同行专家业内评价意见书编号：20250860056

附件1

浙江工程师学院（浙江大学工程师学院）
同行专家业内评价意见书

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学号：22260416

申报工程师职称专业类别（领域）：生物与医药

浙江工程师学院（浙江大学工程师学院）制

2025年05月26日

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一、个人申报

（一）基本情况【围绕《浙江工程师学院（浙江大学工程师学院）工程类专业学位研究生工程师职称评审参考指标》，结合该专业类别(领域)工程师职称评审相关标准，举例说明】

1.对本专业基础理论知识和专业技术知识掌握情况(不少于200字)

本人系统掌握了食品工程相关的基础理论和专业技术知识，尤其在食品生物技术、发酵工程、食品安全控制与检测、生物化学与分子生物学等方面具有扎实的理论基础。在校期间系统学习了《食品安全风险评估与管理》《工程数值分析》《智能装备制造》《高阶工程认知实践》等课程，为后续从事科研及工程实践奠定了坚实基础。此外，我持续通过阅读文献、参与内部培训及行业会议，不断更新自己的知识体系，特别关注食品安全风险评估、、HACCP质量控制体系及食品工艺装备的应用等方向，能够熟练运用AutoCAD、Origin、SPSS等工具进行实验设计、数据分析与技术优化。通过专业实践实践，已形成结构化的知识体系，能够将理论知识有效转化为生产力并指导工程实施。

2.工程实践的经历(不少于200字)

在本专业学习过程中，我参与多个产品开发、工艺优化和生产线设计项目，积累了丰富的工程实践经验。曾在宁波方太厨具有限公司进行为期一年的专业实践，参与宁波市企业创新联合体项目《低碳智慧健康厨房关键技术装备研发及产业化》，项目的研究内容是探究一种高效的应用于洗碗机的杀菌方式，采用两种不同的杀菌方式，分别是超声联合紫外技术以及脉冲强光技术，通过探究其对抗逆性极强的芽孢的灭活效果，并通过透射电子显微镜、拉曼光谱、蛋白质组等技术初步研究灭活机理。最后将该技术应用于实际，探究其具体效果。团队分工方面，我主要负责洗碗机杀菌技术的研究，包括超声联合紫外技术和脉冲强光杀菌技术的实验和优化。我负责洗碗机杀菌技术的研究，具体包括设计实验方案，进行实验操作，数据收集和分析，以及技术参数的优化。通过一系列实验，我初步确定了超声联合紫外技术和脉冲强光杀菌技术在不同条件下的杀菌效果，并提出了进一步优化的方向。存在的主要问题与建议是：杀菌效果在不同实验条件下存在较大差异，需要进一步优化技术参数。设备的稳定性和可靠性有待提高，建议增加设备测试和优化环节。需要进一步探索杀菌技术在实际使用中的适应性和效果。我也参与企业GMP及HACCP认证体系的建立与维护，推动企业质量体系向标准化方向发展。通过这些实践，我不仅提升了动手能力和项目管理水平，也锻炼了跨部门沟通与团队协作能力。

3.在实际工作中综合运用所学知识解决复杂工程问题的案例（不少于1000字)

在参与宁波市科技局支持的“低碳智慧健康厨房关键技术装备研发及产业化”项目过程中，我负责洗碗机杀菌系统的研发与优化工作，面临的复杂工程问题是如何实现对抗逆性极强的微生物（如蜡样芽孢杆菌）的高效灭活，同时满足家庭厨电对低能耗、高集成度、稳定性和用户安全性的多重要求。蜡样芽孢杆菌是一种常见的食源性致病菌，在过夜米饭、果蔬等食品中常常被检测到。据报道，全球食物中毒事件中，蜡样芽孢杆菌中毒比例1.4-12%。蜡样芽孢杆菌能够产生耐热、耐酸的毒素，主要的中毒症状为呕吐或者腹泻。值得注意的是，蜡样芽孢杆菌在极端环境下能够产生休眠体芽孢，极强的抗逆性使得食品中残留蜡样芽孢杆菌难以彻底消除。传统高温杀菌方式虽然能够有效灭活芽孢，但其存在能耗高、对部件和餐具损伤大、效果波动明显等问题，难以适应当前智慧厨房对低碳环保和高效杀菌的综合诉求。因此，我决定以非热杀菌技术为突破口，探索将“超声波（US）+紫外线（UV）”复合技术应用于洗碗机中，通过实验研究和结构分析，解决芽孢灭活效率低、设备兼容性差等一系列技术难点。

在研究过程中，我基于食品微生物学、物理化学、生物杀菌机制及工程流体动力学等理论，

设计并搭建了US+UV多物理场杀菌模拟系统，采用20 kHz、200W的超声波装置与253.7nm UVC光源组合，并在洗碗机模拟腔体内对蜡样芽孢杆菌芽孢进行动态灭活实验，配合平板计数、透射电镜（TEM）、拉曼光谱、Zeta电位、粒径分析等方法，对杀菌效果和芽孢结构变化进行多维评价。实验结果显示，US+UV复合处理20分钟内可实现4.61 log CFU/mL的灭活率，显著优于单一UV（3.50 log）或US（0.27 log）处理效果，验证了其协同增强效应。结构分析表明，超声波破坏了芽孢外层的外壳与蛋白质复合物，提升了紫外线对DNA的穿透与破坏效率；拉曼光谱显示核酸结构出现断裂、蛋白质次级结构解构，进一步削弱了芽孢的抵抗力。

为了实现成果转化，我将该US+UV杀菌模块与洗碗机现有电控系统融合，设计了自动运行程序、安全防护接口及模块化封装方案，并在宁波方太厨具有限公司的研发平台上完成整机联调测试。结果表明，该系统能在保证能耗仅略高于传统模式的情况下，实现餐具的深度灭菌且无化学残留。基于本项成果，我以第一作者发表SCI论文1篇，论文《Inactivation effect and mechanism of ultrasound combined with ultraviolet treatment on Bacillus cereus spores》发表于《Journal of Agriculture and Food Research》，系统阐释了该多物理场复合杀菌技术的原理机制、实验数据与工程转化路径，为推动食品安全设备领域非热杀菌技术的发展提供了理论支撑和实践样本。

通过本项目的深入参与，我不仅将所学多学科理论知识有机结合于实际工程问题中，还系统锻炼了我在实验设计、设备调试、项目管理与成果转化等方面的综合能力。这一复杂工程问题的成功解决，不仅验证了“科技+工程”协同模式在厨电产品中的可行性，更为我后续在食品工程与健康装备领域持续深耕打下坚实基础。

（二）取得的业绩（代表作）【限填3项，须提交证明原件（包括发表的论文、出版的著作、专利证书、获奖证书、科技项目立项文件或合同、企业证明等）供核实，并提供复印件一份】					
1. 公开成果代表作【论文发表、专利成果、软件著作权、标准规范与行业工法制定、著作编写、科技成果获奖、学位论文等】					
成果名称	成果类别 [含论文、授权专利（含发明专利申请）、软件著作权、标准、工法、著作、获奖、学位论文等]	发表时间/授权或申请时间等	刊物名称/专利授权或申请号等	本人排名/总人数	备注
Inactivation effect and mechanism of ultrasound combined with ultraviolet treatment on Bacillus cereus spores	权威期刊	2024年09月16日	Journal of Agriculture and Food Research	1/5	SCI期刊收录
Transcriptomic analysis of biofilm formation by Bacillus cereus under different carbon source conditions	权威期刊	2024年04月26日	Food Quality And Safety	1/6	SCI期刊收录

2.其他代表作【主持或参与的课题研究项目、科技成果应用转化推广、企业技术难题解决方案、自主研发设计的产品或样机、技术报告、设计图纸、软课题研究报告、可行性研究报告、规划设计方案、施工或调试报告、工程实验、技术培训教材、推动行业发展中发挥的作用及取得的经济社会效益等】

（三）在校期间课程、专业实践训练及学位论文相关情况	
课程成绩情况	按课程学分核算的平均成绩： 85 分
专业实践训练时间及考核情况(具有三年及以上工作经历的不作要求)	累计时间： 1 年（要求1年及以上） 考核成绩： 83 分
本人承诺	
个人声明：本人上述所填资料均为真实有效，如有虚假，愿承担一切责任，特此声明！ **申报人签名：** 郝亚卿	

22260416

二、日常表现考核评价及申报材料审核公示结果

日常表现考核评价	非定向生由德育导师考核评价、定向生由所在工作单位考核评价： ☑优秀 ☐良好 ☐合格 ☐不合格 德育导师/定向生所在工作单位分管领导签字（公章）：　　年5月12日
申报材料审核公示	根据评审条件，工程师学院已对申报人员进行材料审核（学位课程成绩、专业实践训练时间及考核、学位论文、代表作等情况），并将符合要求的申报材料在学院网站公示不少于5个工作日，具体公示结果如下： ☐通过 ☐不通过（具体原因：　　） 工程师学院教学管理办公室审核签字（公章）：　　年　月　日

浙 江 大 学 研 究 生 院

攻读硕士学位研究生成绩表

学号：22260416	姓名：祁亚劲	性别：男	学院：工程师学院	专业：食品工程	学制：2.5年
毕业时最低应获：26.0学分		已获得：28.0学分		入学年月：2022-09	毕业年月：
学位证书号：			毕业证书号：		授予学位：

学习时间	课程名称	备注	学分	成绩	课程性质	学习时间	课程名称	备注	学分	成绩	课程性质
2022-2023学年秋季学期	智能物联网与嵌入式应用		1.0	87	专业学位课	2022-2023学年冬季学期	食品安全风险评估与管理		2.0	93	专业选修课
2022-2023学年秋季学期	创新设计方法		2.0	通过	专业选修课	2022-2023学年冬季学期	产业技术发展前沿		1.5	86	专业学位课
2022-2023学年秋季学期	工程技术创新前沿		1.5	91	专业学位课	2022-2023学年春季学期	研究生英语		2.0	免修	公共学位课
2022-2023学年秋季学期	工程数值分析		2.0	78	专业选修课	2022-2023学年春季学期	新时代中国特色社会主义理论与实践		2.0	82	公共学位课
2022-2023学年秋季学期	工程伦理		2.0	85	公共学位课	2022-2023学年春季学期	研究生论文写作指导		1.0	91	专业学位课
2022-2023学年冬季学期	自然辩证法概论		1.0	75	公共学位课	2022-2023学年春季学期	研究生英语基础技能		1.0	免修	公共学位课
2022-2023学年冬季学期	智能装备设计制造		2.0	87	专业学位课	2022-2023学年夏季学期	食品仪器分析实务		2.0	92	专业选修课
2022-2023学年秋冬学期	高阶工程认知实践		3.0	85	专业学位课		硕士生读书报告		2.0	通过	

说明：1.研究生课程按三种方法计分：百分制，两级制（通过、不通过），五级制（优、良、中、及格、不及格）。

2.备注中“*”表示重修课程。

学院成绩校核章：

成绩校核人：张梦依

打印日期：2025-06-03

浙江大学研究生（60）成绩校核章

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Inactivation effect and mechanism of ultrasound combined with ultraviolet treatment on *Bacillus cereus* spores

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ABSTRACT

Bacillus cereus is a common foodborne pathogen, and its formation of strongly resistant spores renders the pathogen difficult to eliminate completely using traditional sterilization methods. This study aimed to investigate the inactivation effect of ultrasound combined with ultraviolet treatment on *Bacillus cereus* spores and the underlying mechanism. The inactivation effect, surface properties, structural changes, heat resistance and germination characteristics, as well as Raman spectroscopy results, were examined. It was found that 20 min of ultrasound combined with ultraviolet treatment resulted in the inactivation of 4.61 log CFU/mL. Structurally, the exosporium and coat were damaged. Moreover, the permeability of the inner membrane increased. Damage to the spores' structure reduced the heat resistance. Raman spectroscopy indicated that the DNA and proteins were severely damaged.

In conclusion, ultrasound combined with ultraviolet treatment demonstrated a synergistic inactivation effect on *Bacillus cereus* spores by destroying the external structures of the spores, as well as the internal DNA and other substances. This study has preliminarily elucidated the mechanism of ultrasound combined with ultraviolet treatment regarding the inactivation of *Bacillus cereus* spores, providing a theoretical foundation for its application in food sterilization.

1. Introduction

Bacillus cereus (*B. cereus*) is a common foodborne pathogen that is often detected in foods such as vegetables, fruits and dairy products [1]. The proportion of *B. cereus* poisoning has been reported to be 1.4–12 % among all global food poisoning incidents [2]. *B. cereus* is capable of producing the heat- and acid-resistant toxin cereulide, and the main toxicity symptom is vomiting or diarrhea [1]. Notably, *B. cereus* is capable of generating dormant spores in extreme environments [3]. The extreme resistance of *B. cereus* spores renders it difficult to eliminate them completely from food products.

Spores are a survival strategy for spore-forming bacteria, enabling them to protect themselves in extreme environments (heat, dryness, nutrient deficiencies, etc.). Spores have a multilayered dense structure, which, from the outside to the inside, includes the exosporium, spore coat, cortex, inner membrane and core [4]. The exosporium is a vesicle-like structure, composed of proteins, lipids and carbohydrates, surrounding the periphery of the spore; its strong adsorptive properties allow the spore to attach itself to new areas [5]. The spore coat is a multilayered protein structure that maintains the formation and integrity of the spores, and it helps to prevent macromolecules from reaching the cortex. Moreover, the spore coat is associated with resistance to several chemicals, such as hydrogen peroxide [6]. In addition to protecting the spore structure, the cortex plays an important role in keeping the internal moisture content low to prevent damage to the spores under adverse conditions. The hydrolysis of the cortex is a necessary step for germination; therefore, the cortex permeability is an indicator of spore germination [7]. The inner membrane (IM) is a critical aspect in maintaining resistance. The compact structure and low fluidity of the IM enable it to block small molecules from entering the core and protect the nucleic acids. The protein composition between the spores and bacterium is different, and there are germination receptors and sporulation stage V protein A (SpoVA) proteins on the IMs of spores [8]. The very low water content, α/β-type small acid-soluble spore proteins (SASPs)

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《ESCI》收录及《JCR》期刊影响因子、分区情况证明

经检索《Web of Science》和《Journal Citation Reports (JCR)》数据库，《Emerging Sources Citation Index (ESCI)》收录论文及其期刊影响因子、分区情况如下。（检索时间：2024年12月23日）

第 1 条，共 1 条

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Edition	JCR® 类别	类别中的排序	JCR 分区
ESCI	FOOD SCIENCE & TECHNOLOGY	36/173	Q1

注：

1. 期刊影响因子及分区情况最新数据以JCR数据库最新数据为准。
2. 以上检索结果来自CALIS查收查引系统。
3. 以上检索结果均得到委托人及被检索作者的确认。

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Transcriptomic analysis of biofilm formation by *Bacillus cereus* under different carbon source conditions

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Abstract

Background: Previous studies found differences in the utilization of different carbon sources during biofilm formation by *Bacillus cereus*. Illumina HiSeq high-throughput sequencing technology was used to investigate the changes in gene transcript levels in *Bacillus cereus* biofilm bacteria under different carbon source conditions.

Results: Compared with the control group, the number of differentially expressed genes in the glucose, maltose, lactose, and skim milk-supplemented groups was 351, 1136, 133, and 487, respectively. The results showed that the pathways involved in the differentially expressed genes were mainly distributed in glycolysis and pentose phosphate pathway, tricarboxylic acid cycle, amino acid metabolism, and fatty acid metabolism. The gene expression of enzymes related to acetoin synthesis from pyruvate was mostly upregulated in the glucose-supplemented group. The gene expression of enzymes related to pyruvate synthesis of branched-chain amino acids in the maltose-supplemented group was mostly upregulated. In the lactose-supplemented group, the gene expression of acetoin biosynthesis from pyruvate was upregulated. Pyruvate production through glycolysis pathway increased in the skim milk-supplemented group, but the metabolic capacity of the tricarboxylic acid cycle did not change significantly.

Conclusion: The content of pyruvate stored by *Bacillus cereus* biofilm bacteria through glycolysis or pentose phosphate pathway increased, but the carbon flux into the tricarboxylic acid cycle did not increase, which suggested that carbon fluxes in the extracellular polysaccharide synthesis pathway of the biofilm may be increased, resulting in increased biofilm biomass formation.

Keywords: Bacterial biofilm; *Bacillus cereus*; carbon metabolism; transcriptomics.

Introduction

Bacillus cereus is a common food-borne pathogen that easily causes contamination in the production, transportation, sale, and storage of food (Enosi Tuipulotu *et al.*, 2020). *Bacillus cereus* is responsible for 1.4% to 12% of foodborne diseases worldwide (Grutsch *et al.*, 2018). The pathogen's capacity to produce toxins that withstand high temperatures and pressures renders it a significant health hazard that should not be underestimated (Stenfors Arnesen *et al.*, 2008). Food poisoning caused by *Bacillus cereus* can be characterized by vomiting or diarrhea, and even death in severe cases (Dietrich *et al.*, 2021; Jovanovic *et al.*, 2021). However, *Bacillus cereus* can adhere to the equipment surface easily and then form biofilm, which is difficult to remove and inactivate (Harada and Nascimento, 2021).

Biofilms are bacterial aggregates attached to the gas–liquid or solid–liquid interface and encapsulated by extracellular polysaccharides, fibronectin, lipoproteins and other substances (Abee *et al.*, 2011). Extracellular substrates are protective to their internal bacteria. They provide mechanical stability to the biofilm and enhance the resistance of the bacteria to adverse external environments (e.g., fungicides, antibiotics, ultraviolet, extreme pH, and high temperatures) (Koo *et al.*, 2017; Vaikundamoorthy *et al.*, 2018; Yan and Bassler, 2019). Compared with planktonic microorganisms, it is more difficult to remove the biofilm adhered to the surface of food equipment. In addition, the morphology and structure of biofilm produced by bacteria are different under different nutritional conditions (Srey *et al.*, 2013). The formation of biofilm is closely related to its available nutrients, temperature, attachment interface, and other environmental factors. Lin and colleages found that the biofilm formation ability of *Bacillus cereus* LS8 in medium with different carbon sources (galactose, sucrose, and fructose) was significantly different (Rode *et al.*, 2007; Lin and Madida, 2015). Pumeesat and colleagues investigated the biofilm formation of *Candida albicans* at different temperatures and found that the biofilm produced at 42 °C had lower mass, thickness, and metabolic activity than that

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