、李洪亮 袁振伟、郭茶秀、刘利平 陈俊英、靳遵龙、韩绍辉	线上一流课程
2	郑州大学	医用物理学	潘志峰	唐伟凯、王晓川、刘佩华 习振琦、秦 立	线上一流课程
3	郑州大学	科举与唐诗	王士祥		线上一流课程
4	郑州大学	文化差异与跨文化交际	曾利娟	赵建斌、陈 莉、郭 华 王郑菊、王 伟	线上一流课程
5	河南大学	现代教育技术应用	汪基德	郝兆杰、张纳林、朱书慧 曾 巍、马永华、梁林梅 赵慧臣、李五洲、刘亚同	线上一流课程
6	河南大学	秦汉考古	张 玲	刘春迎、臧振清、滕亚秋 徐 昂、金 锐	线上一流课程
7	河南大学	德育原理	刘济良	刘志军、王振存、魏宏聚 李世千、杜 静	线上一流课程
8	河南工业大学	国际贸易实务	吕玉花	马松林、高美玲、刘克俭 王 焕、赵秀丽、方满底 关浩杰、车 恒	线上一流课程
				康怀彬、刘丽莉、陈俊亮	

346	河南农业大学	婚姻家庭法学概论	韩 宁	代 莉、张帅梁、程春丽 申 娜	线上线下混合式一流课程
347	河南农业大学	园林树木学	刘艺平	孔德政、贺 丹、栗 燕 张 曼	线上线下混合式一流课程
348	河南农业大学	单片机原理与应用	潘建斌	滕红丽、吴莉莉、邢玉清 李宝方	线上线下混合式一流课程
349	河南农业大学	食品毒理学	高晓平	黄现青、李 宁、沈 玥 毛烨炫	线上线下混合式一流课程

（7）2026.03，河南省本科高校虚拟教研室，食品营养与安全课程群虚拟教研室，宋莲军，主持

河南省教育厅
Education Department Of Henan Province

无障碍阅读 进入适老模式

站内搜索

首页 | 教育动态 | 政务公开 | 政务服务 | 交流互动 | 专题子站

您好，今天是2026年04月17日，欢迎访问中共河南省委教育工委、河南省教育厅网站！

首页 > 政务公开 > 文件通知 >正文

分享：

河南省教育厅办公室关于公布2023年立项省级虚拟教研室结项验收结果的通知

教办高〔2026〕59号

2026-03-10 13:37【浏览字号：大 中 小】来源：教育厅办公室

各普通本科高校：

根据《河南省教育厅办公室关于开展虚拟教研室试点建设工作的通知》（教高函〔2021〕478号）要求，我厅对2023年立项建设的省级虚拟教研室进行了验收，经高校申报、专家评审、网上公示，确定38个虚拟教研室通过结项验收，3个虚拟教研室暂缓通过结项验收。现将结果予以公布（名单见附件）。

各高校要以课程（群）教学、专业建设、教学研究改革等为主题开展多元探索，通过创新教研组织形式、深化教学研究、共建优质资源、强化教师培训等举措，持续扎实推进虚拟教研室建设，形成可借鉴、可推广、可持续的新型教学组织建设模式，发挥辐射引领作用，全面提高教师教书育人能力。

附件：2023年立项省级虚拟教研室结项验收结果汇总表

2026年3月5日

附　件

2023 年立项省级虚拟教研室结项验收结果汇总表

序号	推荐单位	教研室名称	负责人	评审意见
1	郑州大学	药学核心课程虚拟教研室	张振中	通过
2	郑州大学	现代教育技术课程虚拟教研室	徐春华	通过
3	郑州大学	土木工程专业虚拟教研室	钱　辉	通过
4	河南大学	遗传学课程虚拟教研室	王学路	通过
5	河南大学	比较文学跨学科研究虚拟教研室	李伟昉	通过
6	河南农业大学	食品营养与安全课程群虚拟教研室	宋莲军	通过
7	河南师范大学	智慧教育创新实践虚拟教研室	朱　晔	通过
8	河南师范大学	物理化学课程群虚拟教研室	赵　扬	通过
9	河南科技大学	车辆工程专业虚拟教研室	徐立友	通过
10	河南理工大学	安全工程专业虚拟教研室	魏建平	通过
11	河南工业大学	机械原理及设计课程虚拟教研室	武照云	通过
12	河南财经政法大学	金融数字化课程群虚拟教研室	赵紫剑	通过
13	华北水利水电大学	计算机科学与技术专业虚拟教研室	刘雪梅	通过

（8）2026.04，河南农业大学2026年校级本科高等教育教学成果奖特等奖：三阶对标，四联驱动，五维融合：食品营养学跨维度教学创新与实践，李宁，主持

河南农业大学文件

农大教〔2026〕11号

河南农业大学关于公布2026年校级本科教育教学成果奖名单暨推荐省级本科教育教学成果奖名单的通知

各学院，校直各单位：

根据《河南省教育厅关于开展2026年河南省高等教育教学成果等级评定工作的通知》（教高〔2026〕54号）精神，学校开展了2026年校级本科高等教育教学成果奖评选暨省级本科高等教育教学成果奖推荐申报工作。经项目组申报、学院（相关部门）推荐、专家评审和公示等环节，评选出《三位一体 四链同构：扎根中原大地培养卓越农林人才的创新与实践》等87项校级教学成果获奖，其中特等奖41项，一等奖27项，二等奖19项。同时推荐荣获特等奖的前30项成果申报省级本科教育教学成果奖。现予以公布。

特此通知。

— 1 —

附件：河南农业大学2026年校级本科教育教学成果奖名单暨推荐省级本科教育教学成果奖名单

河南农业大学

2026年4月19日

序号	成果名称	成果主持人	主要成员	校级成果奖等级	是否推荐省级
18	农科有机化学智慧教学新模式的构建与实践	徐翠莲	潘振良 吴璐璐 樊良鑫 姜 松 安万凯 史方军 杨国玉	特等奖	是
19	新工科建设农业工程类专业“四年制科创法”教学创新研究	路朝阳	胡建军 蒋丹萍 梁小玉 张志萍 张 寰 荆艳艳 岳建芝	特等奖	是
20	融合CDIO理念与AI赋能的混合式教学模式研究与实践	席 磊	任艳娜 王晓磊 车银超 高俊平 侯丽萍 王 顺 刘合兵 汪 强 时 雷 张 洁	特等奖	是
21	“科教+思政”融合的生命科学拔尖人才培养模式构建与实践	郭 朋	王一涵 曹申全 郭建新 孙丽婷 尚富德 张会勇	特等奖	是
22	产教融合 创新驱动：青年教师研究性教学能力的培育与实践	宋朝鹏	孙亚楠 闫筱筱 刘春奎 段卫东 贺 远 范永超 尹光庭 逯晋松 殷全玉 欧阳铖人 保志娟 崔 冰 陈 征 路绪良 刘劝平	特等奖	是
23	选择与引导一农林高校大类招生建筑学专业人才培养模式研究	李永华	史英霞 张淑梅 郭 楠 姚晓军 刘保国 雷雅凯 蒋 鹤 杨 玫 李东丹 燕亚飞 陈 茜 张毅川 乔丽芳	特等奖	是
24	乡村振兴视域下社会工作专业复合型人才培养模式创新研究与实践	李 伟	苏 迪 刘忠魏 张 晶 王文娟 殷玉如 谢娅婷 张 勃	特等奖	是
25	智慧化教育背景下多元融合教学模式的创新与实践	孔玉华	赖 勇 彭万喜 权金娥 范国强 张志华 孙金华 闫 丽 郑文科	特等奖	是
26	“六维一体”高校研究性教学评价体系系统构建与循证实践	李炳军	郭三党 周 方 王春晖 李红艳 孟凡琳 单 全 徐素华	特等奖	是
27	三阶对标，四联驱动，五维融合：食品营养学跨维度教学创新与实践	李 宁	黄现青 李天歌 宋莲军 王田林 胡二坤 高晓平 李 倩 徐丽娜	特等奖	是
28	五维七能 四元协同：研究性教学中高校教师素质能力模式构建与实践	陈 娟	周 倩 张 璐 王卫兵 王红艳 唐海轩 王金锋 梁 杰 张晓彤 孙 昊 徐慧敏	特等奖	是

荣誉证书

HONORARY CREDENTIAL

三阶对标，四联驱动，五维融合：食品营养学跨维度教学创新与实践 荣获2026年校级本科教育教学成果特等奖。

主 持 人:李宁

主要成员:黄现青、李天歌、宋莲军、王田林、胡二坤、高晓平、李倩、徐丽娜

成果编号:jxcg2026027

河南农业大学

二〇二六年四月

(9) 2024.08,河南农业大学本科教育教学成果一等奖，黄现青主持，宋莲军参与

荣誉证书

HONORARY CREDENTIAL

强化学科引领 深化产教融合 新工科背景下地方高校食品类专业育人模式探索与实践 荣获 2024 年校级本科教育教学成果一等奖。

主 持 人：黄现青

主要成员：赵改名、乔明武、艾志录、宋莲军、李梦琴、黄忠民、张 剑

成果编号：校 JXCG202417

文 件 号：农大教〔2024〕12 号

河南农业大学

2024 年 8 月

（二）教材成果

教材名称	出版社	出版时间	印刷册数	对象	作者位次
食品营养学	中国农业大学出版社	2022.2	2 万册	宋莲军	1
食品营养学	高等教育出版社	2019.12	1.2 万册	宋莲军	2
食品营养学	中国质检出版社、中国标准出版社	2017.11	3 万册	宋莲军	3
食品营养与卫生	武汉理工大学出版社	2023.01	0.5 万册	李天歌	3
营养与食品卫生英语教程	高等教育出版社	2012.01	0.8 万册	李宁	3

（三）学生发表论文

1. Wang T, Xiao Z, Li T, et al. Improving the quality of soluble dietary fiber from Poria cocos peel residue following steam explosion[J]. Food Chemistry: X, 2023, 19: 100829.

Food Chemistry: X 19 (2023) 100829

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x

Improving the quality of soluble dietary fiber from *Poria cocos* peel residue following steam explosion

Tianlin Wang [a], Zhongshan Xiao [b], Tiange Li [a], Ge Guo [a], Suyun Chen [c], Xianqing Huang [a,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, Henan, China
[b] Department of Pharmacy, Puyang Medical College, Puyang 457000, Henan, China
[c] College of Economics and Management, Henan Agricultural University, Zhengzhou 450002, Henan, China

ARTICLE INFO

Keywords:
Poria cocos peel residue
Steam explosion
Soluble dietary fiber

ABSTRACT

Poria cocos peel residue (PCPR) still contains much soluble dietary fiber (SDF), steam explosion (SE) treatment was applied to PCPR to create a superior SDF. Steam pressure of 1.2 MPa, residence period of 120 s, and moisture content of 13% were the optimized parameters for SE treatment of PCPR. Under optimized circumstances, SE treatment of PCPR enhanced its SDF yield from 5.24% to 23.86%. Compared to the original SDF, the SE-treated SDF displayed improved enzyme inhibition, including the inhibition of α-amylase and pancreatic lipase, also enhanced water holding, oil holding, water swelling, nutrient adsorption including cholesterol, nitrite ions, and glucose and antioxidant abilities. Additionally, it had a decreased molecular weight, improved thermal stability, and a rough surface with many pores of different sizes. Given that SDF had been improved physiochemical and functional characteristics thanks to SE treatment, it might be the excellent functional ingredient for the food business.

1. Introduction

Poria cocos is an eatable fungus that is primarily grown in China. Due to the mushroom's high concentration of polysaccharides, triterpenoids, dietary fibers (DFs), proteins, trace elements, and amino acids, it has therapeutic benefits on inflammation, oxidative stress, tumors, and hyperglycemia (Zhao et al., 2023). So, after processing, *Poria cocos* is typically consumed as food or used as medicine (Lan et al., 2023). The *Poria cocos* peel residue (PCPR), produced as a by-product of processing of *Poria cocos* is typically discarded or utilized as animal feed. However, PCPR is abundant in DF, as a result, it might have additional economic worth. DF, as a kind of macromolecular polysaccharide, is one of the seven nutrients. In the small intestine, it is not, however, absorbed (Nepali et al., 2022). According to studies, DF lowers the risk of developing some prolonged ailments, such as heart disease (Khanpit et al., 2022), diabetes (Mazhar et al., 2023) and obesity (Waddell & Orfila, 2022). Based on its solubility, DF can be divided into two categories: insoluble DF and soluble DF (SDF) (Liu et al., 2022; Gan et al., 2020). The surface shape, functional groups, and molecular weight of SDF are typically significant contributors in the physical, chemical and functional characteristics of DF. High-quality DF has an SDF concentration of more than 10% (Khanpit et al., 2021; Qiao et al., 2021). For the sake of reusing PCPR, boosting the SDF content in DF might be one option.

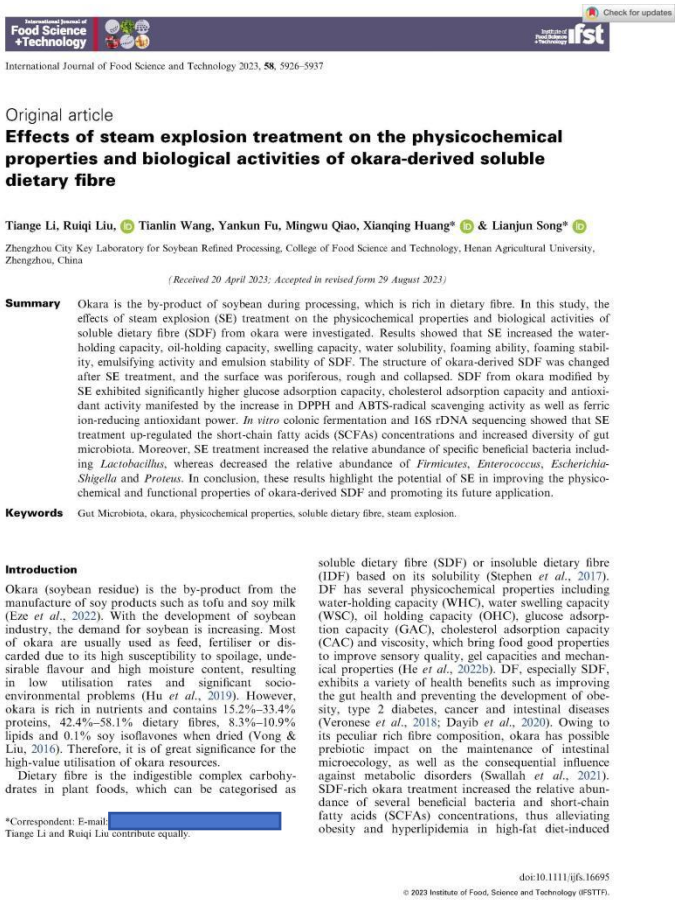
The process known as steam explosion (SE) is a common physical pretreatment in which fibrous raw materials are treated with high temperature pressurized steam for a set amount of time. This pushes the steam into the raw materials' tissues and cells to achieve component separation and mechanical alteration in the materials through the prompt pressure relief procedure (Nader et al., 2022; Wan et al., 2022). SE is better than other pretreatment techniques in terms of affordability, energy efficiency, and absence of chemical pollution (Arshanitsa et al., 2022). During SE processing, cellulose and hemicellulose, which are insoluble macromolecular polysaccharides, are converted into the small-molecule soluble polysaccharide SDF either through thermal degradation or hydrogen bond breaking (Arshanitsa et al., 2022). Therefore, SDF extract yield from by-products including orange peel (Fan et al., 2022), sweet potato waste (Wang et al., 2017), okara (Li et al., 2019) and apple pomace (Zhao et al., 2022), has been improved using SE technology. These results suggest that SE could be used as a pretreatment method to produce high quality SDF from PCPR.

To achieve the highest SDF extraction yield in the current work, PCPR was treated with SE utilizing certain experimental conditions. To

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.fochx.2023.100829
Received 25 November 2022; Received in revised form 31 July 2023; Accepted 5 August 2023
Available online 7 August 2023
2590-1575/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

2. Li T, Liu R, Wang T, et al. Effects of steam explosion treatment on the physicochemical properties and biological activities of okara-derived soluble dietary fibre[J]. International Journal of Food Science and Technology, 2023, 58(11): 5926-5937.



International Journal of Food Science and Technology

Check for updates

5926 International Journal of Food Science and Technology 2023, 58, 5926–5937

Original article

Effects of steam explosion treatment on the physicochemical properties and biological activities of okara-derived soluble dietary fibre

Tiange Li, Ruiqi Liu, Tianlin Wang, Yankun Fu, Mingwu Qiao, Xianqing Huang* & Lianjun Song*

Zhengzhou City Key Laboratory for Soybean Refined Processing, College of Food Science and Technology, Henan Agricultural University, Zhengzhou, China

(Received 20 April 2023; Accepted in revised form 29 August 2023)

Summary Okara is the by-product of soybean during processing, which is rich in dietary fibre. In this study, the effects of steam explosion (SE) treatment on the physicochemical properties and biological activities of soluble dietary fibre (SDF) from okara were investigated. Results showed that SE increased the water-holding capacity, oil-holding capacity, swelling capacity, water solubility, foaming ability, foaming stability, emulsifying activity and emulsion stability of SDF. The structure of okara-derived SDF was changed after SE treatment, and the surface was poriferous, rough and collapsed. SDF from okara modified by SE exhibited significantly higher glucose adsorption capacity, cholesterol adsorption capacity and antioxidant activity manifested by the increase in DPPH and ABTS-radical scavenging activity as well as ferric ion-reducing antioxidant power. *In vitro* colonic fermentation and 16S rDNA sequencing showed that SE treatment up-regulated the short-chain fatty acids (SCFAs) concentrations and increased diversity of gut microbiota. Moreover, SE treatment increased the relative abundance of specific beneficial bacteria including *Lactobacillus*, whereas decreased the relative abundance of *Firmicutes*, *Enterococcus*, *Escherichia-Shigella* and *Proteus*. In conclusion, these results highlight the potential of SE in improving the physicochemical and functional properties of okara-derived SDF and promoting its future application.

Keywords Gut Microbiota, okara, physicochemical properties, soluble dietary fibre, steam explosion.

Introduction

Okara (soybean residue) is the by-product from the manufacture of soy products such as tofu and soy milk (Eze *et al*., 2022). With the development of soybean industry, the demand for soybean is increasing. Most of okara are usually used as feed, fertiliser or discarded due to its high susceptibility to spoilage, undesirable flavour and high moisture content, resulting in low utilisation rates and significant socio-environmental problems (Hu *et al*., 2019). However, okara is rich in nutrients and contains 15.2%–33.4% proteins, 42.4%–58.1% dietary fibres, 8.3%–10.9% lipids and 0.1% soy isoflavones when dried (Vong & Liu, 2016). Therefore, it is of great significance for the high-value utilisation of okara resources.

Dietary fibre is the indigestible complex carbohydrates in plant foods, which can be categorised as soluble dietary fibre (SDF) or insoluble dietary fibre (IDF) based on its solubility (Stephen *et al*., 2017). DF has several physicochemical properties including water-holding capacity (WHC), water swelling capacity (WSC), oil holding capacity (OHC), glucose adsorption capacity (GAC), cholesterol adsorption capacity (CAC) and viscosity, which bring food good properties to improve sensory quality, gel capacities and mechanical properties (He *et al*., 2022b). DF, especially SDF, exhibits a variety of health benefits such as improving the gut health and preventing the development of obesity, type 2 diabetes, cancer and intestinal diseases (Veronese *et al*., 2018; Dayib *et al*., 2020). Owing to its peculiar rich fibre composition, okara has possible prebiotic impact on the maintenance of intestinal microecology, as well as the consequential influence against metabolic disorders (Swallah *et al*., 2021). SDF-rich okara treatment increased the relative abundance of several beneficial bacteria and short-chain fatty acids (SCFAs) concentrations, thus alleviating obesity and hyperlipidemia in high-fat diet-induced

*Correspondent: E-mail:
Tiange Li and Ruiqi Liu contribute equally.

doi:10.1111/ijfs.16695

© 2023 Institute of Food, Science and Technology (IFSTTF).

3. Li N, Wu T, Cai Y, et al. Portable detection platform integrated with smartphone-assisted ratiometric fluorescence sensor for visual on-site detection of lead(II) in aquatic products[J]. Microchemical Journal, 2024, 204: 110997.

Microchemical Journal 204 (2024) 110997

Contents lists available at ScienceDirect

Microchemical Journal

journal homepage: www.elsevier.com/locate/microc

Portable detection platform integrated with smartphone-assisted ratiometric fluorescence sensor for visual on-site detection of lead(II) in aquatic products

Ning Li [a], Tiantian Wu [a], Yuzheng Cai [a], Tiange Li [a], Lianjun Song [a], Xianqing Huang [a], Jiansheng Zhao [b,c], Erkigul Bukyei [d], Tianlin Wang [a,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China
[c] Henan Technology Innovation Center of Meat Processing and Research, Luohe 462000, China
[d] Department for Food Engineering and Hydromechanics, School of Engineering and Technology, Mongolian State University of Life Sciences, Zaisan-53, Ulaanbaatar 17024, Mongolia

ARTICLE INFO

Keywords:
Ratiometric fluorescence sensor
Detection of lead
On-site
Portable detection platform
Aquatic products

ABSTRACT

Lead ion (Pb^{2+}) pollution seriously threatens the quality of aquatic products. In this study, a ratiometric fluorescence sensor consisting of tangerine fluorescent MnZnS QDs (T-QDs) and blue fluorescent Fe-MOF (B-MOF) was developed for selective recognition of Pb^{2+}. Upon exposure to Pb^{2+}, the fluorescence of T-QDs was quenched while the fluorescence of B-QDs was slightly changed, causing the changes of fluorescence colors from tangerine to blue with a detection limit (LOD) of 3.79 nmol/L. The sensor also had the strengths of low cost, easy to operate, excellent sensitivity and selectivity. Significantly, a portable detection platform integrated with the sensor was constructed to achieve on-site visual detection. As expected, the detection platform was successfully applied for testing Pb^{2+} with the LOD of 7.78 nmol/L. The strategy may not only provide a great capacity for on-site monitoring of Pb^{2+} in aquatic products but also expand application in environmental pollution detection.

1. Introduction

Due to rapid industrialization, large amounts of wastewater containing heavy metals are discharged into rivers and lakes, polluting farmland and the aquatic environment [1,2]. Lead (II) ion (Pb^{2+}) is considered one of the most toxic and severely polluted heavy metals, which can accumulate in aquatic animals and plants through the food chain [3,4], causing several diseases such as blood disorders, mental diseases, heart disease, and nervous system damage [5–7]. Consequently, the maximum detection limit of Pb^{2+} in aquatic products has been established by authoritative institutions and departments. For example, the Chinese government and the European Union have set maximum residue limits for Pb^{2+} in aquatic products at 0.5 and 0.3 mg/kg, respectively [4]. Nevertheless, the complex environment and the presence of other substances (such as metal and salt ions) can affect the accuracy of the detection results. Therefore, a novel method that can specifically detect Pb^{2+} and not get affected by other substances should be urgently developed. Traditional analytical methods for Pb^{2+} detection include atomic absorption spectroscopy (AAS) [8], atomic emission spectrometry (AES) [9], and inductively coupled plasma atomic emission spectrometry (ICP-AES) [10]. These methods effectively satisfy the accuracy requirements for detecting Pb^{2+}. However, the limitations in complex instrument operation, time consumption, and high costs are significant. Therefore, the real-time monitoring of the target is difficult [11].

In recent years (Table 1), a range of novel methods are developed for the rapid detection of Pb^{2+}, such as colorimetric [12], fluorescence [13], and electrochemical methods [14], have gradually garnered attention [15]. Among them, the ratiometric fluorescent sensor has become the first candidate for the visual on-site detection of Pb^{2+} due to its multiple fluorescence signal responses [16]. Furtherly, it can self-calibrate by calculating the ratio of fluorescence intensity, improving the sensitivity and accuracy [17]. Presently, the ratiometric fluorescent sensor has garnered widespread attention due to the diversity and convenience of their constituent materials and other fluorescence characteristics, including metal-organic frameworks (MOF), carbon quantum dots (CDs), quantum dots (QDs), metal nanoclusters, and various organic dyes [18]. He et al. designed a ratio fluorescence sensor based on

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.microc.2024.110997
Received 24 March 2024; Received in revised form 11 June 2024; Accepted 14 June 2024
Available online 14 June 2024
0026-265X/© 2024 Elsevier B.V. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

4. Li N, Cui N, Bakry I A, et al. Pea peptide modulates abnormal A β production in PC12 cells induced by lead exposure[J]. Plant Foods for Human Nutrition, 2025, 80(2): 98.

Plant Foods for Human Nutrition (2025) 80:98
https://doi.org/10.1007/s11130-025-01296-w

RESEARCH

Pea Peptide Modulates Abnormal Aβ Production in PC12 Cells Induced by Lead Exposure

Ning Li[1] · Ningning Cui[1] · Ibrahim A. Bakry[1] · Yan Ma[1] · Yongxia Cheng[1] · Guangshan Zhao[1] · Huijie Yang[1] · Lianjun Song[1] · Mingwu Qiao[1] · Dan Hai[1] · Gianni Galaverna[2] · Xianqing Huang[3]

Accepted: 7 January 2025 / Published online: 21 March 2025
© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2025

Abstract
Lead (Pb) exposure poses significant health risks, particularly in neurodegenerative diseases such as Alzheimer's disease (AD). This study investigates the neuroprotective effects of pea peptide (PP4) on PC12 cells exposed to Pb. Using Cell Counting Kit-8 (CCK-8), pretreatment with PP4 at 50 and 200 μM concentrations significantly improved cell viability compared to Pb-only treated cells ($P<0.05$), indicating a protective effect. Moreover, Pb exposure led to increased Amyloid Precursor Protein (APP) expression at 10 and 20 μM after 24 h ($P<0.05$), while β-site amyloid Precursor Protein Cleaving Enzyme 1 (BACE1) levels were elevated across all concentrations tested ($P<0.05$). We established that PP4 can mitigate Pb-induced cytotoxicity and reduce the expression of APP and BACE1 by activating the Phosphoinositide 3-kinase / Protein Kinase (PI3K/AKT) signaling pathway. This study highlights the potential of PP4 as a therapeutic agent in preventing neurotoxic damage associated with lead exposure, suggesting a novel approach for the management of AD.

Keywords Lead · Pea peptide · APP · BACE1 · $A\beta_{1-42}$ · PI3K/AKT

Introduction

Lead (Pb) contamination in food is a growing concern due to its potential health risks, particularly in regions exposed to industrial activities and environmental pollutants [1, 2]. It can enter the food chain through various pathways, including contaminated soil, water, and air. For example, cereals like wheat showed Pb levels reaching 4.04 μg/g, surpassing the cereals' maximum allowable concentration of 0.20 μg/g. At the same time, vegetables from the Tangail district exhibited even higher levels, with specific samples containing up to 2.17 μg/g of Pb [3]. Due to its persistence

[1] College of Food Science and Technology, Henan Agricultural University, 63#Agricultural Road, Zhengzhou 450000, China
[2] Food and Drug Department, University of Parma, Parco Area delle Scienze, 17/a, PARMA 43124, Italy
[3] Key Laboratory for Animal Immunology, Henan Academy of Agricultural Sciences, Huayuan Road 116, Zhengzhou 450002, China

5. Yang H, Wang F, Li Q, et al. Black soybean peptides attenuate lead-induced neurotoxicity: Role of oxidative stress and the RhoA/MAPK signaling pathway[J]. Molecular Neurobiology, 2026, 63(3): 199.

Molecular Neurobiology (2026) 63:199
https://doi.org/10.1007/s12035-025-05540-x

RESEARCH

Black Soybean Peptides Attenuate Lead-Induced Neurotoxicity: Role of Oxidative Stress and the RhoA/MAPK Signaling Pathway

Huijie Yang[1] · Fangyu Wang[2] · Qian Li[1] · Tiange Li[1] · Bei Zhang[1] · Lianjun Song[1] · Xianqing Huang[1] · Shuyang Liu[1] · Gianni Galaverna[3] · Peijun Zhao[1] · Ibrahim A. Bakry[1,4] · Ning Li[1]

Received: 22 September 2025 / Accepted: 13 November 2025
© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2025

Abstract
Lead (Pb) exposure is a major environmental risk factor for neurodegenerative diseases. This study investigates the neuroprotective effects of black soybean peptides (BSPs), particularly BSP1, BSP3, and BSP4, against Pb-induced toxicity in HT22 mouse hippocampal neuron cells, with a mechanistic focus on the RhoA/MAPK signaling pathway. The rationale for targeting RhoA/MAPK stems from their established roles in mediating oxidative stress and apoptosis in Pb-related pathology. Pretreatment with BSP1 or BSP4 (200 μM) increased cell viability by approximately 35% relative to the Pb-only group. At the same time, BSPs also decreased intracellular reactive oxygen species (ROS) levels by up to 40% and malondialdehyde (MDA) by 30%. Antioxidant enzyme activities, including superoxide dismutase (SOD) and catalase (CAT), were restored to near-control levels; for example, SOD activity increased 1.8-fold compared with the Pb group. Western blot and immunofluorescence confirmed that BSPs reduced the Pb-triggered activation of RhoA, ROCK1/2, and MAPK proteins (p38, JNK, ERK). These findings demonstrate that BSPs mitigate Pb-induced neurotoxicity by enhancing antioxidant activity and targeting RhoA/MAPK signaling, highlighting their potential as functional food ingredients or therapeutic agents for neuroprotection.

Keywords Neuroprotection · Black soybean peptides · Lead toxicity · RhoA/MAPK pathway · Oxidative stress

Introduction

Alzheimer's disease (AD) affects over 33 million people worldwide [1]. AD is a significant cause of dementia in older adults and is characterized by the buildup of hyperphosphorylated tau proteins, extracellular amyloid beta (Aβ) plaques, mitochondrial dysfunction, and synaptic damage [2]. Numerous studies have shown that lead disrupts neuronal function, including changes in neurotransmitter release, excitotoxicity, impairments in synaptic formation and plasticity, and the progression of neurological disorders like AD [3–5]. Therefore, it is essential to identify substances that can effectively reduce the impact of heavy metal pollution, especially lead (Pb), on the nervous system.

Recently, through molecular docking of rice bran active peptide KF-8 with various predicted potential antioxidant targets, Yang et al. ultimately identified SIRT1 and CXCR4 as KF-8's antioxidant targets, laying the groundwork for subsequent research on the peptide's antioxidant mechanism [6]. Our previous study found that black soybean peptides (BSP1–BSP5) with sequences KKWNP, KKAFPKD, KAKSPLF, KKATNPLF, and KKKILSYAMDG had high biological activity and purity of more than 80% [7]. BSP has shown potential in mitigating Pb-induced oxidative stress by reducing ROS production via the Keap1/Nrf2/TXNIP signaling pathway, making it a promising candidate for functional foods and therapies [7].

✉ [redacted]
✉ [redacted]

1 College of Food Science and Technology, Henan Agricultural University, 63#Agricultural Road, Zhengzhou 450000, China

2 Key Laboratory for Animal Immunology, Henan Academy of Agricultural Sciences, 116#Huayuan Road, Zhengzhou 450002, China

3 Food and Drug Department, University of Parma, Parco Area Delle Scienze, 17/a, Parma 43124, Italy

4 Department of Food and Dairy Science, Faculty of Technology and Development, Zagazig University, Zagazig 44519, Egypt

Published online: 28 November 2025

6. Zhao R, Qiao M, Ma Y, et al. Optimization of microwave-ultrasound assisted extraction of oligosaccharides from pea seeds and its probiotic proliferative activity[J]. Journal of Food Science and Technology, 2025, 62(10): 2234-2244.

Journal of Food Science and Technology
https://doi.org/10.1007/s13197-025-06320-0

ORIGINAL ARTICLE

Optimization of microwave-ultrasound assisted extraction of oligosaccharides from pea seeds and its probiotic proliferative activity

Ruoqi Zhao[1] · Mingwu Qiao[1,2] · Yan Ma[1,2] · Qian Li[1,2] · Ning Li[1,2] · Xianqing Huang[1,2] · Yongxia Cheng[1,2] · Lianjun Song[1,2]

Revised: 17 March 2025 / Accepted: 8 April 2025
© Association of Food Scientists & Technologists (India) 2025

Abstract
The oligosaccharides present in peas, an important edible legume, play a crucial role in its physiological functions. In this study, the microwave-ultrasonic assisted extraction of pea oligosaccharides was optimized using both single factor and response surface methods with water as the extraction solvent. AB-8 macroporous resin was used for decolorization and purification of these oligosaccharides, followed by investigating their impact on probiotic proliferation in vitro. The optimal conditions for extraction were found to be microwave power at 700 W for 30 s, solid-to-liquid ratio at 1:12 g/mL, ultrasonic power at 190 W for 22 min, resulting in a maximum yield of pea oligosaccharides at 7.97%. Purification of pea oligosaccharides using AB-8 macroporous resin resulted in sugar retention and decolorization rates of 89.39 and 91.13%, respectively. HPLC analysis revealed that stachyose accounted for the largest proportion (34.53%) among the pea oligosaccharide composition, followed by verbascose (23.82%), raffinose (1.15%), and sucrose (17.15%). Furthermore, these pea-derived oligosaccharides exhibited significant effects on promoting the growth of *Lactobacillus paracasei*, *Lactobacillus plantarum*, *Akkermansia muciniphila*, and *Bifidobacterium bifidum* strains; thus suggesting their potential application as high-quality prebiotic materials in functional food development.

Keywords Pea oligosaccharides · Microwave ultrasonic assisted extraction · Response surface methodology · Probiotic proliferation

Abbreviations

RFOs	Raffinose family oligosaccharides
HPLC	High-performance liquid chromatography
BBD	Box-Behnken design
RSM	Response surface methodology
RCM	Reinforced clostridial medium

[redacted]

[1] College of Food Science and Technology, Henan Agricultural University, No. 63, Agricultural Road, Jinshui District, Zhengzhou 450002, China

[2] Zhengzhou City Key Laboratory for Soybean Refined Processing, Zhengzhou 450002, China

Introduction

The cultivation of pea (*Pisum sativum L.*) as a significant legume crop is widespread globally, with major producers including Canada, China, Russia, the United States, and India. Pea seeds are abundant in protein, starch, dietary fiber, oligosaccharides, vitamins, and minerals; thus constituting an essential component of the human diet (Wu et al. 2023). The oligosaccharide content in pea seeds ranges from 5.8% to 15.7% (Gawlowska et al. 2017), playing a crucial role in various physiological functions (Kanwal et al. 2023). Pea oligosaccharides primarily consist of the raffinose family oligosaccharides (RFOs), which are composed of sucrose molecules linked by α-1,6 glycosidic bonds to one or more galactoside groups at the glucose-C6 position. Raffinose serves as an exemplary instance, while stachyose, verbascose, and other sucrose derivatives are also encompassed (Cheng et al. 2024). RFOs are classified as prebiotics, which are indigestible in the human gastrointestinal tract but could be metabolized by beneficial gut bacteria to serve as a source

Published online: 26 May 2025

7. Liang P, Liu S, Han Q, et al. Sensitive detection of aflatoxin B1 in foods using aptasensing based on FGO-mediated CdTe QDs[J]. Chemosensors, 2025, 13(4): 141.

chemosensors

MDPI

Article

Sensitive Detection of Aflatoxin B1 in Foods Using Aptasensing Based on FGO-Mediated CdTe QDs

Puye Liang, Sihan Liu, Qinqing Han, Kaixuan Zhou, Tiange Li, Xianqing Huang, Lianjun Song * and Tianlin Wang *

College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China; liangpuye@stu.henau.edu.cn (P.L.); liusihan@stu.henau.edu.cn (S.L.); hanqinqing@stu.henau.edu.cn (Q.H.); zhoukaixuan@stu.henau.edu.cn (K.Z.); litiange@henau.edu.cn (T.L.); hxq8210@126.com (X.H.)
* Correspondence: slj69@126.com (L.S.); wangtianlin@henau.edu.cn (T.W.)

Abstract: Aflatoxin B_1 (AFB_1) exhibits high toxicity and has the potential to induce cancer, deformities, and mutations. It is therefore highly desirable that sensitive and straightforward methods for detecting AFB_1 be developed. In this study, due to the high specific adsorption capacity of AFB_1 aptamers, we applied a sensing strategy based on quantum dots (QDs) and carboxyl-functionalized graphene oxide (FGO) to construct a simple fluorescence quenching platform. FGO and CdTe QDs modified with AFB_1 aptamers cause a FRET effect that produces CdTe QDs with yellow-green fluorescence quenching. When AFB_1 is present, aptamers form complexes with it and CdTe QDs leave the quenching platform, resulting in fluorescence recovery. In this study, we used a fluorescence aptasensor with a wide detection range of 0.05 to 150 ng/mL and a low limit of detection (LOD) of 8.2 pg/mL. The average recoveries of AFB_1 in peanut and pure milk samples ranged from 94.5% to 107.0%. The aptasensor also exhibited the advantages of simple operation, low cost, and good stability. The sensing strategy reported here can thus serve as a potential candidate for the rapid detection of AFB_1.

Keywords: aflatoxin B_1; aptasensor; carboxyl-functionalized graphene oxide; CdTe QDs; FRET

check for updates

Received: 4 March 2025
Revised: 1 April 2025
Accepted: 9 April 2025
Published: 11 April 2025

Citation: Liang, P.; Liu, S.; Han, Q.; Zhou, K.; Li, T.; Huang, X.; Song, L.; Wang, T. Sensitive Detection of Aflatoxin B1 in Foods Using Aptasensing Based on FGO-Mediated CdTe QDs. *Chemosensors* **2025**, *13*, 141. https://doi.org/10.3390/chemosensors13040141

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Aflatoxin B_1 (AFB_1) is a type of harmful substance generated by *Aspergillus flavus* and *Aspergillus parasiticus*. It is easy for agricultural products to be contaminated by AFB_1 [1,2], which has been closely associated with immunosuppression, kidney disease, and even cancer [3–6]; indeed, AFB_1 is recognized by the International Organization for Cancer as a Class I carcinogen. Contamination of food by AFB_1 is now a major global issue, and the development of effective and user-friendly AFB_1 detection strategies is now highly anticipated.

Today, HPLC, TLC, and LC-MS are the most widely used conventional AFB_1 detection methods [7–9]. These approaches have advantages in terms of detection sensitivity and accuracy. However, their application in rapid detection is constrained by several limitations; these include cumbersome measurement procedures, high costs, and the unsuitability of such methods for screening large samples. In recent years, immunological methods have been developed for the simple and rapid detection of AFB_1, primarily including electrochemical immunoassay, ELISA, and antigen microarray [10–12]. However, the high cost of antibodies used in immunological methods is a concern that cannot be overlooked. Compared with antibodies, aptamers are easier and cheaper to produce [13]. Consequently,

8. Song L, Lu M, Liang P, et al. Smartphone-assisted ratiometric FRET aptasensor based on quantum dots and gold nanoparticles for point-of-care testing of zearalenone in cereals[J]. Food Control, 2024, 165: 110666.

Food Control 165 (2024) 110666

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Smartphone-assisted ratiometric FRET aptasensor based on quantum dots and gold nanoparticles for point-of-care testing of zearalenone in cereals

Lianjun Song [a], Meijun Lu [a], Puye Liang [a], Tiange Li [a], Xianqing Huang [a], Yan Ma [a], Libin Wan [b], Tianlin Wang [a,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou, 450002, China
[b] Henan Academy of Science, Zhengzhou, 450002, China

ARTICLE INFO

Keywords:
Aptasensor
Fluorescence resonance energy transfer
Point-of-care testing
Zearlenone

ABSTRACT

Herein, a ratiometric fluorescence aptasensor was established for zearalenone (ZEN) detection based on fluorescence resonance energy transfer (FRET) between aptamer-modified CdTe quantum dots (QDs) as donor and gold nanoparticles (AuNPs) as acceptor. The fluorescence of CdTe QDs quenched by AuNPs based on FRET, while Si QDs with blue fluorescence as reference. The aptamer-modified CdTe QDs were adsorbed to ZEN in the presence of ZEN, and the distance between the energy receptor and the donor increased, which prevented the FRET and led to the fluorescence recovering of CdTe QDs. The aptasensor exhibited a limit of detection of 3.5 pg/mL with a linear range of 0.01–100 ng/mL. In addition, a portable detection device was constructed by integrating with smartphone for point-of-care testing (POCT) of ZEN with satisfactory results, which could provide a promising application for visual POCT of ZEN in cereals.

1. Introduction

Zearalenone (ZEN), also known as F-2 toxin, is an osteogenic mycotoxin that commonly contaminates cereal crops. The neurological and reproductive systems are the main organs affected by its toxicity, which is detrimental to both humans and animals, leading to underdeveloped embryos, reduces fertility, and abnormal reproductive hormone levels (Zhang, Xu, et al., 2023). Furthermore, ZEN is barely possible to be eliminated through food processing conditions due to its high thermal stability, contaminating the end products (Wan et al., 2022). Dietary intake is the main exposure route. After the toxin enters the body, the toxin residue will accumulate in the body because of the long metabolism time. Currently, the European Union limits ZEN residues in corn and grains (50–350 μg kg^{-1}) (Zhang et al., 2018), and the China National Food Safety Standard limits the ZEN in grains to no more than 60 μg kg^{-1} (Li et al., 2021). Therefore, accurate and sensitive detection of ZEN is of great significance for ensuring physical health.

Up to now, the conventional methods for ZEN detection mainly involve thin layer chromatography (TLC) (Yin et al., 2023), high performance liquid chromatography (HPLC) (Xu et al., 2020), and liquid chromatography coupled with mass spectroscopy (LC-MS) (Zhao et al., 2021). These strategies require expensive large instruments, professional analysts and time-consuming sample preparation, although they have advantages in precision and accuracy. Furtherly, the development of enzyme linked immunosorbent assay (ELISA) makes detection methods simple and efficient. However, the instability of antibodies hindered its wide utilization in accurate quantification (Chen et al., 2020; Liu, Wei, et al., 2022). In comparison with ZEN-targeted antibody, ZEN-aptamer exhibits higher stability and better specificity (Cui et al., 2021; Fan et al., 2023). Thus, the aptamer based sensors (aptasensors) occupy a major position in the prompt and sensitive determination of ZEN (Guo et al., 2023; Na et al., 2023; Sun et al., 2022; Xiang et al., 2023). Among the methods, the aptasensors relying on fluorescence resonance energy transfer (FRET) become excellent candidates for ZEN determination (Sun, Zhang, & Wang, 2021; Zhang et al., 2022).

As for FRET, a prerequisite condition involves the congruence between the emission spectrum of the donor and the absorption spectrum of the acceptor, which induces the quenching of donor fluorescence and reduces fluorescence lifetime (Yang et al., 2023; Lao et al., 2023). To enhance the FRET efficacy and increase the sensor sensitivity, an excellent donor-acceptor pair in recognition device is required. Because of the distinctive colloidal and optical characteristics, semiconductor

* Corresponding author. College of Food Science and Technology, Henan Agricultural University, Zhengzhou, 450002, China.
E-mail address

https://doi.org/10.1016/j.foodcont.2024.110666
Received 19 April 2024; Received in revised form 30 May 2024; Accepted 18 June 2024
Available online 19 June 2024
0956-7135/© 2024 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

9. Wang T, Hu Y, Liang M, et al. Synthesis of a cerium-based nanomaterial with superior oxidase-like activity for colorimetric determination of glutathione in food samples[J]. Microchimica Acta, 2022, 189(3): 132.

Microchimica Acta (2022) 189:132
https://doi.org/10.1007/s00604-022-05197-6

ORIGINAL PAPER

Synthesis of a cerium-based nanomaterial with superior oxidase-like activity for colorimetric determination of glutathione in food samples

Tianlin Wang[1,2] · Yuwen Hu[3] · Mengying Liang[1,2] · Lianjun Song[1,2] · Tiange Li[1,2] · Xiya Zhang[1,2] · Ning Li[1,2] · Xianqing Huang[1,2]

Received: 6 December 2021 / Accepted: 20 January 2022
© The Author(s), under exclusive licence to Springer-Verlag GmbH Austria, part of Springer Nature 2022

Abstract
Enzyme-like nanomaterials have received significant attention for their high stability and low cost. However, most nanomaterials require complicated synthesis processes, limiting the range of their potential applications. In this study, a novel cerium-based nanomaterial was fabricated in a facile manner from a mixture of dipicolinic acid (DPA), guanosine 5′-monophosphate (GMP), and cerium acetate under ambient conditions. The obtained nanomaterial, designated as DPA–Ce–GMP, exhibited superior oxidase-like activity owing to the mixed valence (Ce^{3+}/Ce^{4+}) of cerium ions. DPA–Ce–GMP efficiently catalyzed the oxidation of 3,3,5,5-tetramethylbenzidine (TMB), achieving a color reaction without requiring hydrogen peroxide. Thus, DPA–Ce–GMP was incorporated into a simple, rapid, and sensitive colorimetric sensor for glutathione (GSH) detection. Within this sensor, TMB oxidation is inhibited by the reducibility of GSH. The sensor exhibits a linear response over two concentration ranges (0.05–10 and 10–40 μM), and its detection limit is 17.1 nM (3σ/slope). The proposed sensor was successfully applied to GSH quantification in food samples. The developed sensor provides an efficient biomimic oxidase for GSH detection in real samples.

Keywords Cerium · Nanomaterials · Enzyme-like · Oxidase-like activity · Colorimetry · Glutathione

Introduction

Natural enzymes are widely known to play significant roles in various processes. However, their instability and high cost limit their practical applications [1]. Recently, to resolve these difficulties, natural enzymes have recently been replaced by nanomaterials with enzyme-like properties (nanozymes) [2, 3]. Nanozymes' wide applications range from sensing, imaging, and therapeutics to pollutant removal and beyond [4–8]. Generally, classic nanozymes mainly include metallic oxide nanoparticles such as ferric oxide (Fe_3O_4), manganese dioxide (MnO_2), metal hydroxides, metal–organic frameworks, and carbon-based nanomaterials [9–14].

Cerium (Ce) has attracted significant attention and is a lanthanide element with unique properties that differ from those of other lanthanides. The mixed valence of cerium ion (Ce^{3+}/Ce^{4+}) suggests the possibility of reversible switching from Ce^{3+} to Ce^{4+} [15, 16]. Ce^{3+} exhibits a fluorescence arising from the 4f to 5d transition [17], whereas Ce^{3+}/Ce^{4+} can confer a mimic enzyme property to Ce compounds (e.g., cerium dioxide) [18]. Therefore, Ce-based nanomaterials have been employed as target sensors. For example, Qiu's group proposed a novel luminescent Ce(III)-based coordination polymer nanoparticle for the selective detection of As(III) [19]. Liu's group designed a perylene diimide-functionalized CeO_2 nanocomposite as a peroxidase mimic for the colorimetric determination of hydrogen peroxide and glutathione (GSH) [10]. Like most nanomaterials, Ce-based nanomaterials require complicated synthesis processes,

[redacted]

1 Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, Henan, China

2 Henan Technology Innovation Center of Meat Processing and Research, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, Henan, China

3 College of Food Science, Sichuan Agricultural University, Yaan 625000, Sichuan, China

Published online: 03 March 2022

10. Huang X, Fu Y, Guo Y, et al. Two birds with one stone: A multi-functional nanoplatform for sensitive detection and real-time inactivation of pathogenic bacteria with NIR-triggered PTT/PDT[J]. Chemical Engineering Journal, 2024, 481: 148649.

Chemical Engineering Journal 481 (2024) 148649

Contents lists available at ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Two birds with one stone: A multi-functional nanoplatform for sensitive detection and real-time inactivation of pathogenic bacteria with NIR-triggered PTT/PDT

Xianqing Huang, Yana Fu, Yicheng Guo, Yuzheng Cai, Tiange Li, Peijun Zhao, Yan Ma, Lianjun Song, Tianlin Wang *

Institute of Food Science and Technology, Henan Agricultural University, Zhengzhou 450000, China

ARTICLE INFO

Keywords:
Bacterial infection
Multifunctional nanoplatform
Ratiometric fluorescence probe
Antibacteria
Photodynamic and photothermal therapeutic

ABSTRACT

Given the increase in public safety incidents due to bacterial infections, sensitive detection and real-time inactivation of pathogenic bacteria have garnered increasing attention in the field of food safety, clinical diagnosis, and environmental monitoring. In this study, we constructed a "two-in-one" PB@DPA-Ce-GMP@Van (PCV) nanoplatform possessing enzyme-like properties and photothermal therapeutic (PTT) and photodynamic therapeutic (PDT) abilities for the detection and inactivation of pathogenic bacteria. PCV was captured on the surface of *S. aureus* to form a PCV/S. aureus complex. After centrifugation, PCV suspensions could catalyze non-fluorescent Amplex Red (AR) into fluorescent substrates and fluorescent scopolamine (SC) into non-fluorescent substrates. Hence, a ratiometric fluorescence probe with SC/AR reading was constructed for the sensitive detection of bacteria. The detection range reached 10^1–10^7 colony-forming unit (CFU)/mL, and the detection limit was as low as 5.0 CFU/mL. Furthermore, approximately 99.7 % of free *S. aureus* can be inactivated by the PTT and PDT abilities of PCV. Thus, this nanoplatform exhibits a novel advantage in detecting and inactivating bacteria. Moreover, the bacterial infection wound model indicated that PVC exerts good disinfection ability. This study is of immense significance in the application of targeted sensing, eliminating bacterial infection, and even clinical therapy.

1. Introduction

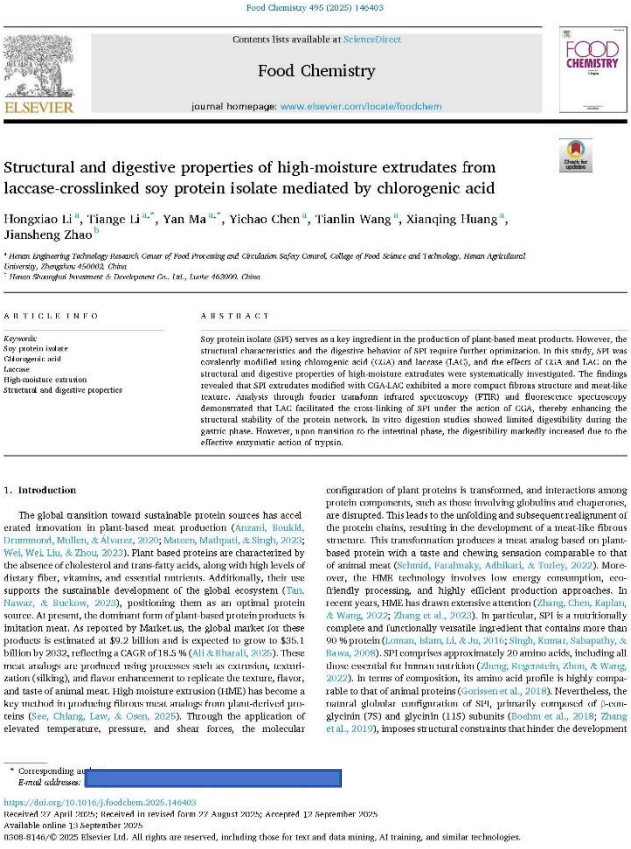
Food or water resources contaminated by pathogenic bacteria can cause food poisoning and intestinal infectious diseases after entering the human body through the food chain, becoming a serious concern and threatening to global public health [1–3]. Pathogenic bacteria possess a high adaptability and reproduction rate, therefore, they can easily cause infections and induce serious damage to tissues or organs, even at low doses [4]. Therefore, rapid and easy-to-use methods should be developed for bacterial detection. Recently, a series of nanomaterial-based biosensors using surface-enhanced Raman scattering [5,6], fluorescence [7,8], electrochemical [9,10], and colorimetric [11,12] were developed for the rapid and sensitive detection of bacteria. Nevertheless, most of the methods only focused on the detection of bacteria, ignoring the significance of further bacterial inactivation [13]. Some nanomaterials, such as polymers or metal oxides, have also been extensively studied in bacterial inactivation due to their flexibility, functional modification, and controllable drug targeting/release [14–17]. Therefore, a multifunctional nanoplatform should be urgently developed for the simultaneous rapid detection and efficient inactivation of bacteria.

Recently, Prussian blue (PB), as a photothermal nanomaterial, has garnered increasing attention for its ability to inactivate bacteria due to its strong near-infrared spectroscopic (NIR) light absorption (λ = 700–900 nm) and high photothermal conversion efficiency [18–20]. For instance, He et al has reported the phytic acid (PA)-PB-CP network aggregates were developed by combining PA-induced PB with cationic polymers (CPs) via electrostatic interaction. The cooperative bactericidal effect of contact-killing induced by the CPs and the localized photothermal effect due to the PB endow the PA-PB-CP with strong antibacterial performance [21]. Furthermore, Hao et al reported a nanoplatform of PB doped with vancomycin (PB-Van). After targeting bacteria and capturing them by PB-Van, the bacteria can be effectively inactivated by PB when the surrounding temperature increases under near-infrared irradiation [22].

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.cej.2024.148649
Received 17 October 2023; Received in revised form 21 December 2023; Accepted 6 January 2024
Available online 8 January 2024
1385-8947/© 2024 Elsevier B.V. All rights reserved.

11. Li H, Li T, Ma Y, et al. Structural and digestive properties of high-moisture extrudates from laccase-crosslinked soy protein isolate mediated by chlorogenic acid[J]. Food Chemistry, 2025, 495: 146403.



Food Chemistry 495 (2025) 146403

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Structural and digestive properties of high-moisture extrudates from laccase-crosslinked soy protein isolate mediated by chlorogenic acid

Hongxiao Li [a], Tiange Li [a,*], Yan Ma [a,*], Yichao Chen [a], Tianlin Wang [a], Xianqing Huang [a], Jiansheng Zhao [b]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China

ARTICLE INFO

Keywords:
Soy protein isolate
Chlorogenic acid
Laccase
High-moisture extrusion
Structural and digestive properties

ABSTRACT

Soy protein isolate (SPI) serves as a key ingredient in the production of plant-based meat products. However, the structural characteristics and the digestive behavior of SPI require further optimization. In this study, SPI was covalently modified using chlorogenic acid (CGA) and laccase (LAC), and the effects of CGA and LAC on the structural and digestive properties of high-moisture extrudates were systematically investigated. The findings revealed that SPI extrudates modified with CGA-LAC exhibited a more compact fibrous structure and meat-like texture. Analysis through fourier transform infrared spectroscopy (FTIR) and fluorescence spectroscopy demonstrated that LAC facilitated the cross-linking of SPI under the action of CGA, thereby enhancing the structural stability of the protein network. In vitro digestion studies showed limited digestibility during the gastric phase. However, upon transition to the intestinal phase, the digestibility markedly increased due to the effective enzymatic action of trypsin.

1. Introduction

The global transition toward sustainable protein sources has accelerated innovation in plant-based meat production (Anzani, Boukid, Drummond, Mullen, & Alvarez, 2020; Mateen, Mathpati, & Singh, 2025; Wei, Wei, Liu, & Zhou, 2023). Plant based proteins are characterized by the absence of cholesterol and trans-fatty acids, along with high levels of dietary fiber, vitamins, and essential nutrients. Additionally, their use supports the sustainable development of the global ecosystem (Tan, Nawaz, & Buckow, 2025), positioning them as an optimal protein source. At present, the dominant form of plant-based protein products is imitation meat. As reported by Market.us, the global market for these products is estimated at $9.2 billion and is expected to grow to $35.1 billion by 2032, reflecting a CAGR of 18.5 % (Ali & Bharali, 2025). These meat analogs are produced using processes such as extrusion, texturization (silking), and flavor enhancement to replicate the texture, flavor, and taste of animal meat. High moisture extrusion (HME) has become a key method in producing fibrous meat analogs from plant-derived proteins (See, Chiang, Law, & Cyen, 2025). Through the application of elevated temperature, pressure, and shear forces, the molecular configuration of plant proteins is transformed, and interactions among protein components, such as those involving globulins and chaperones, are disrupted. This leads to the unfolding and subsequent realignment of the protein chains, resulting in the development of a meat-like fibrous structure. This transformation produces a meat analog based on plant-based protein with a taste and chewing sensation comparable to that of animal meat (Schmid, Faraltnaky, Adhikari, & Torley, 2022). Moreover, the HME technology involves low energy consumption, eco-friendly processing, and highly efficient production approaches. In recent years, HME has drawn extensive attention (Zhang, Chen, Kaplan, & Wang, 2022; Zhang et al., 2023). In particular, SPI is a nutritionally complete and functionally versatile ingredient that contains more than 90 % protein (Loman, Islam, Li, & Ju, 2016; Singh, Kumar, Sabapathy, & Bawa, 2008). SPI comprises approximately 20 amino acids, including all those essential for human nutrition (Zhang, Regenstein, Zhou, & Wang, 2022). In terms of composition, its amino acid profile is highly comparable to that of animal proteins (Gorissen et al., 2018). Nevertheless, the natural globular configuration of SPI, primarily composed of β-conglycinin (7S) and glycinin (11S) subunits (Boehm et al., 2018; Zhang et al., 2019), imposes structural constraints that hinder the development

* Corresponding au
E-mail addresses: [redacted]

https://doi.org/10.1016/j.foodchem.2025.146403
Received 27 April 2025; Received in revised form 27 August 2025; Accepted 12 September 2025
Available online 13 September 2025
0308-8146/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

12. Huang X, Li W, Wang J, et al. NaCl stress on physio-biochemical, phenolics synthesis and antioxidant system of pea (Pisum sativum L.) sprouts[J]. LWT - Food Science and Technology, 2024, 210: 116821.

Journal of Trace Elements in Medicine and Biology 79 (2023) 127233

Contents lists available at ScienceDirect

Journal of Trace Elements in Medicine and Biology

journal homepage: www.elsevier.com/locate/jtemb

Differential expression of SLC30A10 and RAGE in mouse pups by early life lead exposure

Ning Li [*,1], Liuding Wen [1], Yue Shen, Tiange Li, Tianlin Wang, Mingwu Qiao, Lianjun Song, Xianqing Huang [*]

Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Nongye Road, Zhengzhou, Henan, 450002, PR China

ARTICLE INFO

Keywords:
Lead
Hippocampus
Cerebral cortex
SLC30A10
RAGE
Neurotoxicity

ABSTRACT

Background: SLC30A10 and RAGE are widely recognized as pivotal regulators of Aβ plaque transport and accumulation. Prior investigations have established a link between early lead exposure and cerebral harm in offspring, attributable to Aβ buildup and amyloid plaque deposition. However, the impact of lead on the protein expression of SLC30A10 and RAGE has yet to be elucidated. This study seeks to confirm the influence of maternal lead exposure during pregnancy, specifically through lead containing drinking water, on the protein expression of SLC30A10 and RAGE in mice offspring. Furthermore, this research aims to provide further evidence of lead-induced neurotoxicity.

Methods: Four cohorts of mice were subjected to lead exposure at concentrations of 0 mM, 0.25 mM, 0.5 mM, and 1 mM over a period of 42 uninterrupted days, spanning from pregnancy to the weaning phase. On postnatal day 21, the offspring mice underwent assessments. The levels of lead in the blood, hippocampus, and cerebral cortex were scrutinized, while the mice's cognitive abilities pertaining to learning and memory were probed through the utilization of the Morris water maze. Furthermore, Western blotting and immunofluorescence techniques were employed to analyze the expression levels of SLC30A10 and RAGE in the hippocampus and cerebral cortex.

Results: The findings revealed a significant elevation in lead concentration within the brains and bloodstreams of mice, mirroring the increased lead exposure experienced by their mothers during the designated period ($P < 0.05$). Notably, in the Morris water maze assessment, the lead-exposed group exhibited noticeably diminished spatial memory compared to the control group ($P < 0.05$). Both immunofluorescence and Western blot analyses effectively demonstrated the concomitant impact of varying lead exposure levels on the hippocampal and cerebral cortex regions of the offspring. The expression levels of SLC30A10 displayed a negative correlation with lead doses ($P < 0.05$). Surprisingly, under identical circumstances, the expression of RAGE in the hippocampus and cortex of the offspring exhibited a positive correlation with lead doses ($P < 0.05$).

Conclusion: SLC30A10 potentially exerts distinct influence on exacerbated Aβ accumulation and transportation in contrast to RAGE. Disparities in brain expression of RAGE and SLC30A10 may contribute to the neurotoxic effects induced by lead.

1. Introduction

Lead (Pb), an omnipresent toxic heavy metal, pervades certain petroleum derivatives [1]. Lead has the propensity to accumulate in various organs and tissues within the human body, particularly in the intricate nervous system, exerting heightened toxicity during neural development in mammals [2]. Lead possesses the ability to traverse the blood-brain barrier (BBB), gaining entry into the cerebral realm and instigating neurotoxicity [3]. Several scientific inquiries have attested that exposure to lead induces neural impairment, subsequently precipitating diminished cognitive faculties in mice [4,5]. The defining hallmark of Alzheimer's disease (AD) resides in the deposition of amyloid beta protein (Aβ) within the cerebral cortex. It has been hypothesized that lead exposure enhances the expression of amyloid precursor

* Corresponding authors.
E-mail addresses: [redacted]
[1] These authors have contributed equally to this work.

https://doi.org/10.1016/j.jtemb.2023.127233
Received 31 October 2022; Received in revised form 28 May 2023; Accepted 31 May 2023
Available online 9 June 2023
0946-672X/© 2023 Published by Elsevier GmbH.

13. Li N, Wen L, Shen Y, et al. Differential expression of SLC30A10 and RAGE in mouse pups by early life lead exposure[J]. Journal of Trace Elements in Medicine and Biology, 2023, 79: 127233.

LWT - Food Science and Technology 210 (2024) 116821

Contents lists available at ScienceDirect

LWT

journal homepage: www.elsevier.com/locate/lwt

NaCl stress on physio-biochemical, phenolics synthesis and antioxidant system of pea (*Pisum sativum* L.) sprouts

Xianqing Huang, Wenxin Li, Jing Wang, Qian Li, Yue Shen, Yongxia Cheng, Tiange Li, Tianlin Wang, Yinping Wang, Lianjun Song, Yan Ma *

College of Food Science and Technology, Henan Agricultural University, Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, Zhengzhou, 450002, China.

ARTICLE INFO

Keywords:
NaCl stress
Pea sprouts
Phenolics
Key enzymes
Growth status
Antioxidant capacity

ABSTRACT

In this paper, the effects of NaCl stress on physiological and biochemical changes, phenolic compounds and antioxidant system of pea sprouts were studied. Results showed that NaCl stress inhibited the bud length, root length and respiration rate of pea sprouts, and resulted in oxidative damage. However, NaCl promoted the accumulation of total phenolics in pea sprouts, which reached a peak under 60 mmol L^{-1} NaCl stress. At the same time, the key enzymes activities of PAL, C4H, and 4CL were enhanced. In addition, NaCl stress increased the activity of POD, CAT, SOD and APX, enhancing the antioxidant capacity of pea sprouts. The enrichment of phenolic compounds and the increase of antioxidant enzyme activity together promoted the enhancement of antioxidant capacity. This results provided a scientific basis for further improving the functional components of pea.

1. Introduction

Pea (*Pisum sativum* L.) is an annual climbing herbaceous plant in the leguminous family. Due to its diverse processing properties and abundant bioactive substances, it has gradually been widely consumed as a food in recent years. The commercial cultivation of bean sprouts involves precise control of environmental conditions such as temperature and humidity to ensure optimal growth. The harvesting time is also crucial as it directly affects the nutritional content and taste of bean sprouts. In recent years, with the deepening of the understanding of health promoting compounds in pea sprouts, its consumption has gradually increased. Numerous studies have shown that pea sprouts are abundant in carbohydrates, plant proteins, vitamins, minerals, and dietary fiber (Rungruangmaitree & Jiraungkoorskul, 2017). It was reported that the content of health promoting compounds in pea sprouts was considerably higher than that in seeds (López-Amorós, Hernández, & Estrella, 2004; Xu, Fu, Lu, & Wei, 2022). In addition, pea sprouts also contain bioactive compounds with high antioxidant capacity, such as phenolics, whose content was significantly higher than that of phenolics in seeds (Cevallos-Casals & Cisneros-Zevallos, 2003; Tarasevičienė et al., 2019). Borges-Martínez et al. (2022) suggested that the contents of gallic and syringic acids increased during the germination of pea sprouts. Similarly, Zhao et al. (2023) found that the total phenolic content, total flavonoid content and antioxidant activity in pea sprouts were higher than those in pea seeds.

Phenolics are the main secondary metabolites of plant resistance to environmental stress and pathogens (Ampofo & Ngadi, 2021). Pea phenolics mainly include flavonoids (rutin, kaempferol, quercetin), phenolic acids (*p*-coumaric acid, vanillic acid, ferulic acid), tannins, proanthocyanidins and other components. They are mainly synthesized by aromatic amino acids, phenylalanine and tyrosine through the metabolic pathway of shikimic acid and phenylpropane, and are crucial components of plant antioxidant system (Wang et al., 2022). Phenylpropane metabolic pathway is the main pathway of phenolic biosynthesis. Phenylalanine ammonia lyase (PAL), cinnamate 4 hydroxylase (C4H) and 4-coumaric acid coenzyme A ligase (4CL) are key enzymes involved in phenolic biosynthesis (Zhang et al., 2024). The biosynthesis of phenolic is a complex chemical reaction network, which is an endogenous regulation process in the process of plant growth and development. It was also stimulated by external factors such as light (Liu et al., 2016), ultraviolet light (Chen et al., 2019), zinc (Yuan, Jiao, Wang, Shan, & Zhu, 2016) and NaCl (Wang et al., 2020a,b). Researchers have found that the content of phenolic substances in soybean seed germination was increased by stimulating the activity of PAL and other

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.lwt.2024.116821
Received 10 June 2024; Received in revised form 16 September 2024; Accepted 23 September 2024
Available online 24 September 2024
0023-6438/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

14. Li T, Lin X, Mao X, et al. The prebiotics 2'-fucosyllactose prevent high-fat diet induced obesity via the promotion of thermogenesis and modulation of gut microbiota[J]. Journal of Functional Foods, 2024, 119: 106287.

Journal of Functional Foods 119 (2024) 106287

Contents lists available at ScienceDirect

Journal of Functional Foods

journal homepage: www.elsevier.com/locate/jff

The prebiotics 2′-fucosyllactose prevent high-fat diet induced obesity via the promotion of thermogenesis and modulation of gut microbiota

Tiange Li [a,b,d], Xiaoxia Lin [a,b], Xueying Mao [c], Siru Chen [a,b], Zhiqiang Feng [d], Yankun Fu [a,b], Peijun Zhao [a,b], Xianqing Huang [a,b], Yan Ma [a,b], Lianjun Song [a,b], Qiuyan Zhao [a,b], Tianlin Wang [a,b,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Technology Innovation Center of Meat Processing and Research, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[c] Key Laboratory of Functional Dairy, Ministry of Education, College of Food Science and Nutritional Engineering, China Agricultural University, Beijing 100083, China
[d] Synlyn Foods Co., Ltd., Zhengzhou 450044, China

ARTICLE INFO

Keywords:
2′-Fucosyllactose
Obesity
Thermogenesis
High-fat diet
Gut microbiota
Bile acids

ABSTRACT

2′-fucosyllactose (2′-FL) is one of the most prevalent milk oligosaccharides. In this study, the anti-obesity effect of 2′-FL was explored in high-fat diet (HFD) fed mice. Results showed that 2′-FL alleviated body weight gain, improved serum lipid profiles and increased energy expenditure. Under cold exposure, 2′-FL group showed higher body and rectal temperature, improving adaptive thermogenesis. 2′-FL alleviated lipid accumulation, increased mitochondrial DNA content, as well as upregulated the protein expression of thermogenic markers including UCP1, PRDM16, PGC-1α and the phosphorylation of AMPK in both white and brown adipose tissue. 2′-FL also increased the diversity of gut microbiota in HFD mice. The *Bacteroides*/*Firmicutes* ratio, and the *Bifidobacterium* abundance were increased, while *Lachnospiraceae* abundance was decreased after 2′-FL treatment. Moreover, 2′-FL to HFD mice altered the bile acid profiles at levels comparable to normal diet group. These results indicates that 2′-FL promotes thermogenesis and modulates gut microbiota to alleviate obesity.

1. Introduction

Obesity, one of the global epidemics in modern human society, is characterized by the accumulation of fat in the body and energy imbalance (Lin & Li, 2021). There were currently more than 1.9 billion overweight adults and 650 million obese adults worldwide in 2016 according to the WHO (Chakhtoura et al., 2022). It is strongly associated with a shortened lifespan as well as the development of various chronic diseases including hypertension, type 2 diabetes mellitus (T2DM), dyslipidemia, and non-alcoholic fatty liver disease (Fahed et al., 2022). Adipose tissue is multifunctional and controls many aspects of whole-body physiology such as energy homeostasis (Rosen & Spiegelman, 2014). The evolution of three adipocyte subtypes with distinct functions has allowed mammals to adapt to different metabolic needs (Rosen & Spiegelman, 2014). White adipocytes has the function of storing excess energy intake in the form of triglycerides, while brown adipocytes are mainly responsible for energy consumption through thermogenesis (Maurer, Harms, & Rosenwald, 2021). Brown adipocytes possess enriched and metabolically active mitochondria with a high expression of uncoupling protein 1 (UCP1) (Lin et al., 2023a). UCP1, located in the mitochondrial inner membrane, uncouples mitochondrial respiration from ATP synthesis to dissipate chemical energy in the form of heat (Lin et al., 2023a). Beige adipocyte, also called "brite adipocyte", can emerge in white adipose tissue (WAT) under various stimulations such as chronic cold exposure and β3-adrenergic agonists, which is often known as "browning" of WAT (Giralt & Villarroya, 2013). Beige adipocyte contributes to energy expenditure and shares similar characteristics and functions of brown adipocytes, including the expression of UCP1 and multilocular lipid droplets (Altshuler-Keylin et al., 2022). Consequently, the activation of brown adipose tissue (BAT) and the promotion of WAT browning has become a new target for obesity prevention or treatment.

Gut microbiota plays a critical role in maintaining host metabolism

* Corresponding author at: Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China.
E-mail address: [redacted]

https://doi.org/10.1016/j.jff.2024.106287
Received 28 March 2024; Received in revised form 25 May 2024; Accepted 5 June 2024
1756-4646/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

15. Huang X, Wang N, Ma Y, et al. Flaxseed polyphenols: Effects of varieties on its composition and antioxidant capacity[J]. Food Chemistry: X, 2024, 23: 101597.

Food Chemistry: X 23 (2024) 101597

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x

Flaxseed polyphenols: Effects of varieties on its composition and antioxidant capacity

Xianqing Huang [a], Nan Wang [a], Yan Ma [a,*], Xiaoyong Liu [a], Hongtao Guo [b], Lianjun Song [a], Qiuyan Zhao [a], Dan Hai [a], Yongxia Cheng [a], Ge Bai [a], Qi Guo [a]

[a] College of Food Science and Technology, Henan Agricultural University, Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, Zhengzhou 450002, China
[b] Henan Forest Holiday Food Technology Development Co., Ltd, Luohe 462300, China

ARTICLE INFO

Keywords:
Flaxseed
Polyphenols
Phenolic acids
Flavonoids
Antioxidant capacity

ABSTRACT

This study identified phenolic compounds in five flaxseed varieties and evaluated their antioxidant activities. Results showed significant variations in phenolic acids and flavonoids among the varieties. Longya 16 had the lowest flavonoid content, Longya 13 had the lowest phenolic acid content, while Longya 10 exhibited the highest content and diversity of polyphenols, including six flavonoids (vitexin, quercitrin, quercetin, apigenin, kaempferol, (+)-dihydroquercetin) and five phenolic acids (gallic acid, vanillic acid, ferulic acid, sinapic acid, and 4-hydroxybenzoic acid). Antioxidant activity was assessed using DPPH and ABTS radical scavenging assays, and cell-based assays under tBHP-induced oxidative stress. Flaxseed polyphenol extracts significantly reduced ROS, MDA, and GSSG levels and increased SOD and CAT activities, preserving cell vitality and morphology. These findings confirmed the significant antioxidant activity of flaxseed polyphenols, providing a theoretical basis for their application in antioxidative functional areas.

1. Introduction

Flax (*Linum usitatissimum* L.) is an ancient herbaceous plant and is cultivated in over 50 countries and regions worldwide (Han, Yilmaz, & Gulcin, 2018). According to the statistical report of the Food and Agriculture Organization (FAO) of the United Nations, the total production of flaxseed is approximately 3.22 million tons, with the majority grown in the Northern Hemisphere. The largest portion is cultivated in Asia (49.5%), followed by Europe (25.4%), the Americas (21.7%), Africa (3.1%), and Oceania (0.3%) (Sharma & Saini, 2022). The main bioactive components and their contents in flaxseed may vary due to different genetic backgrounds and its environment (Kajla, Sharma, & Sood, 2015). The flaxseed has a crisp texture and rich nutty flavor, often presenting in reddish-brown color. Flaxseed was composed of approximately 40% fat, 35% dietary fiber, and 30% protein. It was also rich in various bioactive compounds, including omega-3 polyunsaturated fatty acids, lignans, cyclolinopeptides, and polysaccharides, among others (Doyen et al., 2014), which is a multi-functional nutritional health food raw material. Adequate intake can lower blood sugar, prevent diseases such as osteoporosis, and reduce the risk of cardiovascular and cerebrovascular diseases. Flaxseed polyphenols are a group of natural plant compounds extracted from flaxseed and are a class of secondary metabolites Flaxseed polyphenols include phenolic acids, flavonoids, lignans, and other compounds (Hajibabaie, Abedpoor, Safavi, & Taghian, 2022). Studies have found that the main compounds in flaxseed include ellagic acid, ferulic acid, quercetin, secoisolariciresinol (SECO), and secoisolariciresinol diglucoside (SDG) (Mechchate et al., 2021). The types and contents of polyphenols vary significantly among different varieties of flaxseeds. Mechchate et al. (2021) dentified 18 phenolic compounds from flaxseed, including oleuropein, hesperetin, ursolic acid, isorhamnetin-7-O-pentoside, luteolin-7-O-glucoside, trans-cinnamic acid, procyanidin, and naringin. Kyselka et al. (Kyselka et al., 2017) isolated ferulic acid, caffeic acid, and p-coumaric acid from flaxseed polyphenol extracts (Al-Jumaily & Al-Azawi, 2015) identified six phenolic substances from flaxseed polyphenol extracts, namely p-hydroxybenzoic acid, vanillin, p-coumaric acid, ascorbic acid, ferulic acid, and ellagic acid. In studies by Zorenc et al. (2017), it was found that compared to red currants, white currants contain no anthocyanins in their polyphenols, but have higher levels of hydroxycinnamic acids and flavonols. Jiang et al. (2021) revealed differences in polyphenol

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.fochx.2024.101597
Received 18 May 2024; Received in revised form 23 June 2024; Accepted 24 June 2024
Available online 27 June 2024
2590-1575/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

16. Li N, Cui N, Li T, et al. Pea Peptides and Heavy Metal Neurotoxicity: Exploring Mechanisms and Mitigation Strategies in PC12 Cells[J]. Plant Foods for Human Nutrition, 2025, 80: 85.

Plant Foods for Human Nutrition (2025) 80:85
https://doi.org/10.1007/s11130-025-01322-x

RESEARCH

Pea Peptides and Heavy Metal Neurotoxicity: Exploring Mechanisms and Mitigation Strategies in PC12 Cells

Ning Li[1] · Ningning Cui[1] · Tiange Li[1] · Peijun Zhao[1] · Ibrahim A. Bakry[1] · Qian Li[1] · Yongxia Cheng[1] · Gianni Galaverna[2] · Huijie Yang[1] · Fangyu Wang[2,3]

Accepted: 9 February 2025
©The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2025

Abstract
Calsyntenin-1 (Clst1) is a sensitive indicator of lead (Pb) toxicity in neural tissue. This study was designed to investigate the impact of lead exposure on Clst1 expression in PC12 cells and the mitigating effect of pea peptide 4 (PP4) on lead-induced neurotoxicity. Data showed that lead exposure, at varying doses and durations, disrupted the mRNA expression and protein levels of Clstn1 in PC12 cells. However, immunofluorescence results showed that treatment with PP4 significantly increased Clstn1 protein expression in the Pb + PP4 and PP4 compared to the Pb groups ($P<0.05$). Lead exposure activates the JNK and p38 pathways; at the same time, PP4 treatment enhances ERK pathway activation and reduces JNK and p38 activation.

Keywords Pea peptide · Calsyntenin-1 · Lead · PC12 · Alzheimer's disease

Introduction

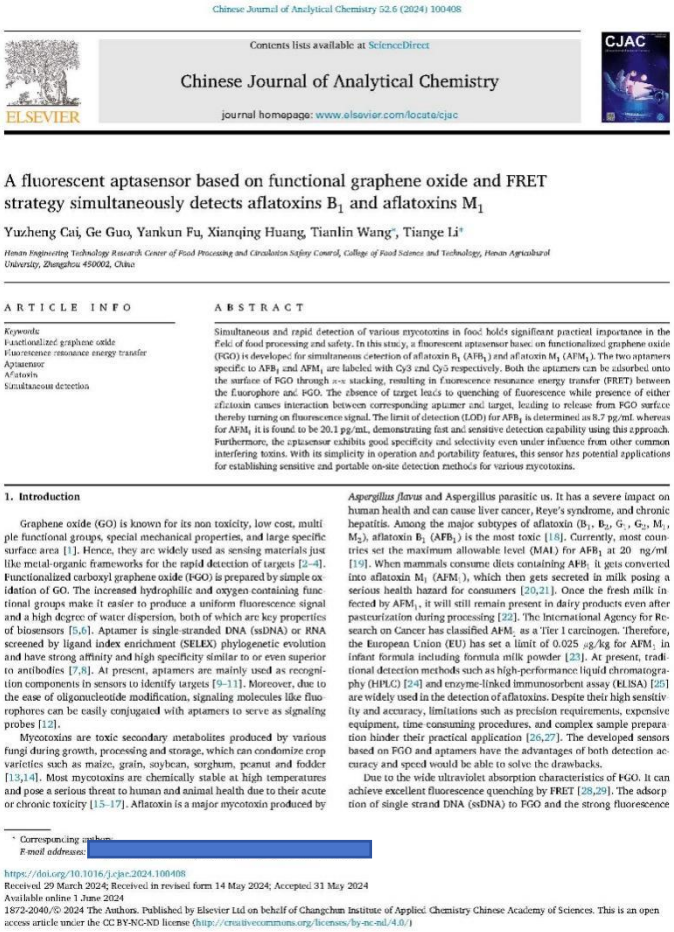
Alzheimer's disease (AD), a neurodegenerative disorder and a major cause of dementia, affects over 50 million people worldwide [1]. While the mechanisms of age-related impairment in AD remain unclear, key pathways include amyloid-beta (Aβ) plaque formation, Tau tangles, neuroinflammation, and cholinergic/oxidative stress, all contributing to neuronal damage [2]. As per the amyloid hypothesis, the buildup of Aβ in the brain is identified as a critical factor in the progression of AD, with the reduction of Aβ believed to alleviate AD symptoms [3]. Despite the existence of other theories, increasing genetic data strongly indicates that changes in the sequential proteolytic breakdown of the amyloid precursor protein (APP) significantly influence AD development [4].

Lead (Pb) exposure is a significant risk factor for neurodegenerative diseases like AD [5]. Neurotoxicity caused by Lead (Pb) is a significant public health problem in developing and developed countries [6]. The mechanisms underlying

1 College of Food Science and Technology, Henan Agricultural University, 63# Agricultural Road, Zhengzhou 450000, China
2 Key Laboratory for Animal Immunology, Henan Academy of Agricultural Sciences, 116# Huayuan Road, Zhengzhou 450002, PR China
3 Food and Drug Department, University of Parma, Parco Area delle Scienze, 17/a, Parma 43124, Italy

Published online: 04 March 2025

17. Cai Y, Guo G, Fu Y, et al. A fluorescent aptasensor based on functional graphene oxide and FRET strategy simultaneously detects aflatoxins B_1 and aflatoxins M_1[J]. Chinese Journal of Analytical Chemistry, 2024, 52(6): 100408.



Chinese Journal of Analytical Chemistry 52.6 (2024) 100408

Contents lists available at ScienceDirect

Chinese Journal of Analytical Chemistry

journal homepage: www.elsevier.com/locate/cjac

A fluorescent aptasensor based on functional graphene oxide and FRET strategy simultaneously detects aflatoxins B_1 and aflatoxins M_1

Yuzheng Cai, Ge Guo, Yankun Fu, Xianqing Huang, Tianlin Wang*, Tiange Li*

Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Sciences and Technology, Henan Agricultural University, Zhengzhou 450002, China

ARTICLE INFO

Keywords:
Functionalized graphene oxide
Fluorescence resonance energy transfer
Aptasensor
Aflatoxin
Simultaneous detection

ABSTRACT

Simultaneous and rapid detection of various mycotoxins in food holds significant practical importance in the field of food processing and safety. In this study, a fluorescent aptasensor based on functionalized graphene oxide (FGO) is developed for simultaneous detection of aflatoxin B_1 (AFB_1) and aflatoxin M_1 (AFM_1). The two aptamers specific to AFB_1 and AFM_1 are labeled with Cy3 and Cy5 respectively. Both the aptamers can be adsorbed onto the surface of FGO through π-π stacking, resulting in fluorescence resonance energy transfer (FRET) between the fluorophore and FGO. The absence of target leads to quenching of fluorescence while presence of either aflatoxin causes interaction between corresponding aptamer and target, leading to release from FGO surface thereby turning on fluorescence signal. The limit of detection (LOD) for AFB_1 is determined as 8.7 pg/mL whereas for AFM_1 it is found to be 20.1 pg/mL, demonstrating fast and sensitive detection capability using this approach. Furthermore, the aptasensor exhibits good specificity and selectivity even under influence from other common interfering toxins. With its simplicity in operation and portability features, this sensor has potential applications for establishing sensitive and portable on-site detection methods for various mycotoxins.

1. Introduction

Graphene oxide (GO) is known for its non toxicity, low cost, multiple functional groups, special mechanical properties, and large specific surface area [1]. Hence, they are widely used as sensing materials just like metal-organic frameworks for the rapid detection of targets [2–4]. Functionalized carboxyl graphene oxide (FGO) is prepared by simple oxidation of GO. The increased hydrophilic and oxygen-containing functional groups make it easier to produce a uniform fluorescence signal and a high degree of water dispersion, both of which are key properties of biosensors [5,6]. Aptamer is single-stranded DNA (ssDNA) or RNA screened by ligand index enrichment (SELEX) phylogenetic evolution and have strong affinity and high specificity similar to or even superior to antibodies [7,8]. At present, aptamers are mainly used as recognition components in sensors to identify targets [9–11]. Moreover, due to the ease of oligonucleotide modification, signaling molecules like fluorophores can be easily conjugated with aptamers to serve as signaling probes [12].

Mycotoxins are toxic secondary metabolites produced by various fungi during growth, processing and storage, which can condomize crop varieties such as maize, grain, soybean, sorghum, peanut and fodder [13,14]. Most mycotoxins are chemically stable at high temperatures and pose a serious threat to human and animal health due to their acute or chronic toxicity [15–17]. Aflatoxin is a major mycotoxin produced by *Aspergillus flavus* and Aspergillus parasitic us. It has a severe impact on human health and can cause liver cancer, Reye's syndrome, and chronic hepatitis. Among the major subtypes of aflatoxin (B_1, B_2, G_1, G_2, M_1, M_2), aflatoxin B_1 (AFB_1) is the most toxic [18]. Currently, most countries set the maximum allowable level (MAL) for AFB_1 at 20 ng/ml [19]. When mammals consume diets containing AFB_1 it gets converted into aflatoxin M_1 (AFM_1), which then gets secreted in milk posing a serious health hazard for consumers [20,21]. Once the fresh milk infected by AFM_1, it will still remain present in dairy products even after pasteurization during processing [22]. The International Agency for Research on Cancer has classified AFM_1 as a Tier 1 carcinogen. Therefore, the European Union (EU) has set a limit of 0.025 μg/kg for AFM_1 in infant formula including formula milk powder [23]. At present, traditional detection methods such as high-performance liquid chromatography (HPLC) [24] and enzyme-linked immunosorbent assay (ELISA) [25] are widely used in the detection of aflatoxins. Despite their high sensitivity and accuracy, limitations such as precision requirements, expensive equipment, time-consuming procedures, and complex sample preparation hinder their practical application [26,27]. The developed sensors based on FGO and aptamers have the advantages of both detection accuracy and speed would be able to solve the drawbacks.

Due to the wide ultraviolet absorption characteristics of FGO. It can achieve excellent fluorescence quenching by FRET [28,29]. The adsorption of single strand DNA (ssDNA) to FGO and the strong fluorescence

* Corresponding authors.
E-mail addresses: [redacted]

https://doi.org/10.1016/j.cjac.2024.100408
Received 29 March 2024; Received in revised form 14 May 2024; Accepted 31 May 2024
Available online 1 June 2024
1872-2040/© 2024 The Authors. Published by Elsevier Ltd on behalf of Changchun Institute of Applied Chemistry Chinese Academy of Sciences. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

18. Li T, Wu T, Lu M, et al. An intelligent device with double fluorescent carbon dots based on smartphone for visual and point-of-care testing of Copper(II) in water and food samples[J]. Food Chemistry: X, 2024, 24: 101834.

Food Chemistry: X 24 (2024) 101834

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x

An intelligent device with double fluorescent carbon dots based on smartphone for visual and point-of-care testing of Copper(II) in water and food samples

Tiange Li [a], Tiantian Wu [a], Meiju Lu [a], Ning Li [a], Yan Ma [a], Lianjun Song [a], Xianqing Huang [a], Jiansheng Zhao [b], Tianlin Wang [a,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China

ARTICLE INFO

Keywords:
Carbon dots
Ratiometric fluorescence
Intelligent device
Point of care testing
Copper (II)

ABSTRACT

The excessive presence of Cu^{2+} could be harmful to human health. Therefore, a ratiometric fluorescence sensor based on multicolor fluorescent carbon dots (CDs) was developed for Cu^{2+} detection. The blue and yellow carbon dots (B-CDs/Y-CDs) were synthesized by one step hydrothermal method. After adding Cu^{2+}, it is captured by the amino groups of B-CDs to form complexes, resulting in a strong fluorescence quenching via photoinduced electron transfer (PET). Meanwhile, the amino groups from Y-CDs also binds with Cu^{2+} that inhibit the internal PET thus enhancing the fluorescence of Y-CDs. The sensor has the merits in rapid, visual, and selective with a low limit of detection (LOD) at 2.29 nM. Furthermore, an intelligent device composed of portable optical detector and smartphone is constructed, which realizes the visual point-of-care testing (POCT) of Cu^{2+} with a LOD of 7.81 nM. The strategy provides an accessible approach for monitoring heavy metal pollution and food safety.

1. Introduction

Copper ion as one of indispensable nutrient with human and animals and plants life activities, can regulate various physiological functions of the human bodies (Chen et al., 2023; Zuo et al., 2023). However, insufficient or excess of Cu^{2+} can lead to many diseases, such as Wilson's disease, Menkes disease, cardiovascular disease, and cancer (Lu, Wei, et al., 2023; Lu, Zhang, et al., 2023; Zhao et al., 2021). In addition, copper ions could easily accumulate in water, fruits, vegetables and aquatic animals through the food chain, eventually endangering human health (Liu, Hao, et al., 2023). Therefore, rapid and sensitive detection of Cu^{2+} ions is very important for environmental protection and human health.

Since a long time ago, some classic methods have been developed for Cu^{2+} detection, such as inductively coupled plasma mass spectrometry (ICP-MS) (Lu, Wei, et al., 2023), atomic absorption spectrometry (AAS) (Pourbasheer et al., 2022), inductively coupled plasma atomic emission spectrometry (ICP-AES) (Hadi et al., 2023), electrochemical (Moussaoui et al., 2023), etc. Although these methods can achieve precise quantitative detection of Cu^{2+}, the drawbacks in large and expensive instrument, time-consuming operation and maintenance problems hindered their application in point of care testing (POCT) of Cu^{2+}. POCT requires the development of detection methods that are fast, convenient, and accurate (Zeng et al., 2024). Satisfyingly, the development of fluorescence sensors based on fluorescent nanomaterials could meet all the requirements of POCT (Wang et al., 2024). In particular, the fluorescence color changes caused by fluorescent sensors in detecting Cu^{2+} is observed by naked-eye, making them occupy an important position in visual POCT (Xu et al., 2023).

Carbon dots (CDs), as a classic class of fluorescent nanomaterials (Alafeef et al., 2024), have the characteristics of good water solubility, low toxicity, easy to synthesize, and fluorescence adjustability (Liu, Guo, et al., 2023; Liu, Hao, et al., 2023; Spesnakuya et al., 2020). Hence, various fluorescent sensors composed of CDs has been developed for visual analysis of Cu^{2+}. Zhang et al. prepared a N and S-doped carbon dots (N/SCDs) using *p*-phenylenediamine and 2-mercaptothiazoline for the detection of Cu^{2+} (Zhang, Xiao, et al., 2024; Zhang, Yin, et al., 2024). In addition, Ge et al. prepared N-CDs by heat treatment with hexamethylenetetramine and ammonium citrate as precursors, which has been successfully used for detection of Cu^{2+} (Ge et al., 2021). However,

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.fochx.2024.101834
Received 12 July 2024; Received in revised form 8 September 2024; Accepted 10 September 2024
Available online 10 September 2024
2590-1575/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

19. Chen S, Fu Y, Wang T, et al. Effect of 2′ -Fucosyllactose on Beige Adipocyte Formation in 3T3-L1 Adipocytes and C3H10T1/2 Cells[J]. Foods, 2023, 12(22): 4137.

foods

MDPI

Article

Effect of 2′-Fucosyllactose on Beige Adipocyte Formation in 3T3-L1 Adipocytes and C3H10T1/2 Cells

Siru Chen [1], Yankun Fu [1], Tianlin Wang [1], Zhenglin Chen [1], Peijun Zhao [1], Xianqing Huang [1,2], Mingwu Qiao [1,2], Tiange Li [1,*] and Lianjun Song [1,2,*]

[1] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China; cc15837026322@163.com (S.C.); chenzhenglin0108@outlook.com (Z.C.)
[2] Henan Technology Innovation Center of Meat Processing and Research, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
* Correspondence: litiange@henau.edu.cn (T.L.); slj698@126.com (L.S.); Tel.: +86-131-2675-0913 (T.L.); +86-139-3909-5293 (L.S.)

Abstract: 2′-Fucosyllactose (2′-FL), the functional oligosaccharide naturally present in milk, has been shown to exert health benefits. This study was aimed to investigate the effect of 2′-fucosyllactose (2′-FL) on the browning of white adipose tissue in 3T3-L1 adipocytes and C3H10T1/2 cells. The results revealed that 2′-FL decreased lipid accumulations with reduced intracellular triglyceride contents in vitro. 2′-FL intervention increased the mitochondria density and the proportion of UCP1-positive cells. The mRNA expressions of the mitochondrial biogenesis-related and browning markers (*Cox7a*, *Cyto C*, *Tfam*, *Ucp1*, *Pgc1a*, *Prdm16*, *Cidea*, *Elovl3*, *Pparx*, *CD137*, and *Tmem26*) were increased after 2′-FL intervention to some extent. Similarly, the protein expression of the browning markers, including UCP1, PGC1α, and PRDM16, was up-regulated in the 2′-FL group. Additionally, an adenosine monophosphate-activated protein kinase (AMPK) inhibitor, compound C (1 μM), significantly decreased the induction of thermogenic proteins expressions mediated by 2′-FL, indicating that the 2′-FL-enhanced beige cell formation was partially dependent on the AMPK pathway. In conclusion, 2′-FL effectively promoted the browning of white adipose in vitro.

Keywords: adipocytes browning; 2′-fucosyllactose; obesity; UCP1; AMPK

check for updates

Citation: Chen, S.; Fu, Y.; Wang, T.; Chen, Z.; Zhao, P.; Huang, X.; Qiao, M.; Li, T.; Song, L. Effect of 2′-Fucosyllactose on Beige Adipocyte Formation in 3T3-L1 Adipocytes and C3H10T1/2 Cells. *Foods* **2023**, *12*, 4137. https://doi.org/10.3390/foods12224137

Received: 25 October 2023
Revised: 11 November 2023
Accepted: 14 November 2023
Published: 15 November 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Obesity, a chronic disease, has become one of the most prevalent health issues that attracts global attention, leading to huge social and economic burdens [1]. A variety of reasons, including genetic factors, environmental influences, unhealthy eating habits, irregular lifestyles, and many other factors, can contribute to overweight and obesity [2]. Obesity occurs when energy intake exceeds energy expenditure, resulting in the excessive accumulation of body fat and weight gain [3]. It has been reported that obesity is also the most significant cause of insulin resistance, hyperlipidemia and other metabolic disorders, and even different types of cancer [4,5]. The prevention and treatment of obesity are mainly divided into three intervention categories—drug, surgical, and behavioral interventions. Among them, drug intervention is the most common despite exerting different degrees of side effects on the human body, such as inducing heart valve damage and hypertension [6]. Therefore, exploring strategies for preventing and combating obesity and related diseases has become a critical challenge worldwide [7]. Food-derived active substances have attracted considerable attention for their safety and efficacy. Numerous studies have investigated the anti-obesity activities of food-derived active substances, which have emerged as a research hotspot in the field of food nutrition and health.

Further, mammalian adipose tissues (AT) can be divided into two types: white AT (WAT) and brown AT (BAT) [8]. WAT is mainly distributed in the lower skin and around the

20. Huang Y, Li T, Lei M, et al. Efficient One-Pot Synthesis of Bright Blue-Emitting Ce^{3+}-Based Phosphor: Application for the Construction of Warm White-Light-Emitting Diodes and Anticounterfeiting[J]. ACS Applied Electronic Materials, 2022, 4(7): 3575-3582.

ACS APPLIED ELECTRONIC MATERIALS

pubs.acs.org/acsaelm Article

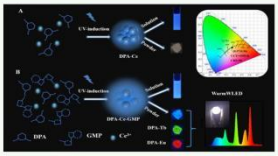
Efficient One-Pot Synthesis of Bright Blue-Emitting Ce^{3+}-Based Phosphor: Application for the Construction of Warm White-Light-Emitting Diodes and Anticounterfeiting

Yuqi Huang, Tiange Li, Mengmeng Lei, Xianqing Huang,* and Tianlin Wang*

Cite This: ACS Appl. Electron. Mater. 2022, 4, 3575−3582 Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: In the present investigation, we demonstrated a simple approach for the reproducible synthesis of cerium(III)-based blue phosphor, which provides versatile applications in the construction of warm white-light-emitting diodes (WLEDs) and anticounterfeiting patterns. It is found that the mixture of dipicolinic acid (DPA) with Ce^{3+} in ethanol (DPA-Ce) emits blue fluorescence under the assistance of ultraviolet (UV) induction. The quantum yield of the DPA-Ce phosphor reaches 44% and is improved to 52% by combining with guanosine 5′-monophosphate (GMP). The obtained DPA-Ce-GMP emits blue fluorescence in both a solid powder and aqueous solution, having advantages of long luminescence lifetimes, ultralong stability, and outstanding antitemperature bleaching. With DPA as a universal ligand, DPA-Tb with green fluorescence and DPA-Eu with red fluorescence are integrated with the blue fluorescence of DPA-Ce-GMP to construct full-color and white-light-emitting devices. The as-prepared warm WLED with a quantum yield of 64% presents an excellent stability and high quality with a color rending index of up to 90, CIE color coordinates of (0.37, 0.36), a correlated color temperature of 3950 K, and a luminous efficiency of 37.8 lm W^{-1}. Multiple anticounterfeiting patterns are further encoded with the as-prepared lanthanide-based phosphors. The investigation offers a simple assay for the cost-effective, large-scale synthesis of phosphors, with great promise in diverse applications including the lighting industry and anticounterfeiting technology.



KEYWORDS: *WLED, anticounterfeiting, lanthanide-based luminescence complex, low-cost, one-pot*

1. INTRODUCTION

White-light-emitting diodes (WLEDs) are considered to play a significant role in next-generation lighting and display devices on account of their merits of high efficiency, long lifetime, and energy savings over traditional incandescent bulbs and fluorescent lamps.[1,2] Nowadays, the most straightforward method for the fabrication of WLEDs is to couple a blue emitting chip with green and red emitting fluorescent materials.[3,4] However, such WLEDs usually suffer from poor color-rendering indices (CRI < 75).[5] Meanwhile, blue light retinal injuries arising from a strong blue spike in the white-light spectrum prevents this technology from widespread applications.[6−8] To reduce light toxicity of the blue chip, an ultraviolet (UV)-LED chip is selected as the light source to excite a mixture of trichromatic [red-(R)/green-(G)/blue-(B)] phosphors for the construction of WLEDs. Diverse materials such as quantum dots, organic compounds, rare-earth metal-doped zeolites, and metal complexes have been synthesized for the construction of WLEDs.[9−12] Among the developed phosphors, lanthanide (Ln)-based materials have emerged as powerful building blocks for the effective preparation of full-color and white-light-emitting diodes thanks to their excellent sharp-emission luminescence properties with suitable sensitization.[13,14] Ln-based green and red phosphors have been extensively investigated because of their characteristics of easily sensitized luminescence.[15,16] However, it is hard to achieve Ln-based phosphors with blue emission, which remains a challenging task.[17] To fabricate WLEDs, green-emitting and red-emitting Ln-based phosphors are usually codoped with other blue phosphors such as organic fluorophores, silicon nanoparticles, and quantum dots,[18,19] which might require different excitation wavelengths, limiting their potential applications in the light industry. To prepare Ln-based blue-emitting phosphors, diverse strategies have been developed. For example, Yin's group reported Dy-doped metal−organic frameworks with blue emission.[20] Highly efficient blue

Received: April 22, 2022
Accepted: June 29, 2022
Published: July 11, 2022

Downloaded via HENAN AGRICULTURAL UNIV on September 14, 2022 at 10:01:39 (UTC).
See https://pubs.acs.org/sharingguidelines for options on how to legitimately share published articles.

ACS Publications © 2022 American Chemical Society

https://doi.org/10.1021/acsaelm.2c00529
ACS Appl. Electron. Mater. 2022, 4, 3575−3582

21. Ma Y, Li W, Zou X, et al. Quantitative proteomics reveals the mechanism of L-glu-induced phenolics enrichment in wheat (Triticum aestivum L.) sprouts under NaCl stress[J]. Food Chemistry, 2025, 494: 145972.

Food Chemistry 494 (2025) 145972

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Quantitative proteomics reveals the mechanism of L-glu-induced phenolics enrichment in wheat (*Triticum aestivum* L.) sprouts under NaCl stress

Yan Ma [a], Wenxin Li [a], Xuchen Zou [a], Yinping Wang [a], Guangshan Zhao [a], Haoru Yu [a], Jingjing Chen [b], Jiansheng Zhao [b], Xianqing Huang [a,*]

[a] College of Food Science and Technology, Henan Agricultural University/Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, Zhengzhou 450002, China

[b] Henan Shuanghui Investment Development Co., Ltd./Henan Intelligent Meat Segmentation and Biotransformation Engineering Research Center, Luohe 462005, China

ARTICLE INFO

Keywords:
Quantitative proteomics
Differentially expressed proteins
Wheat sprouts
L-Glu
NaCl stress

ABSTRACT

The purpose of this study was to reveal the effect and mechanism of L-Glu treatment on the enrichment of phenolic compounds in wheat sprouts under NaCl stress. Results of data independent acquisition (DIA) proteomics analysis showed that there were 978 DAPs in NaCl compared to CK, and 3813, 202, and 3413 DAPs in L-Glu, glutamate receptor antagonist 6,7-dinitriquinoxaline-2,3-dinoe (DNQX), and L-Glu plus DNQX compared to NaCl, respectively. These DAPs were mainly related to cellular metabolism, organic matter metabolism, and polyphenol compound metabolism. Based on KEGG analysis, DAPs were mainly enriched in metabolic pathways such as photosynthesis and phenylpropanoid biosynthesis. In addition, upregulation of phenylalanine ammonia lyase and 4-coumaric acid coenzyme A ligase proteins promoted the accumulation of phenolic compounds in wheat sprouts. This study revealed the mechanism of L-Glu-induced phenolics enrichment in wheat sprouts under NaCl stress, providing a theoretical basis for the growth of wheat under adversity.

1. Introduction

Wheat (*Triticum aestivum* L.), a staple cereal crop globally, was widely cultivated and processed into various food products such as bread, biscuits, and noodles (Shamanin et al., 2022). Wheat was not only rich in nutrients such as starch, protein, fat, minerals, calcium, iron, and vitamin A, but also contained phenolic compounds, including flavonoids and phenolic acids (Wang et al., 2020). These phenolics demonstrated remarkable antioxidant properties, effectively eliminating free radicals in the body, reducing the damage of oxidative stress to cells, and showing potential positive effects in preventing chronic diseases such as cardiovascular diseases and cancer in humans (Miao et al., 2025; Zhao et al., 2024). During germination, a series of biochemical changes occurred inside wheat grains. These changes included the activation of the endogenous enzyme system and the degradation of large storage molecules into smaller molecules that were easier for the body to digest and absorb (Hareland, 2003). At the same time, the content of bioactive substances such as dietary fiber, folic acid and phenols increased significantly (Komurcu & Bilgicli, 2023). Ceccaroni et al. (2020) found that the phenolic content of germinated wheat increased by 79.8 % compared to seeds. Similarly, Chen et al. (2017) found that after four days of germination, the total phenolic content of wheat increased by 442.7 %, and the DPPH free radical scavenging rate was 6–7 times higher than that of seeds. Compared with seeds, germinated wheat was more beneficial to human body.

Salt stress posed a serious threat to crop growth and a severe environmental challenge to global agricultural productivity and food security (Fardus et al., 2021). The most active stage of life for higher plants was the germination process, during which a variety of morphological, physiological, and biochemical changes occurred (Zhao et al., 2021). The germination process was highly susceptible to environmental interference. Salt was an essential abiotic stress factor that significantly affected plant root growth and germination rate, and research has revealed that the stage of seed germination was particularly vulnerable to it (Gao et al., 2023). L-Glu was a common amino acid in plants and played a crucial role in amino acid metabolism (Qiu et al., 2020). In recent years, research has shown that L-Glu also existed as a new signal transducer in many plant physiological processes (Tsuruda & Yoshida, 2023). It was crucial for plant growth and development and enhancing response and adaptability to environmental stress (Liao et al., 2022). L-

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.foodchem.2025.145972
Received 14 January 2025; Received in revised form 17 July 2025; Accepted 13 August 2025
Available online 16 August 2025
0308-8146/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

22. Sun X, Ma G, Hai D, et al. A comprehensive story of pea peptides and pea polyphenols: Research status, existing problems, and development trends[J]. Food Chemistry, 2025, 495: 146428.

Food Chemistry 495 (2025) 146428

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Review

A comprehensive story of pea peptides and pea polyphenols: Research status, existing problems, and development trends

Xinyu Sun [a,b,1], Guocong Ma [a,1], Dan Hai [a], Ge Bai [a], Qi Guo [a], Tianlin Wang [a], Xianqing Huang [a], Lianjun Song [a,*]

[a] College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, Henan, China
[b] Postdoctoral station of Crop science, College of Agronomy, Henan Agricultural University, Zhengzhou 450046, China

ARTICLE INFO

Keywords:
Pea peptides
Pea polyphenols
Functional activity
Delivery system
Future directions

ABSTRACT

Pea peptides and pea polyphenols have gained much attention for their potential nutrition and health benefits, such as antibacterial, antioxidant, anti-inflammatory and hypoglycemic, showing great application potential in developing functional and healthy food. This paper provides a comprehensive review of the preparation technologies, bioactive activities and potential application fields, describing the research status, existing problems and development trends of pea peptides and pea polyphenols. Besides, the antioxidant, antibacterial, antidiabetic, and blood pressure lowering activities of pea peptides, as well as the current research status of delivery systems were mainly summarized and discussed. Additionally, the combination of pea peptides/polyphenols with other nutrients to develop new functional food ingredients will spark a trend in the development of plant-based nutritional health foods. This review will provide clear research ideas for further in depth research and application of pea peptides and pea polyphenols, and point out the direction for scientific researchers committed to pea research.

1. Introduction

Pea is a one-year-old herbaceous plant in the genus Pisum of Leguminosae, which is rich in proteins, carbohydrates (Zhang et al., 2020), dietary fiber (Li, Tian, et al., 2024), vitamins, polyphenols and other nutrients (Siltonen et al., 2024), and play an important role in people's daily diet and the food industry (Taylor et al., 2021). Among them, pea protein and pea polyphenols are two important nutrients in peas, each of them has unique properties and health benefits.

With the rapid rise of the plant-based market, there has been a surge in global demand for plant protein, especially pea protein, a potential sustainable protein source (Roelofs et al., 2024; Tanger et al., 2020). Compared to soy protein, pea protein has various advantages, such as the absence of lactose and cholesterol, low calorie content, lack of genetic modification concerns, relatively low bean odor and less likely to cause allergies (Fischer et al., 2020), which make it suitable for lactose intolerant individuals, those with digestive disorders and advocate vegetarianism. Compared with other plant-based proteins, such as fava bean protein and chickpea protein, pea protein has the most promising prospects for large-scale and sustainable production in terms of raw material supply, process maturity, large-scale production, and market application. According to Equinom statistics, the global pea protein market is expected to reach $2.9 billion by 2027, and the demand for alternative protein based on yellow peas is expected to exceed supply. In the Chinese market, according to CBNData (First Financial Business Data Center), the annual growth rate of pea protein in China exceeds 25 %, far higher than that of soybean protein, which has an annual growth rate of less than 10 %. From production and cultivation, to processing and application, and then to market consumption, pea protein has connected countless enterprises from many countries around the world, attempting to develop new raw materials and products with high nutritional value and market appeal, forming an emerging force that cannot be underestimated in the global plant protein industry chain. At present, pea protein raw materials are widely used in the food and beverage industry to meet consumers' growing pursuit of health and environmental sustainability. In terms of nutritional value, pea protein is a high-quality plant protein containing various essential amino acids, especially lysine that is crucial for protein synthesis and human health (Dong et al.,

* Corresponding author.
E-mail address: [redacted]
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.foodchem.2025.146428
Received 27 April 2025; Received in revised form 9 August 2025; Accepted 15 September 2025
Available online 21 September 2025
0308-8146/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

23. Zhang J, Song L, Li T, et al. Steam explosion modified pea peptides alleviates hepatosteatosis by regulating lipid metabolism pathways and promoting autophagy[J]. Food Research International, 2025, 208: 116182.

Food Research International 208 (2025) 116182

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Steam explosion modified pea peptides alleviates hepatosteatosis by regulating lipid metabolism pathways and promoting autophagy

Jingjing Zhang [a,b], Lianjun Song [a,b,*], Tiange Li [a,b,*], Li Zhu [a,b], Tianlin Wang [a,b], Peijun Zhao [a,b], Yan Ma [a,b], Jiansheng Zhao [c], Xianqing Huang [a,b]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Technology Innovation Center of Meat Processing and Research, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[c] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China

ARTICLE INFO

Keywords:
Steam explosion
Pea peptides
Nonalcoholic fatty liver disease
Lipid metabolism
Mitochondrial autophagy

ABSTRACT

Pea peptides (PP) are natural compounds with multiple biological activities. The purpose of this study was to explore the effect and mechanisms of steam explosion (SE)-modified PP on lipid metabolism *in vivo* and *in vitro*. The findings demonstrated that SE-modified PP treatment significantly inhibited lipid accumulation in HepG2 cells induced by free fatty acids (FFA). In addition, SE-modified PP treatment significantly alleviated liver index, improved biochemical parameters in high-fat diet (HFD) mice. SE-modified PP prevented lipid accumulation through regulating AMPK activity and decreased lipogenesis associated proteins (SREBP, FAS, and ACC), upregulated fatty acid oxidation proteins (PPARα, PGC1α, and CPT-1 A). Moreover, SE-modified PP alleviated hepatic oxidative stress by regulating Nrf2/HO-1 pathway, and relieved liver mitochondrial autophagy by upregulating Beclin 1 and LC3B expression. These results demonstrate that SE-modified PP alleviates NAFLD by reducing lipid accumulation, inhibiting hepatic oxidative stress, and increasing liver mitochondrial autophagy, which providing reference for the development of dietary supplements for the treatment and prevention of NAFLD.

1. Introduction

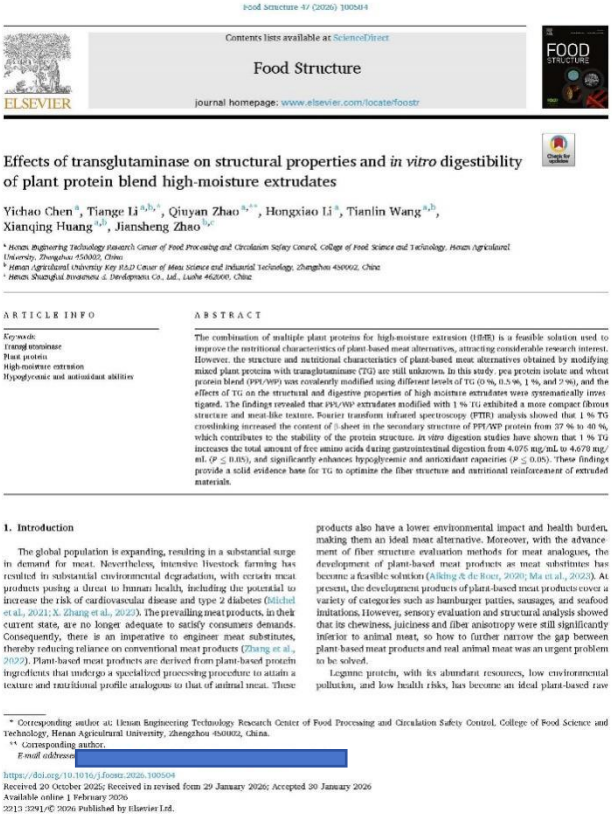
As a liver metabolism disorder, nonalcoholic fatty liver disease (NAFLD) is caused by abnormal lipid metabolism and excessive fat accumulation (Lee et al., 2023; Tandrasasmita et al., 2021). Non-alcoholic steatohepatitis (NASH) may result from NAFLD due to oxidative stress, inflammation, liver damage, fibrosis, and eventually cirrhosis (Park et al., 2022; Pham et al., 2023). Additionally, metabolic problems include obesity, insulin resistance, hyperglycemia, and hypertension are typically linked to NAFLD (Zhang, Liu, et al., 2023). Despite significant advancements in the discovery of medications for NAFLD, clinical practice pharmaceuticals may have hazardous side effect, and no specific therapeutic agent has yet been identified. Consequently, there is an emergency requirement to develop natural active substances that have highly effective and minimal negative effect on NAFLD.

The pathogenesis of NAFLD is related to lipid metabolism disorders (Wang et al., 2019). The increase in *de novo* synthesis of fatty acids, the influx of lipids into adipose tissue, and the decrease in lipolysis can induce excessive lipid deposition in liver, leading to hepatic steatosis (Heeren & Scheja, 2021). Thus, improving NALFD may benefit from reversing hepatic lipid metabolism disorders. AMP-activated protein kinase (AMPK), a member of the serine/threonine kinase family, is involved in energy status perception, energy expenditure and energy storage regulation (Wang, Zhang, Yue, et al., 2023). It is essential for preventing lipogenesis and promoting fatty acid oxidation in the liver (Liou et al., 2020). Activated AMPK can promote their downstream fatty acid oxidation targets such as carnitine palmitoyltransferase-1 A (CPT-1 A), peroxisome proliferator-activated receptor α (PPARα), and peroxisome proliferators-activated receptor-gamma coactivator (PGC)-1alpha. In addition, it can regulate lipid synthesis targets such as sterol regulatory element binding protein (SREBP), fatty acid synthase (FAS), and acetyl-CoA carboxylase (ACC) (Ipsen et al., 2018; Jang & Choi, 2022;

* Corresponding authors at: Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China.
E-mail addresses: [redacted]

https://doi.org/10.1016/j.foodres.2025.116182
Received 10 October 2024; Received in revised form 27 February 2025; Accepted 11 March 2025
Available online 14 March 2025
0963-9969/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

24. Chen Y, Li T, Zhao Q, et al. Effects of transglutaminase on structural properties and in vitro digestibility of plant protein blend high-moisture extrudates[J]. Food Structure, 2026, 47: 100504.



Food Structure 47 (2026) 100504

Contents lists available at ScienceDirect

Food Structure

journal homepage: www.elsevier.com/locate/foostr

Effects of transglutaminase on structural properties and *in vitro* digestibility of plant protein blend high-moisture extrudates

Yichao Chen [a], Tiange Li [a,b,1], Qiuyan Zhao [a,**], Hongxiao Li [a], Tianlin Wang [a,b], Xianqing Huang [a,b], Jiansheng Zhao [b,c]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Agricultural University Key R&D Center of Meat Science and Industrial Technology, Zhengzhou 450002, China
[c] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China

ARTICLE INFO

Keywords:
Transglutaminase
Plant protein
High-moisture extrusion
Hypoglycemic and antioxidant abilities

ABSTRACT

The combination of multiple plant proteins for high-moisture extrusion (HME) is a feasible solution used to improve the nutritional characteristics of plant-based meat alternatives, attracting considerable research interest. However, the structure and nutritional characteristics of plant-based meat alternatives obtained by modifying mixed plant proteins with transglutaminase (TG) are still unknown. In this study, pea protein isolate and wheat protein blend (PPI/WP) was covalently modified using different levels of TG (0 %, 0.5 %, 1 %, and 2 %), and the effects of TG on the structural and digestive properties of high moisture extrudates were systematically investigated. The findings revealed that PPI/WP extrudates modified with 1 % TG exhibited a more compact fibrous structure and meat-like texture. Fourier transform infrared spectroscopy (FTIR) analysis showed that 1 % TG crosslinking increased the content of β sheet in the secondary structure of PPI/WP protein from 37 % to 40 %, which contributes to the stability of the protein structure. *In vitro* digestion studies have shown that 1 % TG increases the total amount of free amino acids during gastrointestinal digestion from 4.075 mg/mL to 4.679 mg/mL ($P \leq 0.05$), and significantly enhances hypoglycemic and antioxidant capacities ($P \leq 0.05$). These findings provide a solid evidence base for TG to optimize the fiber structure and nutritional reinforcement of extruded materials.

1. Introduction

The global population is expanding, resulting in a substantial surge in demand for meat. Nevertheless, intensive livestock farming has resulted in substantial environmental degradation, with certain meat products posing a threat to human health, including the potential to increase the risk of cardiovascular disease and type 2 diabetes (Michel et al., 2021; X. Zhang et al., 2023). The prevailing meat products, in their current state, are no longer adequate to satisfy consumers demands. Consequently, there is an imperative to engineer meat substitutes, thereby reducing reliance on conventional meat products (Zhang et al., 2023). Plant-based meat products are derived from plant-based protein ingredients that undergo a specialized processing procedure to attain a texture and nutritional profile analogous to that of animal meat. These products also have a lower environmental impact and health burden, making them an ideal meat alternative. Moreover, with the advancement of fiber structure evaluation methods for meat analogues, the development of plant-based meat products as meat substitutes has become a feasible solution (Alkhtib & de Roos, 2026; Ma et al., 2023). At present, the development products of plant-based meat products cover a variety of categories such as hamburger patties, sausages, and seafood imitations. However, sensory evaluation and structural analysis showed that its chewiness, juiciness and fiber anisotropy were still significantly inferior to animal meat, so how to further narrow the gap between plant-based meat products and real animal meat was an urgent problem to be solved.

Legume protein, with its abundant resources, low environmental pollution, and low health risks, has become an ideal plant-based raw

* Corresponding author at: Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China.
** Corresponding author.
E-mail addresses: [redacted]

https://doi.org/10.1016/j.foostr.2026.100504
Received 20 October 2025; Received in revised form 29 January 2026; Accepted 30 January 2026
Available online 1 February 2026
2213-3291/© 2026 Published by Elsevier Ltd.

25. Sun X, Ma G, Tian X, et al. Edible starch-based films modified by fruit and vegetable juices: Preparation, performance evaluation and seasoning bag design[J]. Food Packaging and Shelf Life, 2025, 49: 101488.

Food Packaging and Shelf Life 49 (2025) 101488

Contents lists available at ScienceDirect

Food Packaging and Shelf Life

journal homepage: www.elsevier.com/locate/fpsl

Edible starch-based films modified by fruit and vegetable juices: Preparation, performance evaluation and seasoning bag design

Xinyu Sun [a,b], Guocong Ma [a], Xiaoling Tian [a], Dan Hai [a], Yan Ma [a], Ge Bai [a], Lianjun Song [a], Qinghua Yang [b], Xianqing Huang [a,b,*]

[a] College of Food Science and Technology, Henan Agricultural University, Zhengzhou, Henan 450002, China
[b] Postdoctoral Station of Crop Science, College of Agronomy, Henan Agricultural University, Zhengzhou 450046, China

ARTICLE INFO

Keywords:
Potato starch
Fruit and vegetable juices
Edible packaging films
Antioxidant ability
Seasoning bags

ABSTRACT

Edible packaging films (EPFs) currently mainly focus on the performance improvement stage, and the practical application products still need to be further developed and promoted, so as to achieve the real landing of scientific research and promote the rapid development of edible film industry. Herein, the film-forming properties of potato starch (PST), corn starch (CST) and wheat starch (WST) are investigated, and PST is selected as the film-forming matrix. Besides, 0.3 wt% sodium alginate (SA) is introduced into the film-forming matrix of PST, which improves the tensile strength (TS) and elongation at break (EAB) of the film. Further, fruit and vegetable juices are incorporated into the PST/SA film-forming matrix, endowing PST/SA-based EPFs with excellent antioxidant capacities. Finally, the packaging properties of PST/SA-based EPFs incorporated with fruit and vegetable juices are evaluated. Results reveal that the prepared EPFs have good heat-sealing performances and can be successfully used to prepare seasoning packaging bags. Therefore, this study provides a new insight for the reutilization of fruit and vegetable juices, and design a green, convenient and low-cost approach to prepare PST/SA EPFs with good visual effects, strong antioxidant abilities, and excellent packaging properties.

1. Introduction

Biopolymers based edible packaging films (EPFs) gain more and more attention for their good biodegradable and sustainable advantages, which make them eco-friendly and can be used as substitutes for parts of traditional plastic packaging materials (Huang et al., 2023; L. Li et al., 2024a, 2024b; Marangoni Junior, Vieira, Jamroz, & Anjos, 2021). EPFs refer to the film or coating material that can be eaten without damaging human health, which can be used as primary packaging, control the water activity of food, regulate the mass transfer in processed food, provide a delivery system of active/biological components, and can be used as a source of sensory attraction (Khedri et al., 2021; Ribeiro et al., 2024). Among them, EPFs produced by using polysaccharide, protein and lipids as film-forming matrix have been widely concerned by researchers (Atta et al., 2022; Marangoni Junior et al., 2021), lifting a global upsurge in the research of edible food preservation/packaging films (Mohamed, El-Sakhawy, & El-Sakhawy, 2020; Wei et al., 2024).

Due to the advantages of rich resources, low cost, easy to form film, non-toxicity, degradability and edibility, starch-based EPFs have been widely used as edible food packaging materials (H. Chen, et al., 2021; Y. Chen et al., 2019; Hashemi, Kaveh, Abedi, & Phimolsiripol, 2023; Liu et al., 2024). The film-forming properties of various starches have been studied, demonstrating the potential application of starch in the field of EPFs (Zdeck-Tryznowska & Kaluza, 2021). For instance, potato starch-based nanoparticles had been successfully fabricated and applied to improve the flexibility and barrier performance of the edible starch-based films (Q. Yang et al., 2023). A self-reinforced multifunctional starch nanocomposite film was reported and showed excellent preservation effects for litchi fruits (Yu et al., 2024). All these researches proved the popularity of starch-based EPFs, which were developed by incorporating various active components or their nano-encapsulation materials for improving the poor mechanical and active performances of pure starch films, as well as the high brittleness. Wang, Jia, Diao, Zhao, and Yang (2024) discussed in detail the advantages, preparation technologies, film-forming mechanism and performance strengthening strategies of starch-based EPFs, and comprehensively analyzed their application in the preservation of fruits and vegetables, meat products, and dairy products. Finally, they prospected the future development of

* Corresponding author at: College of Food Science and Technology, Henan Agricultural University, Zhengzhou, Henan 450002, China.
E-mail address: [redacted]

https://doi.org/10.1016/j.fpsl.2025.101488
Received 30 December 2024; Received in revised form 20 March 2025; Accepted 20 March 2025
Available online 29 March 2025
2214-2894/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

26. Ma Y, Wang N, Liu X, et al. Construction of flaxseed polyphenol nanolipid emulsions as edible coatings and their application in shelf life extension of spiced beef[J]. Food Chemistry: X, 2025, 27: 102502.

Food Chemistry: X 27 (2025) 102502

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x

Construction of flaxseed polyphenol nanolipid emulsions as edible coatings and their application in shelf life extension of spiced beef

Yan Ma [a], Nan Wang [a], Xiaoyong Liu [a], Xiangjie Ma [b], Shaohua Meng [b], Jiansheng Zhao [b], Jingjing Chen [b], Lianjun Song [a], Mingwu Qiao [a], Xianqing Huang [a,*]

[a] College of Food Science and Technology, Henan Agricultural University, Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, Zhengzhou 450002, China.
[b] Henan Shuanghui Investment Development Co., Ltd./Henan Intelligent Meat Segmentation and Biotransformation Engineering Research Center, Luohe 462005, China

ARTICLE INFO

Keywords:
Flaxseed polyphenol
Emulsion
Stability
Spiced beef
Preservation

ABSTRACT

Flaxseed polyphenols exhibited antibacterial and antioxidant properties; however, their poor solubility and stability limited their application in food products. Incorporation into nano-emulsions improved their dissolution and encapsulation. This study evaluated the stability of flaxseed polyphenol nano-emulsions, formulated with chitosan, lactoferrin, glyceryl monocaprate, and flaxseed gum (FP-CTS-FG, FP-LF-FG,FP-GM-FG), over 28 days of storage, heating at 60/80/100 °C, and freeze-thaw cycles at 20 °C. The initial zeta potentialof these three emulsions are all greater than 30 mV, and the particle sizes are less than 500 nm. Minimal changes in particle size, zeta potential, and phase behavior, along with reduced surface tension and droplet aggregation, indicated good stability. When used as a coating for spiced beef, the emulsion reduced moisture loss, inhibited microbial growth, and delayed lipid oxidation and quality deterioration. Overall, our findings provided new insights and avenues for the application of flaxseed polyphenols in the food industry.

1. Introduction

As a traditional Chinese delicacy, spiced beef possessed a long-established history and distinctive processing techniques. This culinary product was characterized by its palatable flavor profile and considerable nutritional value, while simultaneously reflecting profound cultural significance in Chinese gastronomy. Nevertheless, the moisture content of spiced beef rendered it vulnerable to microbial contamination, ultimately leading to product deterioration. This inherent characteristic significantly restricted its shelf stability and consequently hindered its preservation under conventional storage conditions (Zhang et al., 2021). Extending the shelf life of while maintaining quality stability of spiced beef presented a substantial technological challenge. Traditional preservation methods predominantly employed vacuum packaging or low-temperature storage to prolong product shelf life. Vacuum packaging implementation encountered limitations due to difficulties in recycling packaging materials and associated persistent ecological pollution concerns. Similarly, low-temperature cold storage required specialized refrigeration equipment throughout transportation and storage phases, which significantly increased operational costs. The food industry frequently utilized synthetic preservatives including sodium nitrite and potassium sorbate to inhibit microbial proliferation of both spoilage organisms and pathogenic strains. Nevertheless, epidemiological studies revealed associations between chronic exposure to such chemical additives and adverse health outcomes, particularly allergic response, gastrointestinal disorders and potential carcinogenic risks (Silva & Lidon, 2016). The development of natural, safe plant-based preservatives emerged as a research priority to mitigate quality deterioration and extend the shelf life of spiced beef during storage. Investigations demonstrated that these botanical preservatives not only exhibited strong antimicrobial efficacy but also significantly reduced food safety risks while minimizing adverse environmental impacts, thereby providing a viable preservation strategy for meat products. Plant polyphenols, characterized as secondary metabolites with multiple phenolic hydroxyl groups, were widely distributed in vegetables, fruits, legumes, and tea, demonstrating antioxidant, anticancer, anti-inflammatory, and antibacterial properties (Ding et al., 2020). Their application as natural preservatives in food systems had been extensively investigated. Wang, Chen, et al. (2024) developed a cinnamaldehyde-tea polyphenol coating that extended fresh pork shelf

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.fochx.2025.102502
Received 11 February 2025; Received in revised form 16 April 2025; Accepted 27 April 2025
Available online 28 April 2025
2590-1575/© 2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

27. Wang T, Lu M, Shen Y, et al. On-site visual detection of patulin in fruit juice via FRET ratiometric sensor utilizing portable device integrated with smartphone[J]. Journal of Food Composition and Analysis, 2025, 148: 108219.

Journal of Food Composition and Analysis 148 (2025) 108219

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

On-site visual detection of patulin in fruit juice via FRET ratiometric sensor utilizing portable device integrated with smartphone

Tianlin Wang [a], Meijun Lu [a], Yanbing Shen [a], Qinqing Han [a], Songming Wang [a], Tongyao Li [a], Tiange Li [a], Xianqing Huang [a], Libin Wan [b], Lianjun Song [a,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Academy of Science, Zhengzhou 450002, China

ARTICLE INFO

Keywords:
Ratiometric fluorescence sensor
Patulin
Portable device
Visual
On-site detection

ABSTRACT

Excessive levels of penicillin (PAT) in fruit juice pose significant risks to food safety and human health. In this study, a ratiometric fluorescence sensor with on-site visualization detection capability had been developed for PAT detection based on Förster resonance energy transfer (FRET) in this study. This strategy utilized MIL-101(Cr) with a wide absorption peak as the energy acceptor, while nitrogen/sulfur-doped graphene quantum dots (H,S-GQDs) conjugated with PAT aptamer with stable blue fluorescence serves as the energy donor, triggering the FRET effect and quenching the blue fluorescence. When exposed to PAT, the aptamer preferentially binded to PAT, separating the donor and acceptor, thereby interrupting the FRET effect and recovering the blue fluorescence. Assisted by the red internal reference fluorescence of gold clusters (AuNCs), the fluorescence changes were observed from red to blue with the concentration range of 0.01–300 ng/mL of PAT and a low limit of detection at 3.29 pg/mL. More importantly, a portable detection device integrated with smartphone was designed for on-site visual PAT detection with satisfactory results. This strategy could provide new opportunities for on-site qualitative and quantitative detection of PAT in actual foods.

1. Introduction

Mycotoxins will be found in byproducts such as fruits and juices during growth, harvesting, storage, transportation, and processing. Patulin (PAT) is one of the most frequent natural poisons, having initially been discovered in rotting apples and apple juice and later appearing in all kinds of moldy fruits (Yao et al., 2024; Zhang et al., 2024). Spreading patulin primarily causes pathological alterations in the kidney, liver, and gastrointestinal tract, as well as irreversible damage such as carcinogenesis, teratogenesis, and mutagenesis (Tao et al., 2024). PAT has been classified as a Class 3 carcinogen (Zhang et al., 2025). The issue of food safety stemming from PAT contamination has raised significant concerns. To mitigate the risks associated with mycotoxins, international regulations have set maximum permissible limits for PAT in both raw materials and processed foods. The European Union (EU) has set a threshold of 10 μg/kg for PAT in infant food (Xue et al., 2024), while China's national food safety regulations restrict PAT residues in fruits to approximately 50 μg/kg (Ma et al., 2024).

Analysis and detection procedures are critical instruments for regulators in ensuring food safety. Currently, a lot of work has been done to evaluate the level of PAT in food, chromatography methods such as thin layer chromatography (Kharandi et al., 2013), gas chromatography-mass spectrometry (Rodríguez-Carrasco et al., 2014), and high performance liquid chromatography (Alavian et al., 2024), immunoassay methods such as surface plasmon resonance methods (Liu et al., 2024), enzyme-linked immunosorbent assay (Przybylska et al., 2021) and molecular imprinted polymers (Zhu et al., 2020). The aforementioned techniques offer the benefits of excellent detection and high accuracy, but their disadvantages include long sample preparation time, high cost, and low reproducibility (Qin et al., 2024a). Therefore, it is crucial to create a sensitive, stable, and inexpensive procedure that yields the same outcomes.

Aptamers are single-stranded DNA sequences that can be easy to modify and bound to targets with high affinity by shape complementation. They are produced by systematic evolution of ligands by exponential enrichment (SELEX) through the evolution of the ligand system

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.jfca.2025.108219
Received 4 July 2025; Received in revised form 5 August 2025; Accepted 19 August 2025
Available online 19 August 2025
0889-1575/© 2025 Published by Elsevier Inc.

28. Wang T, Lin X, Wenjie L, et al. Resveratrol-embedded hollow cerium oxide nanomedicine targeted treat inflammatory bowel disease through ROS clearance, intestinal mucosal immune homeostasis recovery and gut microbiota modulation[J]. Materials Today Bio, 2026, 36: 102765.

Materials Today Bio 36 (2026) 102765

Contents lists available at ScienceDirect

Materials Today Bio

journal homepage: www.journals.elsevier.com/materials-today-bio

Resveratrol-embedded hollow cerium oxide nanomedicine targeted treat inflammatory bowel disease through ROS clearance, intestinal mucosal immune homeostasis recovery and gut microbiota modulation

Tianlin Wang [a], Xiaoxia Lin [a], Wenjie Li [b], Xing Li [b], Xiaodong Lin [c], Ning Li [a], Yan Ma [a], Lianjun Song [a], Xianqing Huang [a], Tiange Li [a,*]

[a] College of Food Science and Technology, Henan Agricultural University, Zhengzhou, 450002, China
[b] College of Public Health, Zhengzhou University, Zhengzhou, 450000, China
[c] Department of Bioengineering, University of California, Riverside, CA, 92521, United States

ARTICLE INFO

Keywords:
Inflammatory bowel disease
Resveratrol-embedded hollow cerium oxide
ROS-Inflammation clearance
Intestinal mucosal immune homeostasis recovery
Gut microbiota modulation

ABSTRACT

Inflammatory bowel disease (IBD) is a chronic inflammatory disorder of the gastrointestinal tract that is difficult to cure. The crucial pathogenic factors of IBD are mainly caused by the overexpression of pro-inflammatory cytokines and the disturbance of gut microbiota triggered by excessive reactive oxygen species (ROS). Herein, the resveratrol-embedded hollow cerium oxide composite nanomaterials with surface modified hyaluronic acid (Res-CeO_2@HA) is developed to restore intestinal mucosal immune homeostasis and modulate gut microbiota via effective elimination of ROS-inflammation. The synthetic nanomedicine integrates the enzyme-like activity of CeO_2, the antioxidant properties of Res, and the targeting capabilities of HA. Results showed that Res-CeO_2@HA had significant advantages in ROS clearance and colon targeting. And it balanced the expression of inflammatory cytokines by inhibiting M1 macrophage polarization, promoting M2 macrophage polarization, and modulating the TLR4/NF-κB signaling pathway to alleviate IBD in mice. Furthermore, it is found that Res-CeO_2@HA significantly improved the homeostasis of the intestinal microbiota. This friendly and multifunctional nanomedicine may provide new strategies for the clinical treatment of IBD.

1. Introduction

Inflammatory bowel disease (IBD) is a chronic intestinal inflammatory disease that includes two subtypes: ulcerative colitis (UC) and Crohn's disease (CD). It is prone to recurrence and cannot be completely cured. IBD has a significant impact on physical health, as evidenced by its alarming clinical symptoms such as weight loss, abdominal pain, bloody stools, and the potential development of colon cancer [1–3]. The conventional treatment method is to use antibiotics and immunosuppressants for clinical intervention. However, frequent and prolonged use of medication can lead to multiple complications, including autoimmune disorders, liver damage, and malignant tumors [4,5]. Therefore, developing effective and safe IBD treatment strategies is highly anticipated.

Although the pathogenesis of IBD remains unclear, mounting evidence indicates that excessive production of ROS is one of the significant etiological factors in the pathogenesis of IBD. Excessive ROS originating from gastrointestinal mucosal cells can trigger inflammatory responses, resulting in excessive secretion of pro-inflammatory cytokines [6,7]. One of the molecular mechanisms involves the sustained activation of NF-κB, which is induced by excessive ROS. This causes the release of increased cytokines to further activate NF-κB, thus inducing an inflammation cascade and ultimately forming a positive feedback loop regulation mode of "inflammation-NF-κB-inflammation" [8,9]. Furthermore, excessive stimulation of pro-inflammatory cytokines activates immune cells, including macrophages and neutrophils, which is accompanied by impaired intestinal barrier function and symptoms of intestinal microbiota imbalance [10,11]. Therefore, developing promising strategies capable of effectively restoring intestinal mucosal immune homeostasis and regulating intestinal microbiota by eliminating ROS-inflammation responses holds immense practical significance for the clinical treatment of IBD [12,13].

Recently, many treatment strategies have been proposed to address the complex interaction between ROS and inflammatory response.

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.mtbio.2026.102765
Received 23 July 2025; Received in revised form 27 December 2025; Accepted 4 January 2026
Available online 7 January 2026
2590-0064/© 2026 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

29. Chen S, Li T, Zhao P, et al. Stachyose alleviates high-fat diet-induced obesity via browning of white adipose tissue and modulation of gut microbiota[J]. Current Research in Food Science, 2025, 10: 101081.

Current Research in Food Science 10 (2025) 101081

Contents lists available at ScienceDirect

Current Research in Food Science

journal homepage: www.sciencedirect.com/journal/current-research-in-food-science

Stachyose alleviates high-fat diet-induced obesity via browning of white adipose tissue and modulation of gut microbiota

Siru Chen , Tiange Li , Peijun Zhao , Puye Liang , Xianqing Huang , Lianjun Song , Tianlin Wang *

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

ARTICLE INFO

Handling Editor: Dr. Yeonhwa Park

Keywords:
Stachyose
Obesity
UCP1
Browning of white adipose tissue
Gut microbiota

ABSTRACT

Obesity is closely associated with cardiovascular disease, type 2 diabetes, and other long-term health complications. The indication of browning in white adipose tissue (WAT) has emerged as a promising strategy to combat obesity. This study investigates the effect of stachyose (STA) on WAT browning in mice fed a high-fat diet (HFD). Our findings demonstrated that STA significantly inhibited body weight gain, improved glucose tolerance, and reduced serum levels of inflammatory biomarkers in HFD-induced overweight mice. STA administration promoted WAT browning and enhanced brown adipose tissue activity, as evidenced by increased protein levels of uncoupling protein 1 and other browning markers. Additionally, STA treatment modulated gut microbiota composition, regulated hepatic bile acids levels, and maintained intestinal barrier integrity. These results suggest that STA alleviates obesity by inducing WAT browning and modulating gut microbiota.

1. Introduction

Obesity has become a global public health concern. According to data from the World Health Organization in 2022, one in eight individuals worldwide is classified as obese (body mass index (BMI) ≥ 30) (Blüher et al., 2023). Pathological fat accumulation in the body increases the risk of various chronic conditions, including type 2 diabetes, cardiovascular disease, hypertension, asthma, depression, and several types of cancer (Gudzune and Kushner, 2024). Therefore, effective prevention and management strategies for obesity are urgently needed in modern society.

Adipose tissue plays a multifaceted role in human physiology. The white adipose tissue (WAT), primarily located subcutaneously, serves as an energy reservoir and functions as an endocrine organ that regulates numerous physiological processes (Z. Li et al., 2024). Brown adipose tissue (BAT), mainly found in the supraclavicular region, is involved in thermoregulation and energy balance through adaptive thermogenesis (Jurado-Fasoli et al., 2024). BAT cells are characterized by high expression of uncoupling protein 1 (UCP1) in the mitochondria (T. Wang et al., 2024), enabling efficient fat oxidation (Lu et al., 2024). Besides white and brown adipocytes, a third type—beige (or brite) adipocytes—has been identified. While brown adipocytes develop during embryogenesis, beige adipocytes emerge postnatally within WAT depots (Scheja and Heeren, 2016). Although differing in origin and distribution, both brown and beige adipocytes exhibit similar metabolic and morphological features, including multilocular lipid droplets, numerous mitochondria, and elevated UCP1 expression (Wen et al., 2024). The selective activiation of beige adipocytes in WAT, triggered by cold exposure, dietary components, hormones, and various genetic and pharmacological interventions, is known as "browning" (Cheong and Xu, 2021). Promoting BAT activation and WAT browning is thus considered a promising therapeutic strategy for obesity.

Prebiotics are compounds, including polysaccharides, oligosaccharides, and polyphenols, that are indigestible by the host but can enhance the growth and activity of beneficial gut microbiota (Y. Li et al., 2024). Recent studies have suggested that prebiotics may reduce obesity by enhancing thermogenesis in both WAT and BAT (Vallianou et al., 2020). Functional oligosaccharides, including chitosan oligosaccharide (COS) and 2′-fucosyllactose (2′-FL), have been shown to stimulate the formation of beige adipocytes and activate BAT through the modulation of gut microbiota and bile acid (BA) metabolism (Chen et al., 2023; Tiange Li et al., 2024; Lun et al., 2023; J. Wang et al., 2019). Stachyose (STA), a naturally occurring water-soluble tetrasaccharide found in plants, exhibits high stability and water solubility. It possesses various physiological benefits such as immune regulation, gut microbiota modulation, metabolism promotion, and neuroprotection (Ta et al., 2024). Studies have shown that STA can effectively reduce body weight, attenuate WAT expansion, and alleviate hyperlipidemia in HFD-fed mice (Ting Li et al.,

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.crfs.2025.101081
Received 23 February 2025; Received in revised form 13 May 2025; Accepted 13 May 2025
Available online 14 May 2025
2665-9271/© 2025 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

30. Yang H, Wang F, Zhao P, et al. Black soybean peptide mediates the AMPK/SIRT1/NF-κB signaling pathway to alleviate Alzheimer's-related neuroinflammation in lead-exposed HT22 cells[J]. International Journal of Biological Macromolecules, 2025, 286: 138404.

International Journal of Biological Macromolecules 286 (2025) 138404

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

Black soybean peptide mediates the AMPK/SIRT1/NF-κB signaling pathway to alleviate Alzheimer's-related neuroinflammation in lead-exposed HT22 cells

Huijie Yang [a], Fangyu Wang [b], Peijun Zhao [a], Saif Ullah [a], Yan Ma [a], Guangshan Zhao [a], Yongxia Cheng [a], Qian Li [a], Tiange Li [a], Mingwu Qiao [a], Lianjun Song [a], Lei Zhang [a], Gianni Galaverna [c], Xianqing Huang [a,*], Ning Li [a,*]

[a] College of Food Science and Technology, Henan Agricultural University, 63#Agricultural Road, 450000 Zhengzhou, China
[b] Key Laboratory for Animal Immunology, Henan Academy of Agricultural Sciences, 116#Huayuan Road, 450002 Zhengzhou, China
[c] Food and Drug Department, University of Parma, Parco Area delle Scienze, 17/a, 43124 Parma, Italy

ARTICLE INFO

Keywords:
Black soybean peptide
Lead (Pb)
Alzheimer's disease
Neuroinflammation
AMPK/SIRT1/NF-κB pathway

ABSTRACT

Alzheimer's disease (AD) is a neurodegenerative disorder characterized by hyperphosphorylation of tau, neuroinflammation, and amyloid-beta (Aβ) plaques. Lead (Pb) exposure has been linked to an increased risk of AD and neuroinflammation. The purpose of this study is to determine if black soybean peptide (BSP1) may reduce neuroinflammation caused by Pb and associated AD-like pathology. Pb exposure was given to mouse hippocampus HT22 cells in the presence or absence of BSP1, positive control resveratrol (Rsv), or the SIRT1 inhibitor EX-527. Our findings suggest that BSP1 downregulates the expression of beta-secretase (BACE1) and amyloid precursor protein (APP), inhibits tau phosphorylation, and reduces Aβ1–42 deposition. In addition, BSP1 effectively alleviated Pb-induced neuroinflammation by reducing the phosphorylation of NF-κB and the expression of pro-inflammatory cytokines (IL-1β, TNF-α, NLRP3, and IL-18). BSP1 provides neuroprotective effect via phosphorylating LKB1 and AMPK, inhibiting mTOR signaling, and activating the AMPK/SIRT1 pathway. These results suggest that BSP1 may be therapeutically beneficial for preventing or treating AD by reducing Pb-induced neuroinflammation.

1. Introduction

The clinical pathogenesis of Alzheimer's disease (AD), an irreversible degenerative condition of the central nervous system, is still unclear. It is impacted by numerous intricate genetic and environmental variables. The two main pathogenic hallmarks are abnormal tau protein phosphorylation, which collects into neurofibrillary tangles and eliminates cholinergic neurons, ultimately leading to neuronal loss, and amyloid-beta (Aβ) accumulation, which results in the formation of senile plaques [1]. Aβ is generated by the subsequent cleavage of amyloid precursor protein (APP) by γ-secretase and β-site amyloid precursor protein cleaving enzyme 1 (BACE1). One of the main causes of neuronal degeneration and a contributing factor to the pathophysiology of neurodegenerative disease such as AD is an imbalance between the synthesis and clearance of Aβ [2]. Consequently, improving Aβ clearance is a viable approach to both treating and preventing AD. A common environmental contaminant, lead (Pb) is known to harm the central nervous system, endangering human health and increasing the development of AD and other dementias [3]. Several studies have shown that Pb exposure increases the development of AD, enhances neuroinflammation, and inhibits the clearance of Aβ, increasing Aβ deposition and amyloid plaque formation in the brain [4].

Neuroinflammation describes the central nervous system's (CNS) persistent inflammatory response. It is essential to the development of AD. Important inflammatory pathways include the NOD-like receptor protein 3 (NLRP3) inflammasome axis and the nuclear factor kappa B (NF-κB) signaling network [5]. Cells release NF-κB into the nucleus in response to either internal or external stimuli. It attaches itself to particular DNA sequences and controls the synthesis of pro-inflammatory cytokines like interleukin-1β (IL-1β) and tumor necrosis factor-α (TNF-α) [6]. NLRP3 detects a range of threat indicators. When Caspase-1 is activated, mature IL-1β and IL-18 are released and cleaved,

* Corresponding authors.
E-mail addresses: [redacted]

https://doi.org/10.1016/j.ijbiomac.2024.138404
Received 22 October 2024; Received in revised form 26 November 2024; Accepted 3 December 2024
Available online 4 December 2024
0141-8130/© 2024 Elsevier B.V. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

31. Lu M, Wang T, Li T, et al. Aptamer based ratiometric determination of DON by exploiting the FRET between carbon dots and graphene oxide[J]. Journal of Food Composition and Analysis, 2025, 141: 107384.

Journal of Food Composition and Analysis 141 (2025) 107384

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

Aptamer based ratiometric determination of DON by exploiting the FRET between carbon dots and graphene oxide

Meijun Lu [a], Tianlin Wang [a], Tiange Li [a], Yan Ma [a], Xianqing Huang [a], Libin Wan [b], Fayun Wang [b], Lianjun Song [a,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Academy of Sciences, Zhengzhou 450002, China

ARTICLE INFO

Keywords:
Fluorescence resonance energy transfer
Aptasensor
Ratiometric
Deoxynivalenol

ABSTRACT

A ratiometric aptasensor for deoxynivalenol (DON) detection was developed based on FRET between graphene oxide (GO) and carbon dots. Blue carbon dots, functionalized with aptamers, act as energy donors, while GO functions as the energy acceptor. In the absence of DON, the addition of GO quenches the fluorescence of the blue carbon dots, while the fluorescence of red carbon dots, used as internal reference signals, remains unchanged. When DON is introduced, the aptamer selectively binds to the target, increasing the distance between the donor and acceptor, disrupting FRET, and gradually restoring the blue fluorescence. The sensor demonstrated a strong linear relationship within the concentration range of 0.05–200 ng/mL of DON, with a detection limit of 14.7 pg/mL. The superior analytical performance and high sensitivity indicate the potential of the sensor for DON detection in real sample matrices.

1. Introduction

Deoxynivalenol (DON), a harmful secondary metabolite, is also referred to as vomitoxin due to its ability to cause vomiting. It is mainly produced by *Fusarium oxysporum* and *Fusarium graminearum* (Yu et al., 2023a; Zhao et al., 2022). DON poses significant health risks to both humans and animals because of its thermal stability and toxicity, which remain intact even after standard food processing and cooking methods (Hao et al., 2023; Zhou et al., 2023). DON is commonly present in cereal products such as corn, wheat, and oats. Prolonged exposure to DON can lead to adverse effects, including anorexia, immunotoxicity, reproductive toxicity, and inhibition of protein synthesis (Shu et al., 2023; Yu et al., 2023b). Traditional DON detection methods, such as high-performance liquid chromatography (HPLC) (Shen et al., 2024), liquid chromatography tandem mass spectrometry (LC-MS) (Kim et al., 2016), and thin layer chromatography (TLC) (Kappenberg and Jurascheck, 2021), offer high accuracy and a broad detection range, but they require extensive sample preparation and analysis time (Rocha et al., 2017). Enzyme-linked immunosorbent assay (ELISA) provides a faster response, simpler operation, and no complex sample pretreatment (Qin et al., 2021), but it may suffer from false positives, non-specific reactions, and the need for expensive antibodies with strict storage conditions (Wu et al., 2021; Zhang et al., 2021). Hence, there is a need for a simple, sensitive, rapid, and precise method for detecting DON.

The fluorescent assay, valued for its speed, sensitivity, simplicity, and ability for on-site detection, has become widely used in biological diagnostics (Peng et al., 2023), environmental monitoring (Yan et al., 2017), and food safety (Li et al., 2022). Aptamers are single-stranded RNA or DNA molecules that are selected from a random oligonucleotide library through the use of the systematic evolution of ligands by exponential enrichment (SELEX) method. Aptamers are single-stranded RNA or DNA molecules selected from a random oligonucleotide library through the systematic evolution of ligands by exponential enrichment (SELEX) process. In fluorescence detection, short, chemically synthesized oligonucleotides are typically chosen to ensure efficient and effective interaction with target molecules (Zhang et al., 2024). Furthermore, aptamers have low molecular weight, simple change of functional groups, and good environmental tolerance (Chen et al., 2024a; 2024b; Guo et al., 2024). These characteristics have made aptamers popular as recognition probes in the development of biosensors for fluorescence-based assays.

Fluorescence Resonance Energy Transfer (FRET) is a non-radiative

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.jfca.2025.107384
Received 10 November 2024; Received in revised form 12 February 2025; Accepted 17 February 2025
Available online 18 February 2025
0889-1575/© 2025 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

32. Ma Y, Liu X, Sun H, et al. Preparation of flaxseed oil nanoemulsion and its effect on oxidation stability of flaxseed oil and prediction of shelf life[J]. LWT – Food Science and Technology, 2025, 217: 117404.

LWT - Food Science and Technology 217 (2025) 117404

Contents lists available at ScienceDirect

LWT

journal homepage: www.elsevier.com/locate/lwt

Preparation of flaxseed oil nanoemulsion and its effect on oxidation stability of flaxseed oil and prediction of shelf life

Yan Ma, Xiaoyong Liu, Hongtao Sun, Yinping Wang, Ge Bai, Qi Guo, Siyu Xiao, Yishan Peng, Lianjun Song, Mingwu Qiao, Xianqing Huang *

College of Food Science and Technology, Henan Agricultural University, Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, Zhengzhou, 450002, China

ARTICLE INFO

Keywords:
Flaxseed oil
Nanoemulsion
Storage conditions
Oxidation stability
Shelf life

ABSTRACT

In this study, the effect of nanoemulsion on oxidation stability and shelf life prediction of flaxseed oil were studied. Firstly, flaxseed oil nanoemulsion was prepared by using high-pressure microfluidization technique. Then, the oxidative stability of flaxseed oil and flaxseed oil nanoemulsions was investigated under different storage materials, illumination conditions and storage temperatures. The oxidation index of flaxseed oil was measured by accelerated oxidation test, and the shelf life model was established according to Arrhenius equation. Results showed that the flaxseed oil and its nanoemulsion were suitable for storage in low temperature, dark conditions and ceramic containers. Under various conditions, the oxidation stability of flaxseed oil was significantly improved by nanoemulsion encapsulation system, and the peroxide value (POV) and thiobarbiturate value (TBARs) of flaxseed oil nanoemulsion were significantly lower than those of flaxseed oil. The shelf life of flaxseed oil was significantly prolonged by the nanoemulsion system. The shelf life of flaxseed oil was 35, 33, 27 days at 20 °C, 25 °C, 30 °C, while that of flaxseed oil nanoemulsion was 55, 48, 42 days, respectively. The results provided a reference for improving the oxidation stability of flaxseed oil.

1. Introduction

Flaxseed oil is rich in polyunsaturated fatty acids, especially α-linolenic acid (Derbyshire, 2018). As an essential fatty acid, α-linolenic acid has been shown to play an important role in promoting brain development, preventing cardiovascular disease, regulating blood lipids, and inhibiting tumor (D'Eliseo & Velotti, 2016; Goyal et al., 2014; Nasirpour-Tabrizi et al., 2020). In addition, flaxseed oil also contains active ingredients such as lipids, lignans, proteins, dietary fiber, and micronutrients, which has a variety of bioactive functions. In recent years, flaxseed oil has become increasingly popular, and it is recognized that adding functional lipids containing omega-3 fatty acids to food is a strategy to improve the nutritional status of food (Almasi et al., 2021). However, flaxseed oil is easily oxidized by external factors during processing or preservation (Laye et al., 2018). This is mainly due to the fact that unsaturated fatty acids have multiple double bonds, which are easy to be oxidized to form unstable hydroperoxides, and further oxidized to produce short carbon chain ketones, aldehydes and acids, etc., resulting in oxidative acid reaction (Yadav et al., 2018). This destroys the flavor of flaxseed oil, leading to loss of nutrients and biological activity, and even formation of potentially toxic compounds (Shahidi & Zhong, 2010), limiting the application and development of flaxseed oil in the food industry. In order to ensure good food quality of flaxseed oil, it is necessary to explore how to improve its oxidation stability to extend shelf life and ensure food safety.

At present, the improvement of oxidation stability of flaxseed oil is mainly divided into two categories: adding antioxidants and nanoemulsion embedding. The addition of antioxidants is a common method to prevent oil oxidation. The commonly used synthetic antioxidants are petroleum centred antioxidants which comprises of butylated hydroxytoluene, butylated hydroxyanisole, and tert-butylhydroquinone (Neha et al., 2019). Synthetic antioxidants are considered powerful antioxidants that prevented food from spoiling, but their effects on human health are also controversial (Liu et al., 2016). Nanoemulsion is an important form of oil in food (Liu et al., 2023), and the nanoemulsion embedding system provides a promising way to solve the poor oxidation stability of flaxseed oil. In recent years, researchers have tried to develop effective encapsulation systems to improve the problems of poor

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.lwt.2025.117404
Received 30 May 2024; Received in revised form 9 October 2024; Accepted 18 January 2025
Available online 27 January 2025
0023-6438/© 2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

33. Li T, Guo G, Lu M, et al. A fluorescence and colorimetric dual-mode sensor based on the aptamer-adsorbed hollow cerium oxide for sensitive and visual detection of Aflatoxin B_1 in food[J]. Microchemical Journal, 2025, 208: 112387.

Microchemical Journal 208 (2025) 112387

Contents lists available at ScienceDirect

Microchemical Journal

journal homepage: www.elsevier.com/locate/microc

A fluorescence and colorimetric dual-mode sensor based on the aptamer-adsorbed hollow cerium oxide for sensitive and visual detection of Aflatoxin B_1 in food

Tiange Li [a], Ge Guo [a], Meijun Lu [a], Puye Liang [a], Yan Ma [a], Lianjun Song [a], Xianqing Huang [a], Jiansheng Zhao [b], Tianlin Wang [a,*]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China

ARTICLE INFO

Keywords:
Fluorescence and colorimetric
Dual-mode
Aflatoxin B_1
Aptamer
Hollow cerium oxide

ABSTRACT

A sensor capable of dual-mode operation was developed to detect Aflatoxin B_1 (AFB_1) through the concurrent alterations in fluorescence and colorimetric signals. The AFB_1 aptamer modified with Cy5 (Cy5-Apt) was adsorbed on the surface of hollow cerium oxide ($HCeO_2$) to form Cy5-Apt@$HCeO_2$ sensor. The fluorescence of Cy5 was extinguished, whereas the peroxidase-like activity of $HCeO_2$ was amplified, enabling it to catalyze the reaction between TMB and H_2O_2, resulting in a profound blue coloration. Once exposed to AFB_1, the strong binding occurred between AFB_1 and aptamer induced the separation of Cy5-Apt from the $HCeO_2$ surface, resulting in the recovery of Cy5-Apt fluorescence and the decrease of $HCeO_2$ peroxidase-like activity. The sensor exhibited two linear ranges of 0.02–175 ng/mL and 0.05–650 ng/mL. The limit of detection was calculated as 3.39 pg/mL and 10.74 pg/mL, respectively. The mutual verification of the sensor can ensure the reliability and accuracy of AFB_1 detection in food.

1. Introduction

Aflatoxins (AFs) are a group of compounds sharing analogous chemical structures, all of which are derivatives of dihydrofuran coumarins. AFs are the secondary metabolite primarily produced by *Aspergillus flavus*, which parasitizes *Aspergillus*, and most likely to be found in food and feed in areas with high humidity and heat [1,2]. They are prone to contaminating agricultural products such as peanuts and wheat [3,4]. Currently, more than 20 types of AFs and their derivatives have been isolated (B, G, M, and Q). Among them, aflatoxin B_1 (AFB_1) is considered to be the most toxic and severely polluting toxin in food due to the huge risks in carcinogenic, hepatotoxic, mutagenic, and teratogenic [5,6]. As a result, AFB_1 has been designated as a Group 1 substance by the International Agency for Research on Cancer [7].

Government departments of most countries also have established their own maximum levels for AFB_1 detection in food. For example, the National Food Safety Standard of China restricts the concentration of AFB_1 in cereals to a maximum of 5 μg/kg. European Union (EU) requires that the AFB_1 in peanuts and milk should not exceed 2 μg/kg and 0.05 μg/kg, respectively. Hence, developing precise and dependable techniques for detecting AFB_1 are imperative to guarantee the quality of food. For a long time, the detection methods depend on large-scale instruments are used to detect AFB_1, including high performance liquid chromatography (HPLC) [8], thin layer chromatography (TLC) [9] and liquid chromatography mass spectrometry (LC-MS) [10]. These methods exhibit great advantages in detection accuracy and sensitivity, which have been designated as official testing methods by many countries. However, expensive instruments, complex operations, and the need for professional technicians are the main factors hindering the methods in practical rapid detection. Although the enzyme-linked immunosorbent assay (ELISA) has addressed most challenges. The complexity and instability of antibody preparation remain two major obstacles in practical applications for ELISA [11,12]. Up to now, fluorescence and colorimetric methods have garnered significant attention in the detection of AFB_1 due to their appealing advantages in rapid response, ease to operation and low cost. The responses of colorimetric signals are based on the color changes of the catalyzed substrates [13,14]. And the responses of fluorescence signals are owing to the changes in fluorescence

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.microc.2024.112387
Received 25 September 2024; Received in revised form 2 December 2024; Accepted 4 December 2024
Available online 6 December 2024
0026-265X/© 2024 Elsevier B.V. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

34. Ma Y, Li W, Zou X, et al. Quantitative proteomics reveals the mechanism of L-glu-induced phenolics enrichment in wheat (Triticum aestivum L.) sprouts under NaCl stress[J]. Food Chemistry, 2025, 494: 145972.

Food Chemistry 494 (2025) 145972

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Quantitative proteomics reveals the mechanism of L-glu-induced phenolics enrichment in wheat (*Triticum aestivum* L.) sprouts under NaCl stress

Yan Ma [a], Wenxin Li [a], Xuchen Zou [a], Yinping Wang [a], Guangshan Zhao [a], Haoru Yu [a], Jingjing Chen [b], Jiansheng Zhao [b], Xianqing Huang [a,*]

[a] College of Food Science and Technology, Henan Agricultural University/Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, Zhengzhou 450002, China.
[b] Henan Shuanghui Investment Development Co., Ltd./Henan Intelligent Meat Segmentation and Biotransformation Engineering Research Center, Luohe 462005, China

ARTICLE INFO

Keywords:
Quantitative proteomics
Differentially expressed proteins
Wheat sprouts
L-Glu
NaCl stress

ABSTRACT

The purpose of this study was to reveal the effect and mechanism of L-Glu treatment on the enrichment of phenolic compounds in wheat sprouts under NaCl stress. Results of data independent acquisition (DIA) proteomics analysis showed that there were 978 DAPs in NaCl compared to CK, and 3813, 202, and 3413 DAPs in L-Glu, glutamate receptor antagonist 6,7-dinitriquinoxaline-2,3-dinoe (DNQX), and L-Glu plus DNQX compared to NaCl, respectively. These DAPs were mainly related to cellular metabolism, organic matter metabolism, and polyphenol compound metabolism. Based on KEGG analysis, DAPs were mainly enriched in metabolic pathways such as photosynthesis and phenylpropanoid biosynthesis. In addition, upregulation of phenylalanine ammonia lyase and 4-coumaric acid coenzyme A ligase proteins promoted the accumulation of phenolic compounds in wheat sprouts. This study revealed the mechanism of L-Glu-induced phenolics enrichment in wheat sprouts under NaCl stress, providing a theoretical basis for the growth of wheat under adversity.

1. Introduction

Wheat (*Triticum aestivum* L.), a staple cereal crop globally, was widely cultivated and processed into various food products such as bread, biscuits, and noodles (Shamanin et al., 2022). Wheat was not only rich in nutrients such as starch, protein, fat, minerals, calcium, iron, and vitamin A, but also contained phenolic compounds, including flavonoids and phenolic acids (Wang et al., 2020). These phenolics demonstrated remarkable antioxidant properties, effectively eliminating free radicals in the body, reducing the damage of oxidative stress to cells, and showing potential positive effects in preventing chronic diseases such as cardiovascular diseases and cancer in humans (Miao et al., 2025; Zhao et al., 2024). During germination, a series of biochemical changes occurred inside wheat grains. These changes included the activation of the endogenous enzyme system and the degradation of large storage molecules into smaller molecules that were easier for the body to digest and absorb (Hareland, 2003). At the same time, the content of bioactive substances such as dietary fiber, folic acid and phenols increased significantly (Komurcu & Bilgicli, 2023). Ceccaroni et al. (2020) found that the phenolic content of germinated wheat increased by 79.8 % compared to seeds. Similarly, Chen et al. (2017) found that after four days of germination, the total phenolic content of wheat increased by 442.7 %, and the DPPH free radical scavenging rate was 6–7 times higher than that of seeds. Compared with seeds, germinated wheat was more beneficial to human body.

Salt stress posed a serious threat to crop growth and a severe environmental challenge to global agricultural productivity and food security (Fardus et al., 2021). The most active stage of life for higher plants was the germination process, during which a variety of morphological, physiological, and biochemical changes occurred (Zhao et al., 2021). The germination process was highly susceptible to environmental interference. Salt was an essential abiotic stress factor that significantly affected plant root growth and germination rate, and research has revealed that the stage of seed germination was particularly vulnerable to it (Gao et al., 2023). L-Glu was a common amino acid in plants and played a crucial role in amino acid metabolism (Qiu et al., 2020). In recent years, research has shown that L-Glu also existed as a new signal transducer in many plant physiological processes (Tsuruda & Yoshida, 2023). It was crucial for plant growth and development and enhancing response and adaptability to environmental stress (Liao et al., 2022). L-

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.foodchem.2025.145972
Received 14 January 2025; Received in revised form 17 July 2025; Accepted 13 August 2025
Available online 16 August 2025
0308-8146/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

35. Sun X, Ma G, Hai D, et al. A comprehensive story of pea peptides and pea polyphenols: Research status, existing problems, and development trends[J]. Food Chemistry, 2025, 495: 146428

Food Chemistry 495 (2025) 146428

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Review

A comprehensive story of pea peptides and pea polyphenols: Research status, existing problems, and development trends

Xinyu Sun [a,b,1], Guocong Ma [a,1], Dan Hai [a], Ge Bai [a], Qi Guo [a], Tianlin Wang [a], Xianqing Huang [a], Lianjun Song [a,*]

[a] College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, Henan, China
[b] Postdoctoral station of Crop science, College of Agronomy, Henan Agricultural University, Zhengzhou 450046, China

ARTICLE INFO

Keywords:
Pea peptides
Pea polyphenols
Functional activity
Delivery system
Future directions

ABSTRACT

Pea peptides and pea polyphenols have gained much attention for their potential nutrition and health benefits, such as antibacterial, antioxidant, anti-inflammatory and hypoglycemic, showing great application potential in developing functional and healthy food. This paper provides a comprehensive review of the preparation technologies, bioactive activities and potential application fields, describing the research status, existing problems and development trends of pea peptides and pea polyphenols. Besides, the antioxidant, antibacterial, antidiabetic, and blood pressure lowering activities of pea peptides, as well as the current research status of delivery systems were mainly summarized and discussed. Additionally, the combination of pea peptides/polyphenols with other nutrients to develop new functional food ingredients will spark a trend in the development of plant-based nutritional health foods. This review will provide clear research ideas for further in-depth research and application of pea peptides and pea polyphenols, and point out the direction for scientific researchers committed to pea research.

1. Introduction

Pea is a one-year-old herbaceous plant in the genus Pisum of Leguminosae, which is rich in proteins, carbohydrates (Zhang et al., 2020), dietary fiber (Li, Tian, et al., 2024), vitamins, polyphenols and other nutrients (Siitonen et al., 2024), and play an important role in people's daily diet and the food industry (Taylor et al., 2021). Among them, pea protein and pea polyphenols are two important nutrients in peas, each of them has unique properties and health benefits.

With the rapid rise of the plant-based market, there has been a surge in global demand for plant protein, especially pea protein, a potential sustainable protein source (Roelofs et al., 2024; Tanger et al., 2020). Compared to soy protein, pea protein has various advantages, such as the absence of lactose and cholesterol, low calorie content, lack of genetic modification concerns, relatively low bean odor and less likely to cause allergies (Fischer et al., 2020), which make it suitable for lactose intolerant individuals, those with digestive disorders and advocate vegetarianism. Compared with other plant-based proteins, such as fava bean protein and chickpea protein, pea protein has the most promising prospects for large-scale and sustainable production in terms of raw material supply, process maturity, large-scale production, and market application. According to Equinom statistics, the global pea protein market is expected to reach $2.9 billion by 2027, and the demand for alternative protein based on yellow peas is expected to exceed supply. In the Chinese market, according to CBNData (First Financial Business Data Center), the annual growth rate of pea protein in China exceeds 25 %, far higher than that of soybean protein, which has an annual growth rate of less than 10 %. From production and cultivation, to processing and application, and then to market consumption, pea protein has connected countless enterprises from many countries around the world, attempting to develop new raw materials and products with high nutritional value and market appeal, forming an emerging force that cannot be underestimated in the global plant protein industry chain. At present, pea protein raw materials are widely used in the food and beverage industry to meet consumers' growing pursuit of health and environmental sustainability. In terms of nutritional value, pea protein is a high-quality plant protein containing various essential amino acids, especially lysine that is crucial for protein synthesis and human health (Dong et al.,

* Corresponding author.
E-mail address: [redacted]
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.foodchem.2025.146428
Received 27 April 2025; Received in revised form 9 August 2025; Accepted 15 September 2025
Available online 21 September 2025
0308-8146/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

36. Zhang J, Song L, Li T, et al. Steam explosion modified pea peptides alleviates hepatosteatosis by regulating lipid metabolism pathways and promoting autophagy[J]. Food Research International, 2025, 208: 116182.

Food Research International 208 (2025) 116182

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Steam explosion modified pea peptides alleviates hepatosteatosis by regulating lipid metabolism pathways and promoting autophagy

Jingjing Zhang [a,b], Lianjun Song [a,b,*], Tiange Li [a,b,*], Li Zhu [a,b], Tianlin Wang [a,b], Peijun Zhao [a,b], Yan Ma [a,b], Jiansheng Zhao [c], Xianqing Huang [a,b]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[b] Henan Technology Innovation Center of Meat Processing and Research, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China
[c] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China

ARTICLE INFO

Keywords:
Steam explosion
Pea peptides
Nonalcoholic fatty liver disease
Lipid metabolism
Mitochondrial autophagy

ABSTRACT

Pea peptides (PP) are natural compounds with multiple biological activities. The purpose of this study was to explore the effect and mechanisms of steam explosion (SE)-modified PP on lipid metabolism in vivo and in vitro. The findings demonstrated that SE-modified PP treatment significantly inhibited lipid accumulation in HepG2 cells induced by free fatty acids (FFA). In addition, SE-modified PP treatment significantly alleviated liver index, improved biochemical parameters in high-fat diet (HFD) mice. SE-modified PP prevented lipid accumulation through regulating AMPK activity and decreased lipogenesis associated proteins (SREBP, FAS, and ACC), upregulated fatty acid oxidation proteins (PPARα, PGC1α, and CPT-1 A). Moreover, SE-modified PP alleviated hepatic oxidative stress by regulating Nrf2/HO-1 pathway, and relieved liver mitochondrial autophagy by upregulating Beclin 1 and LC3B expression. These results demonstrate that SE-modified PP alleviates NAFLD by reducing lipid accumulation, inhibiting hepatic oxidative stress, and increasing liver mitochondrial autophagy, which providing reference for the development of dietary supplements for the treatment and prevention of NAFLD.

1. Introduction

As a liver metabolism disorder, nonalcoholic fatty liver disease (NAFLD) is caused by abnormal lipid metabolism and excessive fat accumulation (Lee et al., 2023; Tandrasasmita et al., 2021). Non-alcoholic steatohepatitis (NASH) may result from NAFLD due to oxidative stress, inflammation, liver damage, fibrosis, and eventually cirrhosis (Park et al., 2022; Pham et al., 2023). Additionally, metabolic problems include obesity, insulin resistance, hyperglycemia, and hypertension are typically linked to NAFLD (Zhang, Liu, et al., 2023). Despite significant advancements in the discovery of medications for NAFLD, clinical practice pharmaceuticals may have hazardous side effect, and no specific therapeutic agent has yet been identified. Consequently, there is an emergency requirement to develop natural active substances that have highly effective and minimal negative effect on NAFLD.

The pathogenesis of NAFLD is related to lipid metabolism disorders (Wang et al., 2019). The increase in *de novo* synthesis of fatty acids, the influx of lipids into adipose tissue, and the decrease in lipolysis can induce excessive lipid deposition in liver, leading to hepatic steatosis (Heeren & Scheja, 2021). Thus, improving NALFD may benefit from reversing hepatic lipid metabolism disorders. AMP-activated protein kinase (AMPK), a member of the serine/threonine kinase family, is involved in energy status perception, energy expenditure and energy storage regulation (Wang, Zhang, Yue, et al., 2023). It is essential for preventing lipogenesis and promoting fatty acid oxidation in the liver (Lkou et al., 2020). Activated AMPK can promote their downstream fatty acid oxidation targets such as carnithe palmitoyltransferase-1 A (CPT-1 A), peroxisome proliferator-activated receptor α (PPARα), and peroxisome proliferators-activated receptor-gamma coactivator (PGC)-1alpha. In addition, it can regulate lipid synthesis targets such as sterol regulatory element binding protein (SREBP), fatty acid synthase (FAS), and acetyl-CoA carboxylase (ACC) (Ipsen et al., 2018; Jang & Choi, 2022;

* Corresponding authors at: Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China.
E-mail addresses: [redacted]

https://doi.org/10.1016/j.foodres.2025.116182
Received 10 October 2024; Received in revised form 27 February 2025; Accepted 11 March 2025
Available online 14 March 2025
0963-9969/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

37. Chen Y, Li T, Zhao Q, et al. Effects of transglutaminase on structural properties and in vitro digestibility of plant protein blend high-moisture extrudates[J]. Food Structure, 2026, 47: 100504.

Food Structure 47 (2026) 100504

Contents lists available at ScienceDirect

Food Structure

journal homepage: www.elsevier.com/locate/foostr

Effects of transglutaminase on structural properties and *in vitro* digestibility of plant protein blend high-moisture extrudates

Yichao Chen [a], Tiange Li [a,b,*], Qiuyan Zhao [a,**], Hongxiao Li [a], Tianlin Wang [a,b], Xianqing Huang [a,b], Jiansheng Zhao [b,c]

[a] Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China.
[b] Henan Agricultural University Key R&D Center of Meat Science and Industrial Technology, Zhengzhou 450002, China.
[c] Henan Shuanghui Investment & Development Co., Ltd., Luohe 462000, China.

ARTICLE INFO

Keywords:
Transglutaminase
Plant protein
High-moisture extrusion
Hypoglycemic and antioxidant abilities

ABSTRACT

The combination of multiple plant proteins for high-moisture extrusion (HME) is a feasible solution used to improve the nutritional characteristics of plant-based meat alternatives, attracting considerable research interest. However, the structure and nutritional characteristics of plant-based meat alternatives obtained by modifying mixed plant proteins with transglutaminase (TG) are still unknown. In this study, pea protein isolate and wheat protein blend (PPI/WP) was covalently modified using different levels of TG (0 %, 0.5 %, 1 %, and 2 %), and the effects of TG on the structural and digestive properties of high moisture extrudates were systematically investigated. The findings revealed that PPI/WP extrudates modified with 1 % TG exhibited a more compact fibrous structure and meat-like texture. Fourier transform infrared spectroscopy (FTIR) analysis showed that 1 % TG crosslinking increased the content of β-sheet in the secondary structure of PPI/WP protein from 37 % to 40 %, which contributes to the stability of the protein structure. *In vitro* digestion studies have shown that 1 % TG increases the total amount of free amino acids during gastrointestinal digestion from 4.075 mg/mL to 4.678 mg/mL ($P \leq 0.05$), and significantly enhances hypoglycemic and antioxidant capacities ($P \leq 0.05$). These findings provide a solid evidence base for TG to optimize the fiber structure and nutritional reinforcement of extruded materials.

1. Introduction

The global population is expanding, resulting in a substantial surge in demand for meat. Nevertheless, intensive livestock farming has resulted in substantial environmental degradation, with certain meat products posing a threat to human health, including the potential to increase the risk of cardiovascular disease and type 2 diabetes (Michel et al., 2021; X. Zhang et al., 2023). The prevailing meat products, in their current state, are no longer adequate to satisfy consumers demands. Consequently, there is an imperative to engineer meat substitutes, thereby reducing reliance on conventional meat products (Zhang et al., 2022). Plant-based meat products are derived from plant-based protein ingredients that undergo a specialized processing procedure to attain a texture and nutritional profile analogous to that of animal meat. These products also have a lower environmental impact and health burden, making them an ideal meat alternative. Moreover, with the advancement of fiber structure evaluation methods for meat analogues, the development of plant-based meat products as meat substitutes has become a feasible solution (Aiking & de Boer, 2020; Ma et al., 2023). At present, the development products of plant-based meat products cover a variety of categories such as hamburger patties, sausages, and seafood imitations, However, sensory evaluation and structural analysis showed that its chewiness, juiciness and fiber anisotropy were still significantly inferior to animal meat, so how to further narrow the gap between plant-based meat products and real animal meat was an urgent problem to be solved.

Legume protein, with its abundant resources, low environmental pollution, and low health risks, has become an ideal plant-based raw

* Corresponding author at: Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, College of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China.
** Corresponding author.
E-mail addresses: [redacted]

https://doi.org/10.1016/j.foostr.2026.100504
Received 20 October 2025; Received in revised form 29 January 2026; Accepted 30 January 2026
Available online 1 February 2026
2213-3291/© 2026 Published by Elsevier Ltd.

38. Sun X, Ma G, Tian X, et al. Edible starch-based films modified by fruit and vegetable juices: Preparation, performance evaluation and seasoning bag design[J]. Food Packaging and Shelf Life, 2025, 49: 101488.

Food Packaging and Shelf Life 49 (2025) 101488

Contents lists available at ScienceDirect

Food Packaging and Shelf Life

journal homepage: www.elsevier.com/locate/fpsl

Edible starch-based films modified by fruit and vegetable juices: Preparation, performance evaluation and seasoning bag design

Xinyu Sun [a,b], Guocong Ma [a], Xiaoling Tian [a], Dan Hai [a], Yan Ma [a], Ge Bai [a], Lianjun Song [a], Qinghua Yang [b], Xianqing Huang [a,b,*]

[a] College of Food Science and Technology, Henan Agricultural University, Zhengzhou, Henan 450002, China
[b] Postdoctoral Station of Crop Science, College of Agronomy, Henan Agricultural University, Zhengzhou 450046, China

ARTICLE INFO

Keywords:
Potato starch
Fruit and vegetable juices
Edible packaging films
Antioxidant ability
Seasoning bags

ABSTRACT

Edible packaging films (EPFs) currently mainly focus on the performance improvement stage, and the practical application products still need to be further developed and promoted, so as to achieve the real landing of scientific research and promote the rapid development of edible film industry. Herein, the film-forming properties of potato starch (PST), corn starch (CST) and wheat starch (WST) are investigated, and PST is selected as the film-forming matrix. Besides, 0.3 wt% sodium alginate (SA) is introduced into the film-forming matrix of PST, which improves the tensile strength (TS) and elongation at break (EAB) of the film. Further, fruit and vegetable juices are incorporated into the PST/SA film-forming matrix, endowing PST/SA-based EPFs with excellent antioxidant capacities. Finally, the packaging properties of PST/SA-based EPFs incorporated with fruit and vegetable juices are evaluated. Results reveal that the prepared EPFs have good heat-sealing performances and can be successfully used to prepare seasoning packaging bags. Therefore, this study provides a new insight for the reutilization of fruit and vegetable juices, and design a green, convenient and low-cost approach to prepare PST/SA EPFs with good visual effects, strong antioxidant abilities, and excellent packaging properties.

1. Introduction

Biopolymers based edible packaging films (EPFs) gain more and more attention for their good biodegradable and sustainable advantages, which make them eco-friendly and can be used as substitutes for parts of traditional plastic packaging materials (Huang et al., 2023; L. Li et al., 2024a, 2024b; Marangoni Junior, Vieira, Jamroz, & Anjos, 2021). EPFs refer to the film or coating material that can be eaten without damaging human health, which can be used as primary packaging, control the water activity of food, regulate the mass transfer in processed food, provide a delivery system of active/biological components, and can be used as a source of sensory attraction (Khedri et al., 2021; Ribeiro et al., 2024). Among them, EPFs produced by using polysaccharide, protein and lipids as film-forming matrix have been widely concerned by researchers (Atta et al., 2022; Marangoni Junior et al., 2021), lifting a global upsurge in the research of edible food preservation/packaging films (Mohamed, El-Sakhawy, & El-Sakhawy, 2020; Wei et al., 2024).

Due to the advantages of rich resources, low cost, easy to form film, non-toxicity, degradability and edibility, starch-based EPFs have been widely used as edible food packaging materials (H. Chen, et al., 2021; Y. Chen et al., 2019; Hashemi, Kaveh, Abedi, & Phimolsiripol, 2023; Liu et al., 2024). The film-forming properties of various starches have been studied, demonstrating the potential application of starch in the field of EPFs (Zolek-Tryznowska & Kaluza, 2021). For instance, potato starch-based nanoparticles had been successfully fabricated and applied to improve the flexibility and barrier performance of the edible starch-based films (Q. Yang et al., 2023). A self-reinforced multifunctional starch nanocomposite film was reported and showed excellent preservation effects for litchi fruits (Yu et al., 2024). All these researches proved the popularity of starch-based EPFs, which were developed by incorporating various active components or their nano-encapsulation materials for improving the poor mechanical and active performances of pure starch films, as well as the high brittleness. Wang, Ju, Diao, Zhao, and Yang (2024) discussed in detail the advantages, preparation technologies, film-forming mechanism and performance strengthening strategies of starch-based EPFs, and comprehensively analyzed their application in the preservation of fruits and vegetables, meat products, and dairy products. Finally, they prospected the future development of

* Corresponding author at: College of Food Science and Technology, Henan Agricultural University, Zhengzhou, Henan 450002, China.
E-mail address: [redacted]

https://doi.org/10.1016/j.fpsl.2025.101488
Received 30 December 2024; Received in revised form 20 March 2025; Accepted 20 March 2025
Available online 29 March 2025
2214-2894/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

39. Ma Y, Wang N, Liu X, et al. Construction of flaxseed polyphenol nanolipid emulsions as edible coatings and their application in shelf life extension of spiced beef[J]. Food Chemistry: X, 2025, 27: 102502.

Food Chemistry: X 27 (2025) 102502

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x

Construction of flaxseed polyphenol nanolipid emulsions as edible coatings and their application in shelf life extension of spiced beef

Yan Ma [a], Nan Wang [a], Xiaoyong Liu [a], Xiangjie Ma [b], Shaohua Meng [b], Jiansheng Zhao [b], Jingjing Chen [b], Lianjun Song [a], Mingwu Qiao [a], Xianqing Huang [a,*]

[a] College of Food Science and Technology, Henan Agricultural University, Henan Engineering Technology Research Center of Food Processing and Circulation Safety Control, Zhengzhou 450002, China.
[b] Henan Shuanghui Investment Development Co., Ltd./Henan Intelligent Meat Segmentation and Biotransformation Engineering Research Center, Luohe 462005, China.

ARTICLE INFO

Keywords:
Flaxseed polyphenol
Emulsion
Stability
Spiced beef
Preservation

ABSTRACT

Flaxseed polyphenols exhibited antibacterial and antioxidant properties; however, their poor solubility and stability limited their application in food products. Incorporation into nano-emulsions improved their dissolution and encapsulation. This study evaluated the stability of flaxseed polyphenol nano-emulsions, formulated with chitosan, lactoferrin, glyceryl monocaprate, and flaxseed gum (FP-CTS-FG, FP-LF-FG,FP-GM-FG), over 28 days of storage, heating at 60/80/100 °C, and freeze-thaw cycles at −20 °C. The initial zeta potentialof these three emulsions are all greater than 30 mV, and the particle sizes are less than 500 nm. Minimal changes in particle size, zeta potential, and phase behavior, along with reduced surface tension and droplet aggregation, indicated good stability. When used as a coating for spiced beef, the emulsion reduced moisture loss, inhibited microbial growth, and delayed lipid oxidation and quality deterioration. Overall, our findings provided new insights and avenues for the application of flaxseed polyphenols in the food industry.

1. Introduction

As a traditional Chinese delicacy, spiced beef possessed a long-established history and distinctive processing techniques. This culinary product was characterized by its palatable flavor profile and considerable nutritional value, while simultaneously reflecting profound cultural significance in Chinese gastronomy. Nevertheless, the moisture content of spiced beef rendered it vulnerable to microbial contamination, ultimately leading to product deterioration. This inherent characteristic significantly restricted its shelf stability and consequently hindered its preservation under conventional storage conditions (Zhang et al., 2021). Extending the shelf life of while maintaining quality stability of spiced beef presented a substantial technological challenge. Traditional preservation methods predominantly employed vacuum packaging or low-temperature storage to prolong product shelf life. Vacuum packaging implementation encountered limitations due to difficulties in recycling packaging materials and associated persistent ecological pollution concerns. Similarly, low-temperature cold storage required specialized refrigeration equipment throughout transportation and storage phases, which significantly increased operational costs. The food industry frequently utilized synthetic preservatives including sodium nitrite and potassium sorbate to inhibit microbial proliferation of both spoilage organisms and pathogenic strains. Nevertheless, epidemiological studies revealed associations between chronic exposure to such chemical additives and adverse health outcomes, particularly allergic response, gastrointestinal disorders and potential carcinogenic risks (Silva & Lidon, 2016). The development of natural, safe plant-based preservatives emerged as a research priority to mitigate quality deterioration and extend the shelf life of spiced beef during storage. Investigations demonstrated that these botanical preservatives not only exhibited strong antimicrobial efficacy but also significantly reduced food safety risks while minimizing adverse environmental impacts, thereby providing a viable preservation strategy for meat products. Plant polyphenols, characterized as secondary metabolites with multiple phenolic hydroxyl groups, were widely distributed in vegetables, fruits, legumes, and tea, demonstrating antioxidant, anticancer, anti-inflammatory, and antibacterial properties (Ding et al., 2020). Their application as natural preservatives in food systems had been extensively investigated. Wang, Chen, et al. (2024) developed a cinnamaldehyde-tea polyphenol coating that extended fresh pork shelf

* Corresponding author.
E-mail address: [redacted]

https://doi.org/10.1016/j.fochx.2025.102502
Received 11 February 2025; Received in revised form 16 April 2025; Accepted 27 April 2025
Available online 28 April 2025
2590-1575/© 2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

40. 林晓霞, 朱莉（本科生）, 马静怡（本科生）, 冯志强, 王田林, 赵建生, 宋莲军, 黄现青, 赵秋艳, 李天歌*（通讯作者）. 槲皮素杜仲多糖纳米颗粒的表征、抗氧化及抗炎活性[J].食品工业科技, 2025, 46(15): 126-134.

林晓霞, 朱莉, 马静怡, 等. 槲皮素杜仲多糖纳米颗粒的表征、抗氧化及抗炎活性 [J]. 食品工业科技, 2025, 46(15): 126−134. doi: 10.13386/j.issn1002-0306.2024080206

LIN Xiaoxia, ZHU Li, MA Jingyi, et al. Characterization, Antioxidant and Anti-inflammatory Activities of Quercetin-*Eucommia ulmoides* Polysaccharide Nanoparticles[J]. Science and Technology of Food Industry, 2025, 46(15): 126−134. (in Chinese with English abstract). doi: 10.13386/j.issn1002-0306.2024080206

· 研究与探讨 ·

槲皮素杜仲多糖纳米颗粒的表征、抗氧化及抗炎活性

林晓霞[1], 朱　莉[1], 马静怡[1], 冯志强[2], 王田林[1], 赵建生[3], 宋莲军[1], 黄现青[1], 赵秋艳[1], 李天歌[1,*]

(1.河南农业大学食品科学技术学院, 河南郑州 450044;
2.三全食品股份有限公司, 河南郑州 450044;
3.河南双汇投资发展股份有限公司, 河南漯河 462005)

摘　要: 本研究旨在对杜仲多糖纳米颗粒进行制备与表征, 并探究其体外抗炎活性。利用反溶剂沉淀法制备负载槲皮素的两亲性杜仲多糖纳米颗粒（QT/LA-EUP NPs）; 通过粒径、多分散指数（PDI）以及电位的测定对纳米材料的稳定性进行表征; 通过透射电镜、紫外可见光谱、傅里叶红外光谱等方法对纳米颗粒结构进行表征; 通过对 DPPH、ABTS$^+$自由基清除能力测定对材料的抗氧化能力进行检测; 通过建立脂多糖（Lipopolysaccharide, LPS）诱导的 RAW264.7 巨噬细胞炎症模型对纳米颗粒的抗炎活性进行检测。结果表明, LA-EUP NPs 对槲皮素的包封率达到了 70.4%±2.4%, 负载率为 5.6%±0.2%; 在不同的 pH 和储藏时间条件下对纳米颗粒粒径及 PDI 几乎没有影响, 且在不同浓度谷胱甘肽刺激下, 槲皮素释放率随浓度增大而增加。对 DPPH、ABTS$^+$自由基清除能力测定显示, 在一定浓度范围下, QT/LA-EUP NPs 具备良好的抗氧化能力。此外, QT/LA-EUP NPs 能明显缓解 LPS 造成的 RAW264.7 巨噬细胞活力下降并抑制了一氧化氮（NO）的生成。本研究成功制备出稳定性较好的 QT/LA-EUP NPs, 其具有良好的抗氧化活性, 并能够减轻 LPS 诱导的炎症细胞损伤, 可望用于食品功能因子纳米运载体系。

关键词: 杜仲多糖, 槲皮素, 纳米颗粒, 抗氧化活性, 抗炎活性
中图分类号: TS201.2; TS201.4　　**文献标识码:** A　　**文章编号:** 1002−0306(2025)15−0126−09
DOI: 10.13386/j.issn1002-0306.2024080206
本文网刊:

Characterization, Antioxidant and Anti-inflammatory Activities of Quercetin-*Eucommia ulmoides* Polysaccharide Nanoparticles

LIN Xiaoxia[1], ZHU Li[1], MA Jingyi[1], FENG Zhiqiang[2], WANG Tianlin[1], ZHAO Jiansheng[3], SONG Lianjun[1], HUANG Xianqing[1], ZHAO Qiuyan[1], LI Tiange[1,*]

(1.School of Food Science and Technology, Henan Agricultural University, Zhengzhou 450044, China;
2.Sanquan Foods Co., Ltd., Zhengzhou 450044, China;
3.Henan Shuanghui Investment Development Co., Ltd., Luohe 462005, China)

Abstract: The aim of this study was to prepare and characterize *Eucommia ulmoides* polysaccharide nanoparticles (EUP NPs) and investigate their anti-inflammatory *in vitro*. Amphiphilic *Eucommia ulmoides* polysaccharide nanoparticles loaded with quercetin (QT/LA-EUP NPs) were prepared using the anti-solvent precipitation method. The stability of the nanomaterial was characterized through the measurement of particle size, polydispersity index (PDI), and Zeta potential.

收稿日期: 2024−08−22
基金项目: 国家自然科学基金（32101966）; 2022 年河南省研究生联合培养基地项目（YJS2022JD16）; 河南省高校科技创新团队支持计划资助项目（23IRTSTHN023）。
作者简介: 林晓霞（2000−）, 女, 硕士研究生, 研究方向: 食品营养与健康, E-mail: [redacted]
*** 通信作者:** 李天歌（1992−）, 女, 博士, 讲师, 研究方向: 食品营养与健康, E-mail: [redacted]

中国知网 https://www.cnki.net

41. 付严昆（本科生），蔡语铮（本科生），冯志强，陈思如，王田林，宋莲军，李天歌*（通讯作者）. 核桃肽通过促进白色脂肪棕色化预防肥胖的作用[J]. 食品工业科技, 2025, 46(03): 376-385.

付严昆, 蔡语铮, 冯志强, 等. 核桃肽通过促进白色脂肪棕色化预防肥胖的作用 [J]. 食品工业科技, 2025, 46(3): 376−385. doi: 10.13386/j.issn1002-0306.2024030122

FU Yankun, CAI Yuzheng, FENG Zhiqiang, et al. Effects of Walnut Protein Peptides on Promotion of White Adipose Tissue Browning and Prevention of Obesity[J]. Science and Technology of Food Industry, 2025, 46(3): 376−385. (in Chinese with English abstract). doi: 10.13386/j.issn1002-0306.2024030122

·营养与保健·

核桃肽通过促进白色脂肪棕色化预防肥胖的作用

付严昆[1]，蔡语铮[1]，冯志强[2]，陈思如[1]，王田林[1]，宋莲军[1]，李天歌[1,2,*]
（1.河南农业大学食品科学技术学院，河南郑州 450002；
2.三全食品股份有限公司，河南郑州 450044）

摘　要：目的：探究核桃肽对促进白色脂肪棕色化及预防肥胖的作用。方法：在 3T3-L1 前脂肪细胞分化过程中加入核桃肽（0.25、1.00 mg/mL），分化成功后检测脂肪细胞脂质积累、线粒体数量、白色脂肪棕色化关键因子蛋白表达水平的变化。进一步，采用核桃肽（400 mg/kg BW）干预高脂饮食（High-fat diet，HFD）雄性 C57BL/6 小鼠 8 周后，监测体重、脂肪组织重量、血脂水平并进行口服葡萄糖耐量试验（Oral glucose tolerance test，OGTT），观察腹股沟白色脂肪组织形态变化，同时检测腹股沟白色脂肪组织中棕色化标志物的蛋白表达情况。结果：在细胞水平，核桃肽干预 3T3-L1 脂肪细胞后脂滴减小，脂质积累水平降低，线粒体数量增加，上调了解偶联蛋白 1（Uncoupling protein 1，UCP1）、过氧化物酶体增殖物激活受体 γ 辅激活因子 1α（Peroxisomal proliferator-activated receptor γ coactivator-1α，PGC-1α）、PR 结构域蛋白 16（PR domain-containing 16，PRDM16）、过氧化物酶体增殖物激活受体 α（Peroxisomal proliferator-activated receptor α，PPARα）的蛋白表达。在动物水平，与 HFD 组小鼠相比，核桃肽干预 8 周显著缓解了体重过度增加，降低了白色脂肪组织（附睾脂肪、腹股沟脂肪）质量指数，降低了血清中甘油三酯（Triglyceride，TG）、总胆固醇（Total cholesterol，TC）、低密度脂蛋白（Low-density lipoprotein cholesterol，LDL-C）的水平，增加了高密度脂蛋白（High-density lipoprotein cholesterol，HDL-C）水平，并增加了葡萄糖耐受能力。腹股沟脂肪组织苏木精-伊红染色（Hematoxylin-eosin staining，H&E）及免疫组化结果分析显示，核桃肽明显降低了 HFD 导致的平均脂肪细胞面积增加，并上调了 UCP1 阳性细胞数量。此外，核桃肽同样增加了腹股沟脂肪组织中棕色化关键因子 UCP1、PGC-1α、PRDM16、PPARα 的蛋白表达。结论：核桃肽具有促进白色脂肪棕色化的效果，能够预防由 HFD 引发的肥胖及代谢紊乱，具有作为抗肥胖功能性食品配料的潜力。

关键词：核桃肽，高脂饮食，白色脂肪棕色化，肥胖
中图分类号：TS201.4　　**文献标识码**：A　　**文章编号**：1002-0306(2025)03-0376-10
DOI：10.13386/j.issn1002-0306.2024030122　　本文网刊：

Effects of Walnut Protein Peptides on Promotion of White Adipose Tissue Browning and Prevention of Obesity

FU Yankun[1], CAI Yuzheng[1], FENG Zhiqiang[2], CHEN Siru[1], WANG Tianlin[1], SONG Lianjun[1], LI Tiange[1,2,*]
(1.School of Food Science and Technology, Henan Agricultural University, Zhengzhou 450002, China;
2.Sanquan Foods Co., Ltd., Zhengzhou 450044, China)

Abstract: Objective: The aim of this study was to investigate the effect of walnut protein peptides (WPP) on the promotion

收稿日期：2024-03-11
基金项目：国家自然科学基金（32101966）；河南省重点研发与推广专项（科技攻关）项目（232102110171）；国家级大学生创新创业训练计划项目（202310466057）；2022 年河南省研究生联合培养基地项目（YJS2022JD16）；河南省高校科技创新团队支持计划资助项目（23IRTSTHN023）。
作者简介：付严昆（2003−），女，本科，研究方向：食品营养与健康，E-mail:
*** 通信作者**：李天歌（1992−），女，博士，副教授，研究方向：食品营养与健康，E-mail:

中国知网 https://www.cnki.net

42. 于佳琪（本科生），马静怡（本科生），张静静，冯志强，赵培均，王田林，黄现青，宋莲军，李天歌*（通讯作者）．蒸汽爆破对石榴皮渣膳食纤维结构、理化及功能性质的影响[J].食品与发酵工业, 2025, 51(11): 263-272.

研究报告

DOI:10.13995/j.cnki.11-1802/ts.040455
引用格式:于佳琪,马静怡,张静静,等.蒸汽爆破对石榴皮渣膳食纤维结构、理化及功能性质的影响[J].食品与发酵工业,2025,51(11):263-272.YU Jiaqi,MA Jingyi,ZHANG Jingjing,et al.Effects of steam explosion on structural,physicochemical,and functional properties of dietary fiber from pomegranate peel residue[J].Food and Fermentation Industries,2025,51(11):263-272.

蒸汽爆破对石榴皮渣膳食纤维结构、理化及功能性质的影响

于佳琪[1,2],马静怡[1],张静静[1],冯志强[3],赵培均[1],王田林[1],黄现青[1],宋莲军[1],李天歌[1,3]*

1(河南农业大学 食品科学技术学院,河南 郑州,450002)2(河南农业大学 国际教育学院,河南 郑州,450002)
3(三全食品股份有限公司,河南 郑州,450044)

摘　要　该研究旨在探究蒸汽爆破改性技术对石榴皮渣可溶性膳食纤维(soluble dietary fiber,SDF)结构、理化和功能性质的影响。结果表明,以SDF提取率为指标,经单因素试验得到蒸汽爆破改性的最优工艺为,石榴皮渣粒径60目,压力0.60 MPa,维压时间140 s,此条件下石榴皮渣SDF提取率为(13.42±0.12)%,相比改性前提高(5.91±0.04)%。利用傅里叶变换红外光谱、X射线衍射和扫描电镜探究了蒸汽爆破对SDF结构性质的影响,研究发现改性后石榴皮渣SDF暴露出更多化学基团,分子间氢键作用力加强,结晶度下降,表面变成粗糙多孔的网状结构,出现大量褶皱。蒸汽爆破改性后SDF的持水力、持油力和膨胀力分别提升至蒸汽爆破前的(1.19±0.09)倍、(1.60±0.16)倍和(1.95±0.03)倍。此外,蒸汽爆破增加了石榴皮渣SDF的葡萄糖吸附能力、α-淀粉酶抑制能力、胆固醇吸附能力及抗氧化能力。综上,该研究证明了蒸汽爆破技术可以有效提升石榴皮渣SDF的理化特性和功能特性,为石榴皮渣SDF的提取和应用提供了理论基础。

关键词　蒸汽爆破;石榴皮渣;膳食纤维;物理改性;理化性质;功能性质

石榴(*Punica granatum* L.),别名安石榴、丹若等,在全球范围内广泛种植,中国作为石榴的主要种植国家之一,在豫鲁皖苏地区、陕晋地区和新疆等地种植颇为集中[1]。据估计,2021年全球石榴市场规模已达到2.359 4亿美元,预计到2030年将增加到3.386亿美元[2]。石榴因营养丰富、具有药用价值,其产量不断攀升,发展前景较为广阔[3]。石榴的主要食用方式为鲜食,石榴汁、石榴酒等产品的加工则居其次[4]。然而,在石榴食用和加工过程中,占石榴果实总质量近半的副产物被大量遗弃,这将直接引发环境污染和资源浪费等严峻问题[5]。而石榴的副产物蕴藏着丰富的营养与功能性成分,如蛋白质、脂质、纤维素、游离氨基酸、可溶性糖类、多酚化合物、黄酮类化合物等[6]。以上成分不仅为石榴副产物的综合利用提供了坚实的物质基础,也为石榴在食品、医药等领域的应用开辟了广阔前景[4]。现阶段对石榴副产物综合利用的研究主要集中在提取石榴皮中的多酚物质和石榴籽油上,对其他活性成分的利用则有所忽视。因此,针对石榴皮渣中其他活性成分的挖掘与利用成为了目前的研究热点之一。

膳食纤维(dietary fiber,DF)是指植物细胞壁、多糖、木质素及相关物质的总和,不易被人体消化吸收。DF可有效促进肠道蠕动,具有降血糖、降低血清胆固醇、预防便秘、增加肠道有益菌等多种功效。依照其在水中的溶解特性分为可溶性膳食纤维(soluble dietary fiber,SDF)和不溶性膳食纤维(insoluble dietary fiber,IDF)。SDF含量的高低可作为评价DF品质的关键指标之一,若SDF的含量在10%以上,可最大限度地发挥其良好的加工特性、生理活性和保健功能[6]。石榴皮渣中SDF含量较低约为7.5%,因此,通过合适的改性处理手段,不仅能提高石榴皮渣中SDF含量,还能够进一步优化SDF的品质特性。

蒸汽爆破技术的原理是物料在高温、高压处理的条件下,蒸汽爆破瞬间释放的压力导致纤维紧密结构断裂,改变了纤维的性质,共价键断裂、聚合物链内重组形成新的键,使低分子物质溶出,从而改变聚合物的最终结构[7]。蒸汽爆破技术已被应用于蔬菜、水果、粮谷类食品的DF改性,且效果显著。如王田林[8]以甘薯渣为原料进行蒸汽爆破,结果表明,蒸汽爆破技术能显著提高甘薯渣DF中SDF含量,并增加

第一作者:本科生(李天歌副教授为通信作者,E-mail [redacted])
基金项目:国家自然科学基金项目(32101966);河南省高校科技创新团队支持计划资助项目(23IRTSTHN023);2022年河南省研究生联合培养基地项目(YJS2022JD16)
收稿日期:2024-07-10,改回日期:2024-08-29

中国知网 https://www.cnki.net

（四）学生参与的授权专利

1. 李宁，黄现青，李天歌，王田林，乔明武，宋莲军，马燕，沈玥，张西亚，毛烨炫, 赵秋艳, 杨慧洁, A polypeptide sequence targeting the specific binding of PSH protein and its application，2025-4-10，欧洲，N2038198（专利）

Rijksdienst voor Ondernemend Nederland

OCTROOINUMMER 2038198

Octrooicentrum Nederland verklaart dat op grond van octrooiaanvraag 2038198 , ingediend op 11 juli 2024 octrooi is verleend aan:

Henan Agricultural University te Zhengzhou, China

Uitvinder(s):
Ning Li te Zhengzhou , China
Xianqing Huang te Zhengzhou , China
Tiange Li te Zhengzhou , China
Tianlin Wang te Zhengzhou , China
Mingwu Qiao te Zhengzhou, China
Lianjun Song te Zhengzhou, China
Yan Ma te Zhengzhou , China
Yue Shen te Zhengzhou, China
Xiya Zhang te Zhengzhou , China
Yexuan Mao te Zhengzhou , China
Qiuyan Zhao te Zhengzhou, China
Huijie Yang te Zhengzhou , China

Voor: POLYPEPTIDE SEQUENCE TARGETING SPECIFIC BINDING TO PSH PROTEIN AND APPLICATION THEREOF

Een recht van voorrang werd ingeroepen, gebaseerd op octrooiaanvraag: 202410158990.5, ingediend op 4 februari 2024 in China.

Aan dit bewijs is een exemplaar van het octrooischrift gehecht met nummer 2038198 en dagtekening 10 april 2025.

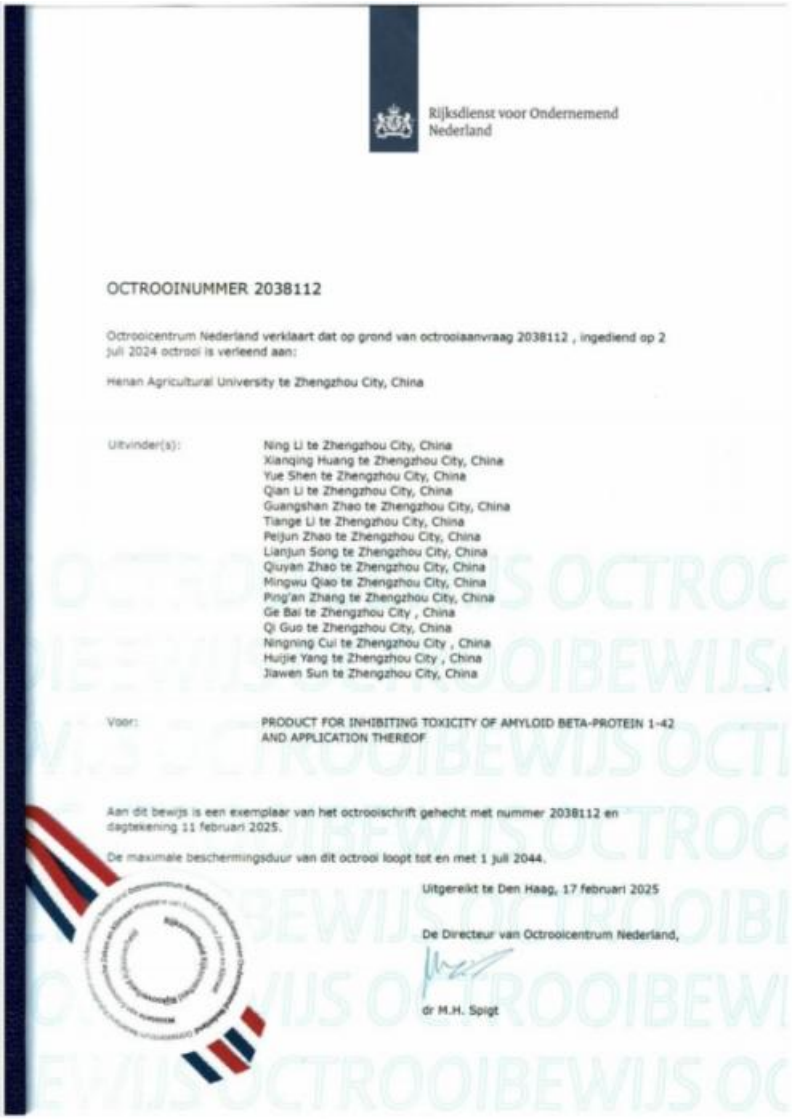
De maximale beschermingsduur van dit octrooi loopt tot en met 10 juli 2044.

Uitgereikt te Den Haag, 10 april 2025

De Directeur van Octrooicentrum Nederland,

dr M.H. Spigt

2. 李宁，黄现青，沈玥，李倩，赵广山，李天歌，赵培均，宋莲军，赵秋艳，乔明武，张平安，白歌，郭琪，崔宁宁，杨慧洁，孙佳雯，Product for Inhibiting the Toxicity of Amyloid beta-Protein 1-42 and Applications thereof, 2025-2-11，欧洲，N2038112 (专利)。



Rijksdienst voor Ondernemend Nederland

OCTROOINUMMER 2038112

Octrooicentrum Nederland verklaart dat op grond van octrooiaanvraag 2038112 , ingediend op 2 juli 2024 octrooi is verleend aan:

Henan Agricultural University te Zhengzhou City, China

Uitvinder(s):
Ning Li te Zhengzhou City, China
Xianqing Huang te Zhengzhou City, China
Yue Shen te Zhengzhou City, China
Qian Li te Zhengzhou City, China
Guangshan Zhao te Zhengzhou City, China
Tiange Li te Zhengzhou City, China
Peijun Zhao te Zhengzhou City, China
Lianjun Song te Zhengzhou City, China
Qiuyan Zhao te Zhengzhou City, China
Mingwu Qiao te Zhengzhou City, China
Ping'an Zhang te Zhengzhou City, China
Ge Bai te Zhengzhou City , China
Qi Guo te Zhengzhou City, China
Ningning Cui te Zhengzhou City , China
Huijie Yang te Zhengzhou City , China
Jiawen Sun te Zhengzhou City, China

Voor: PRODUCT FOR INHIBITING TOXICITY OF AMYLOID BETA-PROTEIN 1-42 AND APPLICATION THEREOF

Aan dit bewijs is een exemplaar van het octrooischrift gehecht met nummer 2038112 en dagtekening 11 februari 2025.

De maximale beschermingsduur van dit octrooi loopt tot en met 1 juli 2044.

Uitgereikt te Den Haag, 17 februari 2025

De Directeur van Octrooicentrum Nederland,

dr M.H. Spigt

3. 李天歌，王田林，梁梦莹(本科生)，黄宇琪(本科生)，李中惠(本科生)，朱亚威(本科生),马如想(本科生)，黄现青．实用新型专利：一种用于食品检测的便携式取样装置[P]. ZL202221212984.6，授权日期 2023.01.

证书号第18272255号

实用新型专利证书

实用新型名称：一种用于食品检测的便携式取样装置

发　明　人：李天歌;王田林;梁梦莹;黄宇琪;李中惠;朱亚威;马如想
黄现青

专　利　号：ZL 2022 2 1212984.6

专利申请日：2022年05月20日

专利权人：河南农业大学

地　　址：450000 河南省郑州市郑东新区龙子湖高校园区15号

授权公告日：2023年01月13日　　授权公告号：CN 218297622 U

国家知识产权局依照中华人民共和国专利法经过初步审查，决定授予专利权，颁发实用新型专利证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。专利权期限为十年，自申请日起算。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

国家知识产权局

2023年01月13日

第1页(共2页)

其他事项参见续页

4.国家级大学生创新创业训练计划项目结题证书，由河南农业大学付严昆同学（本科生）主持，指导教师李天歌。

国家级大学生创新创业训练计划项目

结题证书

由河南农业大学付严昆同学主持，贺阳春、谢姗姗、张祎、李悦同学参与的2023年国家级大学生创新创业训练计划项目：蒸汽爆破对石榴皮渣膳食纤维理化特性及功能性质影响的研究(项目编号: 202310466057)，经结题验收，圆满完成项目研究任务，同意结项。

指导教师：李天歌

特发此证，以资鼓励。

证书编号：20231860

二〇二四年一一月