2025第五屆醱酵技術研討會
2025 Fermentation Technology Workshop

活動時間：
中華民國一一四年三月十三日星期四
上午九點至下午四點

活動地點：
臺灣大學食科所演講廳四樓 (台北市羅斯福路4段1號)

INNOVATIVE CULTIVATION SOLUTIONS

研討會內容時間表
Agenda

時段		負責單位/講者	演講題目	主持人
09:00 ~ 09:30	報到			
09:30 ~ 09:50	貴賓致詞 大合照	臺大生農學院 林裕彬院長 臺大生 科 院 何佳安副院長		鄭光成教授
09:50 ~ 10:40	時段一	輔大食科 蔡宗佑教授	乳酸菌大豆發酵食品應用於促進口腔保健之研究	
10:40 ~ 11:00	Break 1			
11:00 ~ 11:40	時段二	台大生技所 劉啟德教授	光合菌在永續農業與淨零碳排之應用	
11:40 ~ 12:00	時段三	major science產品開發經理 林泰宏	研究到生產：醱酵代工	
12:00 ~ 12:20		山水經理 林名宏	誘變育種儀(ARTP)&發酵全自動取樣分析儀(BODS)	
12:20 ~ 13:20	午餐 (提供餐盒 / 用餐教室: R102 / R222)			
13:20 ~ 14:00	時段四	高科大水食系 謝承哲教授	精準發酵創新應用	林欣平教授
14:00 ~ 14:40	時段五	北醫食安系 林欣平教授	Innovative Production of Foaming Bacterial Cellulose and Its Potential Applications	
14:40 ~ 15:00	Break 2			
15:00 ~ 15:20	時段六	Hamilton台灣區產品經理 白耀嘉	online digital dCO2 probe and VCD/ TCD probe	
15:20 ~ 15:40		進階產品經理 周家豪	創新高速影像計數器於發酵領域應用 A novel image-based cell viability counting method for fermentation industrial	
15:40 ~ 16:00	領取紀念品			

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發酵研討會主持人

鄭光成 教授 (2019/8~)
臺大食科所與生技所合聘
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學歷:
博士 美國賓州州立大學農業生物工程學系 (2010)
碩士 國立臺灣大學微生物與生化學研究所 (2005)
學士 國立臺灣大學農業化學系農產製造組 (2001)

主要經歷:
台灣農業化學會誌總編輯
美國 Rutgers 大學食品科學系訪問學者 (2016/6~8)
臺大生技中心產學合作組組長
臺大國家食品安全教育暨研究中心學術組組長

服務與榮譽:
國際食品科學院 (IAFoST Fellow) 院士
臺灣乳酸菌協會現任秘書長
台灣食科學會第 26 屆常務理事
台灣食品保護協會現任常務理事
台灣農業化學會現任常務理事
台灣農業化學會第 106 年度學術獎獲獎人
台灣保健食品學會 2022 傑出學術研究獎獲獎人
台灣食品科技學會 2019 食品學術研究榮譽獎獲獎人
ELSEVIER 2021 Top 2% 全球頂尖研究學者 (2020~2023)
中研院第 11 屆楊祥發院士傑出農業科學年輕優秀學者獎獲獎人
臺大生農學院 2023 院級勵進青年學術講座

實驗室研究主題

- **藥用菇類發酵與生理活性探討:**

藥用菇類為泛指能於菌絲體、子實體等產生對人體健康有益，或對疾病有抑制或治療作用的一級或次級代謝物之真菌，目前藥用菇類為中草藥的新藥及保健食品開發的一大研究指標，過去許多研究著重於靈芝及台灣牛樟芝等藥用菇類的次級代謝物之生物活性做開發，而本研究室目前針對不同靈芝，例如台灣紫芝及重傘靈芝，其菌絲體之液態發酵生產靈芝多醣與靈芝酸及生物活性研究為主軸。如抗癌、抗氧化及美白功效等。

- **釀酒酵母育種與酒類發酵:**

自有人類文明記載以來，各種酒類與人群日常生活存在密切關係。紅酒具有多種保健成分，其中白藜蘆醇 (resveratrol) 的臨床觀察更備受矚目，包括減少心臟病與中風、預防動脈硬化、抗腫瘤、抗發炎、預防第二型糖尿病、預防神經系統退化等 。本實驗室之開發重點即為酒類 (紅酒與啤酒) 發酵製

程研究與產香酵母菌育種。

生醫敷料開發與應用:

近年來，生物醫材研發著重在提高生物活性、生物降解性、生物可吸收性及無細胞毒性。此外，傷口促癒效果、無痛治療等特性亦是選擇材料重點。本實驗室利用細菌發酵所生產的細菌性纖維素(簡稱 BCel)。可透過加工修飾，提升抑菌能力，或使其負載藥物釋放至傷口進而促癒。藉由這幾種特性開發出適用於不同傷口照護所需的新式敷材，或是醫美級面膜產品。

銀髮保健食品開發:

根據統計，現在的台灣人，平均 6 個人照顧一個老人，在 2025 年，台灣已經迎來超高齡社會。因此，可預期且將倍數成長的銀髮族人口，讓銀髮族食品需求及商機展露，成為近年國內外關注的趨勢議題。本研究團隊積極開發以發酵台灣本土素材，如台灣藜、樹豆等強化對於銀髮族健康有助益之發酵產品，並進行後續營養效能評估。

生物反應器設計與開發:

生物反應器為微生物醱酵生產之重要工具，不同微生物所需之生長環境亦有不同。針對特定微生物進行生物反應器之設計與開法，為生物工程領域之重要子題。本研究室亦針對不同微生物如黴菌、酵母菌與細菌等工業微生物之生產，進行生物反應器開發與設計，以期提高產能與利用效率。並針對不同之微生物生產系統，進行生物模擬與評估，以追求實驗數據之正確性與可預測性。

<u>重要發表 (2022~2025)</u>

1. Khumsupan, D, Lin, SC, Huang, YC, Chen, CM, Chi, HW, Jantama, K, Lin, HW*, **Cheng, KC*. 2025**. Creating a robust and reusable cell immobilization system for bioethanol production by thermotolerant yeast using 3D printing and soybean waste. *Industrial Crops & Products*, 224:120434.
2. Lin, SP, Hong, L, Hsieh, CC, Lin, YH, Chou, YC, Santoso, SP, Hsieh, CW, Tsai, TY, **Cheng, KC***. **2024**. In situ modification of foaming bacterial cellulose with chitosan and its application to active food packaging. *International Journal of Biological Macromolecules.* 279(3), 135114
3. Huang, YC, Khumsupan, D, Lin, SP, Santoso, SP, Hsu, HY, **Cheng, KC*. 2024.** Production of Bacterial cellulose (BC)/nisin composite with enhanced antibacterial and mechanical properties through co-cultivation of *Komagataeibacter xylinum* and *Lactococcus lactis* subsp. Lactis. *International Journal of Biological Macromolecules*. 258(2):128977.
4. Chen, HY, Khumsupan, D, Patel, AK, Kee, PE, Ng, HS, Hsu, HY, Lin, SP, **Cheng, KC*. 2024**. Immobilization of *Kluyveromyces marxianus* K21 via coaxial electrospinning of PVA and sugarcane bagasse composite for bioethanol production. *Applied Energy*. 356:122405.
5. Hsieh, CC, Yu, SH, Kuo, HC, Cheng, KW, Hsu, CC, Lin, YP, Khumsupan, D, Lin, SP, Angkawijaya, AE, **Cheng, KC*. 2024.** Alleviation of PM2.5-induced alveolar macrophage inflammation using extract of fermented *Chenopodium formosanum* (Djulis) sprouts via regulation of NF-κB pathway. *Journal of Ethnopharmacology*. 318(B):116980.

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臺大食品科技研究所

食科所成立於 1976 年，為臺大生物資源暨農學院中第一個未設大學部之獨立研究所。70 年代國內食品工業尚處萌芽階段，對於食品科技人才之需求極為殷切。有鑑於此，當時在美國羅格斯大學食品科學系任教，且擔任我國經濟部食品科技顧問之張駟祥教授等人乃提出建議，由臺大向教育部申請設置「食品科技研究所」，在經濟部、農委會及食品產業界等之支持下，本所因而獲准成立。本所現任所長為羅翊禎教授。

本所為一獨立研究所，所有教學研究均集中於獨立的四層樓建築，包括「食品科技館」與「食品研發大樓」兩部分，總樓板面積為 3,441 平方米。

1. 獨立研究單位 11 個，每一單位包括教師研究室、實驗室與研究生研究室或個人儀器室的空間。
2. 兩間共同核心儀器室: 一為食品物性分析儀器室，建置有三部質地輪廓分析儀、一部動態流變分析儀、兩部示差熱掃瞄分析儀、色差儀、粒徑分析儀、界面電位分析儀(Zeta Potential Analyzer)、膜通透性分析儀等；另一為食品化學實驗室，建置有兩套高效能液相層析儀、三套氣相層析儀、毛細管電泳分析儀、螢光波譜分析儀等。
3. 共同實驗室七間：(1)化學分析室；(2)細胞培養室；(3)免疫分析室；(4)動物房；(5)動物犧牲室；(6)發酵實驗室；(7)液相層析質譜儀室。
4. 五間教室和討論室：教室均具有完善的現代 E 化(電子控制)設備。
5. 實習工廠

本所設置之宗旨為「培育我國食品工業及教育研究機構所需之高級食品科技人才」。當前的任務包括：

- 教學：

  以培養具有保健營養知識之食品科技人才為教育目標。碩士班的教育目標是「培育我國在食品科學與技術領域所需之學術研究與產品開發人才」；博士班的教育目標是「培育我國在食品科學與技術領域所需之學術研究與產品研發之高級人才」。

- 研究：

  注重創新，進行具應用價值之基礎研究或具理論基礎之應用研究。

- 服務：

  對本所國際聲譽有助益之學術活動，以及公益性服務。優先順序為：有益於人群或國家者，有益於整體食品相關產業者，有益於機構單位或個別公司企業者。

臺大生物科技研究所

本所於 95 年 8 月 1 日正式成立，並於 95 學年度招收博士班學生，於 103 學年度招生碩士班學生。目前共有 9 位正式教師，皆具有博士學位。本所發展方向與重點：本所博士班的發展方向與重點在於培育我國「挑戰二〇〇八國家發展重點計畫」中所需之「生物科技」人才，此等人才在我國未來之發展重點包括「生物資訊」、「奈米生物醫學」、「組織工程與再生醫學」、「替代能源」及「基因體與蛋白質體學」等領域中將擔綱起關鍵之角色，而本所最主要的特色，除在於延攬國際傑出師資來台授課及研究，形成國際一流生物科技研究團隊，協助我生技產業發展外，亦將藉由本所之增設而進一步統合本校各學院有關生物科技的教學與研究資源，配合本校『生物技術研究中心』所開設的核心課程，集結成一個跨院系的龐大力量；再加入引入法律學院與管理學院的課程訓練，強化學生對生技產業的經營與管理能力，以便將來能夠實際投入生技產業界。同時，因為生技產業致勝的關鍵在於高科技研發，將以培養高級研究人力為積極目標，期能把握科技產業成功的最基本源頭。本所現任所長為林劭品教授。

教育目標與宗旨

專業知識的養成：培育學生具備紮實的生物科技的專業知識。

科技整合理念與研發精神的養成：培育學生獨立思考，主動發掘、分析、探討及解決問題，具備良好的表達能力，重視團隊合作。

生物科技倫理的認知：培養學生專業倫理的素養，體認身為國家科技人才所肩負的社會責任。

產業與國際視野的擴展：因應全球生物科技發展趨勢，培育學生具備前瞻性恢弘的國際觀，體認身為地球公民的社會責任。

核心能力

核心能力一：細胞與組織之再生科技學理知識與實務操作能力

核心能力二：生物科技核心技術操作能力

核心能力三：高等分子生物學與基因調控核心知識

核心能力四：生物科技倫理

核心能力五：創新思考及問題解決能力

核心能力六：團隊溝通與合作能力

核心能力七：領導與跨領域整合能力

核心能力八：國際觀

核心能力九：終身自我學習

臺大生物技術研究中心

本中心成立的宗旨在培育生技研發與產業人才，負責整合校內外資源，提供生技產業相關的轉譯研究媒合及教學平台，增進學生對分子生物學相關的生物科技知識與技能，期能提升國內生技研發的人才素質。過去十五年，我們已經建立旗艦般的 BCT 核心課程、三個專業學程與轉譯醫農專業與跨領域課程；我們籌設四個核心服務研究室，增加對全校師生的研究服務；我們成立產學研發實驗室，提供產學合作的新模式，最近四年，促成超過 30 個研究計畫；我們開拓國際學術合作與交流，擴展師生的國際視野，推動三個國際遠距教學課程，促成四個國際雙學位學程。在 2012 年，我們提出新的座右銘，希望能達成新的使命。現任主任為臺大生化科技系-何佳安特聘教授兼臺大生科院副院長。

新座右銘，新的使命

前瞻	能前瞻設想方能提出好的未來願景
創新	具創新創意方能發揮優勢的競爭力
培力	培養優質人才以便發展生技的未來
博涯	塑造中心成為生技產業人才的基石

組織與職掌

生物技術研究中心最高指導單位是由本校副校長從產、官、學各界召集 15 位專家學者組成的諮議委員會。中心行政則由中心主任率五位組長，分掌教學、研究開發、技術服務、產學合作與資訊智財各項業務，各由本校生物技術相關教師兼任，此外中心合聘研究人員 17 位與助理研究學者 1 位，於各領域從事研究工作。

國立臺灣大學
生物技術研究中心

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臺灣農業化學會

組織與會員

「台灣農業化學會－Agricultural Chemical Society of Taiwan」成立於 1963 年 5 月 1 日，原名為「中國農業化學會－The Chinese Agricultural Chemical Society」，於 2003 年 6 月更名為目前名稱，為國內最早向內政部登記立案的非營利學術性社團之一。本學會涵蓋學術範圍包括微生物、食品科學、生化與營養及土壤環境與植物營養等領域，以聯絡國內外專業人士共同增進我國農業化學之貢獻及發揚學術研究為宗旨。目前會員人數有 500 餘位，其中永久會員 259 位，普通會員 200 餘位及團體會員 5 單位。本學會現任理事長為臺大食科所呂廷璋教授。

任務

本學會之任務定為：(1)提倡農業化學研究、(2)舉辦農業化學演講及討論、(3)搜集國內外有關農業化學圖書供學術界及實業界之參考、(4)發行學術刊物，以及(5)辦理其他有關農業化學事項。

學會期刊

臺灣農業化學與食品科學 (Taiwanese Journal of Agriculture Chemistry and Food Science) 學術期刊是由台灣農業化學會與台灣食品科學技術學會共同發行，內容以刊載台灣農業化學會與台灣食品科學技術學會兩學會會員之研究論文，舉凡與農業化學、生物化學、分子生物學、生物技術、微生物學、發酵化學、土壤與環境保護、污染土壤整治與復育、食品科學以及食品營養學等相關之研究報告或論著，且從未在國內外雜誌發表或投稿者均為本刊徵稿之對象。「臺灣農業化學與食品科學」學術期刊內容俱為國內外一流研究機構及大學院校研究人員的研究心血，並或有國外大學及研究機構著名學者之論著，堪稱一內容豐富且具高學術水準之刊物。本刊隨時接受作者投稿，稿件收件登錄後，由編輯委員或總編輯邀請符合該稿件領域之專家學者二人進行審查，並經修訂及復審通過與仔細的文字編輯校訂後，方能刊印於期刊上。「臺灣農業化學與食品科學」期刊為國內最具盛名的學術研究期刊之一，其刊載之學術論文內容創新，編排印刷精美，是從事相關研究的學者與其他專家分享研究成果及最具參考價值的學術期刊。現任期刊總編輯為臺大食科所鄭光成教授。

臺灣食品保護協會

沿革

台灣食品保護協會 (Taiwan Association for Food Protection, TAFP) 之台灣在地組織，於民國 100 年 10 月 28 日向內政部申請籌組，經內政部民國 100 年 12 月 19 日台內社字第 1000242821 號函准同意辦理籌組事宜。本會現任理事長為黑松企業董事長張斌堂先生。

協會宗旨

台灣食品保護協會為國際食品保護協會 (International Association for Food Protection, IAFP) 之第 48 號國際分會。國際食品保護協會成立於 1911 年，成立目的在於提供會員與國際同步的食品安全最新相關資訊、先進的食品安全相關科學技術、提升全球國際食品安全適用之食品製造與供應方法及有效食品安全預防措施之水準，並作為與國際食品安全組織重要之溝通橋樑。目前 IAFP 會員遍佈全球超過 50 個國家，透過網路、教學計畫、期刊雜誌等多元化運作達成維護食品安全的宗旨。

IAFP 國際分會更進一步提升臺灣食品安全

民國 100 年也適逢 IAFP 創立百年，在 IAFP 的百週年慶與來自全球 2500 多位與會者的見證下，台灣食品保護協會接受 IAFP 主席 Dr. Jaykus 授予國際組織分會證書 (Charter)。在台大食科所沈立言教授、周正俊教授、公衛系陳家揚教授，海洋大學潘崇良教授、輔大蔡宗佑助理教授和衛生福利部食品藥物管理署黃翠萍技正的努力與美國友人的協助下，讓台灣在對於雙方都具有特殊意義的時間點獲得國際組織分會資格認可，取得第 48 號 IAFP 國際分會的資格，實屬不易與榮耀！期盼藉此提升台灣的食品安全並取得最新的國際食品安全資訊，除了為國人把關食品安全，更能協助食品產業了解國際規範，對台灣的經濟發展將有莫大的助益！

會徽意涵

台灣食品保護協會會徽，在國際食品保護協會 (IAFP) LOGO 當中，加入台灣圖形，代表台灣食品保護協會為國際食品保護協會之台灣分會之意涵。

台灣乳酸菌協會

人類對於健康，除了注重醫療科技的進步使身體恢復健康、壽命延長之外；現代人對健康的觀念，則更進一步提昇到如何透過飲食來達到自體保養、免於求醫用藥而活的健康為積極目標。因著此概念的普及，使健康食品在這幾年蔚為風潮，而在衛生署健康食品認證的食品中，乳酸菌就佔了近一半，因此在現代人的心目中，乳酸菌幾乎成了"健康"的代名詞。而亞洲乳酸菌產業市場雖頗具規模，然而學術研究卻落後歐美各國，為此自 2000 年起，在幾位學界與業界之乳酸菌同好召集下，我國與日本、韓國等開始策劃並於 2002 年在日本東京正式成立亞洲乳酸菌協會(Asian Federation of Societies for Lactic Acid Bacteria,簡稱 AFSLAB)。而在參與策劃 AFSLAB 的同時，也積極策劃成立台灣乳酸菌協會（Taiwan Association for Lactic Acid Bacteria, 簡稱 TALAB），訂定「學術研究、國際交流、消費者教育、產業振興」為協會宗旨，希望結合產官學研，群策群力，除了謀求學術研究向下紮根，振興乳酸菌產業，更希望社會大眾因而同享乳酸菌保健的功效！現任理事長為國立海洋大學蔡國珍特聘教授。

學會工作

- ✧ 推動乳酸菌之研究發展、資訊交流與產業應用。
- ✧ 推動消費者教育，拓展乳酸菌相關產品市場。
- ✧ 參加國際乳酸菌相關會議，並經常與國內外乳酸菌相關組織聯繫與交流。
- ✧ 舉辦學術演講及研討會。
- ✧ 建議有關乳酸菌產業政策、標準及法規等相關事項。
- ✧ 辦理其他與本協會章程宗旨相關之事項。

本會預計於 2025/11/19~21 於台北市福華文教會館舉辦 15 屆亞洲乳酸菌研討會 (ACLAB15)，歡迎產官學研同好熱情參與。報名網址:
(https://www.aclab15.org/motion.asp?siteid=1007550&menuid=50148&postid=697938&lgid=1)

FUJEN CATHOLIC UNIVERSITY

乳 酸 菌 大 豆 發 酵 食 品 應 用 於 促 進 口 腔 保 健 之 研 究

The Application of Lactic Acid Bacteria-Fermented Soybean Products on Oral Health

蔡宗佑 學術特聘教授兼教務長

天主教輔仁大學食品科學系

2025.03.13 THU.

天主教輔仁大學 FUJEN CATHOLIC UNIVERSITY

以實證科學理論為基礎的乳酸菌發酵保健食品應用於預防醫學

Application functional foods fermented with lactic acid bacteria in prevention medicine based on EBR

- 發酵基質與乳酸菌株篩選

  Substrate of fermentation and screening the LAB from fermented vegetable

- 胚芽乳酸桿菌 TWK10 發酵豆奶對口腔健康促進之研究

  Study on the LAB-fermented soymilk for promoting oral heath

Soybean and soymilk

- The soybean (*Glycine max*), or soya bean, is a species of legume native to East Asia, widely grown for its edible bean, which has numerous uses.
- Approximately 85% of the world's soybean crop is processed into soybean meal and oil.
- soy sauce, soymilk, tofu, soy meal, soy flour, textured vegetable protein, tempeh, soy lecithin and soybean oil.
- Soymilk is the common soy-based foods in Asia

Isoflavones

- Conversion of glucoside isoflavones (GI) to aglycone isoflavones (AI) conjugated are conducted by ß-glucosidase

(Esaki and others 1994)

- AI are absorbed faster and in greater amount than GI in hosts.

(Setchell and others 2001)

- AI-rich products were more effective than GI-rich products in:
  - Improving anti-oxidant activity, anti-mutagenesis, and NO-mediated vascular relaxation
  - preventing chronic disease such as coronary heart disease
  - preventing menopausal syndromes symptoms
  - preventing cancer

(Anthony and others 1998, Clarkson and others 2001, Hendrich and Murphy 2001)

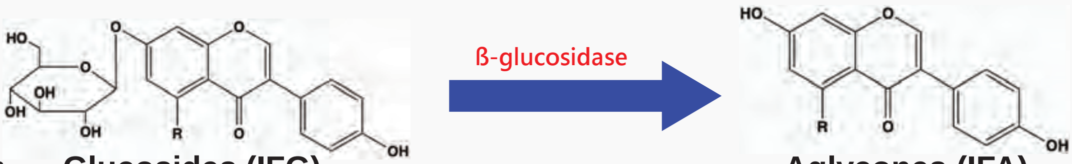
Fermented Soymilk

- Fermented soymilk have more isoflavone aglycone forms than the unfermented soymilk

(Chun and others 2007)

- Isoflavone aglycones are the biologically active estrogen-like isoflavones with the prevention and potential treatment of hormone-dependent disorders

(Chien and others 2006, Wei and others 2007)



R=OH: Genistin
R=H: Daidzin

Glucosides (IFG) → Aglycones (IFA)

R=OH: Genistein
R=H: Daidzein

辣椒
Taiwanese pepper
TWP

苦瓜
Taiwanese Bitter Gourd
TWBG

綠花椰菜
Taiwanese Broccoli
TWB

山藥
Taiwanese Yam
TWY

白花椰菜
Taiwanese White Cauliflower
TWCF

白蘿蔔
Taiwanese White Radish
TWR

紅蘿蔔
Taiwanese Carrot
TWCT

甜椒
Taiwanese Sweet Pepper
TWSP

大白菜
Chinese Cabbage
CHC

金針菇
Taiwanese Golden Mushroom
TWG

Screened the LABs from fermented vegetable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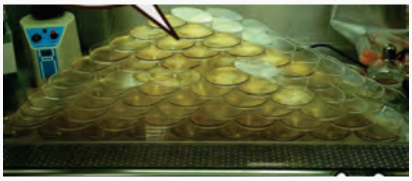
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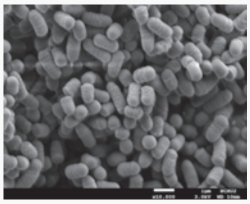
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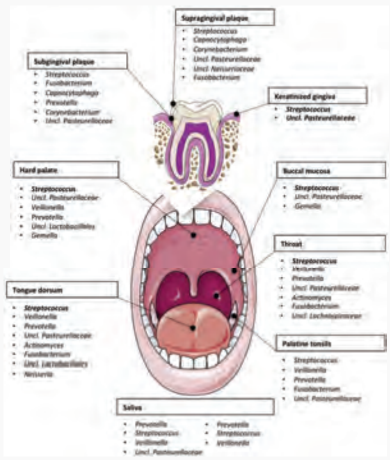
Oral microflora and pathogens

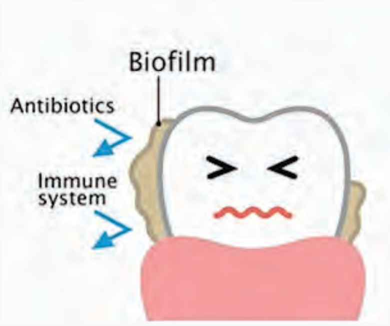
- Colonization:
  - teeth, buccal mucosa, tongue, soft and hard palate
  - species-rich and highly dynamic heterogeneous ecological system
- Cariogenic bacteria:
  - *Streptococcus mutans*
- Periodontal pathogens:
  - *Porphyromonas gingivalis* (PG)
  - *Aggregatibacter actinomycetemcomitans* (AA)
- Pathogenic factor:
  - oral biofilm (dental plaque)



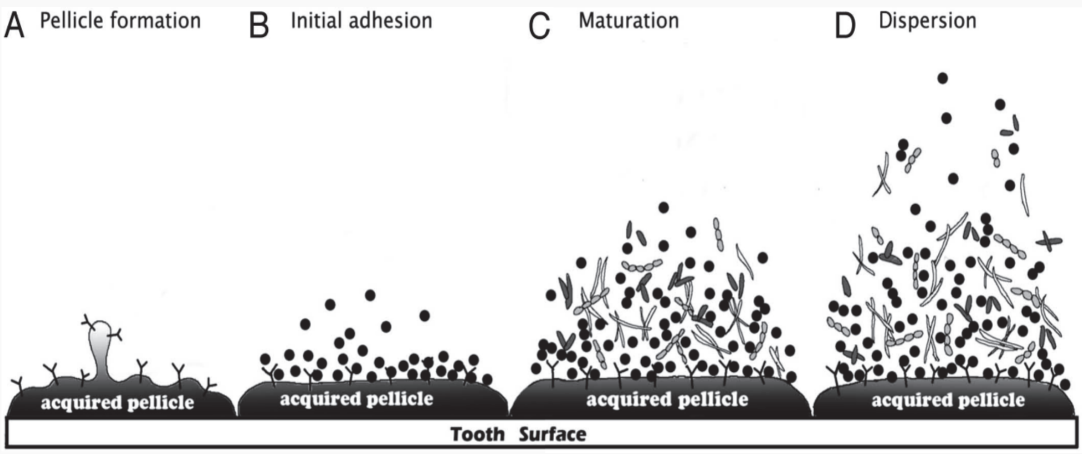
(Singhrao et al., 2015)

Oral biofilm

- Community of microorganisms that adhere to the surface of organic and inorganic materials at the solid-liquid boundary
- Dysbiosis
  - Dental caries
  - Periodontal disease
  - oral candidiasis
- Conventional treatments
  - nonsurgical treatment (scaling and root planning)
  - surgical treatment (flap surgery, guided tissue regeneration…)
- Side effects
  - reducing the perception of human taste
  - increasing resistance of pathogens to antibiotics



(Kriebel et al. 2018; Marsh and Zaura 2017; Zhang et al. 2017)



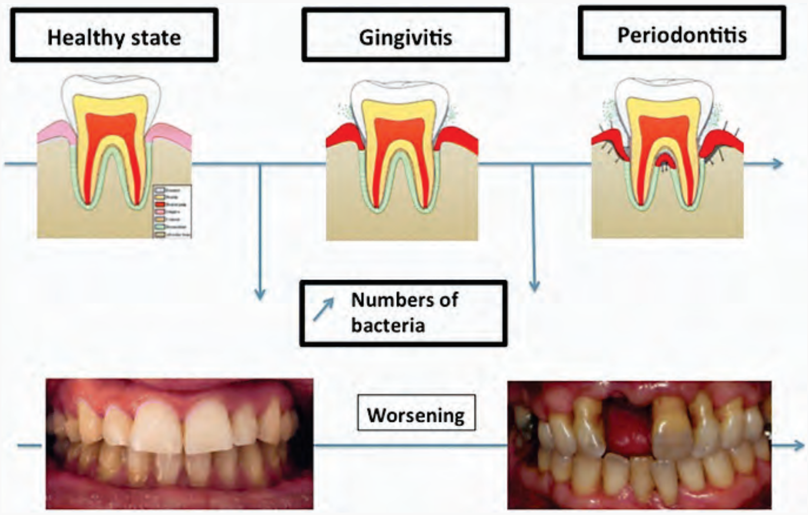
圖四、口腔生物膜形成。該圖呈現口腔生物膜形成的每一步。(A) 薄膜形成，薄膜是源自附著在牙齒表面的唾液糖蛋白、(B) 初始附著，唾液中的初始定殖細菌識別薄膜中的結合蛋白並附著在上面，這種粘附是可逆的、(C) 成熟，不同的細菌共聚集並形成成熟的生物膜、(D) 分散，細菌從生物膜表面脫離到新的位置。

Figure 4. Oral biofilm formation. This diagram represents each step of oral biofilm formation. (A) Pellicle formation. The pellicle is a thin film derived from salivary glycoproteins attached to a clean tooth surface. (B) Initial adhesion. Pioneer bacteria in saliva recognize the binding proteins in acquired pellicle and attach to them. This adhesion is reversible. (C) Maturation. Different bacterial species coaggregate and mature biofilm forms. (D) Dispersion. Bacteria disperse from the biofilm surface and spread to colonize a new site.

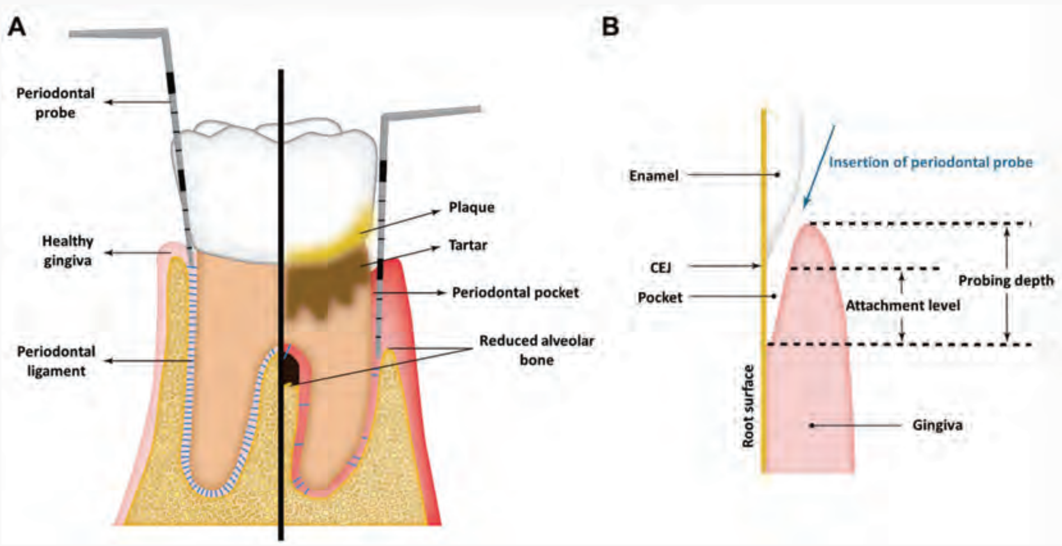
(Huang et al. 2011)

Oral disease-periodontitis

- Chronic inflammatory destruction of the gingival connective tissue resulting from continuous inflammatory response triggered by subgingival bacterial biofilm
- Risk factors:
  - oral biofilm (dental plaque)
  - smoke
  - diabetes
- Chronic periodontitis:
  - *P. gingivalis*
  - *Fusobacterium nucleatum*
- Aggressive periodontitis:
  - *A. actinomycetemcomitans*

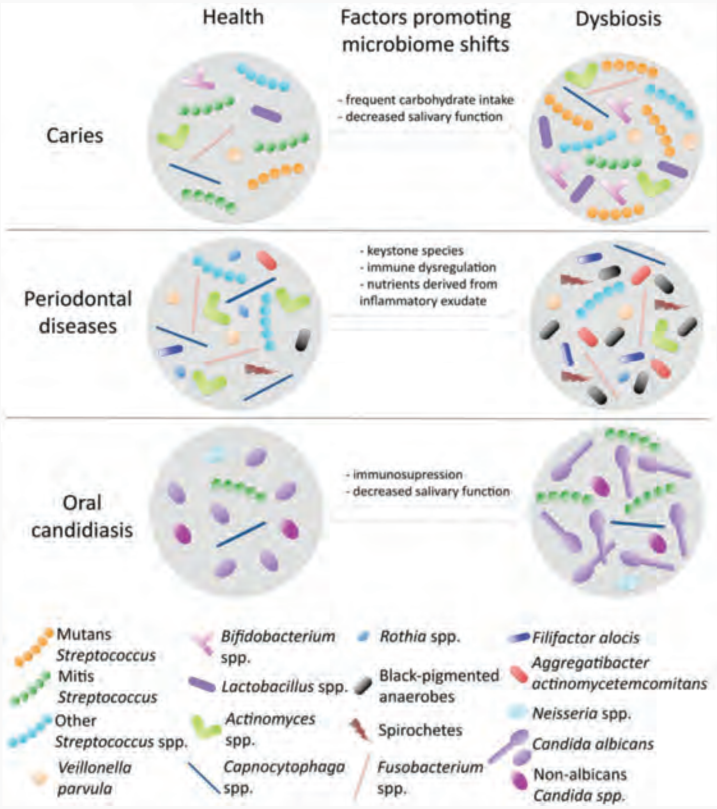


(Minty et al., 2019; Singhrao et al., 2015)



圖五、(A) 使用牙周探針測量牙周囊袋之深度與 (B) 健康牙齦組織之牙周囊袋深度不會超過 1-3 毫米。
Figure 5. (A) Examination of the gingival tissue with the use of a perioprobe to measure the depth of the gingival sulcus, or pocket depth. (B) Healthy gingival tissue will produce a pocket depth of no more than 1–3 mm. CEJ, cemento-enamel junction

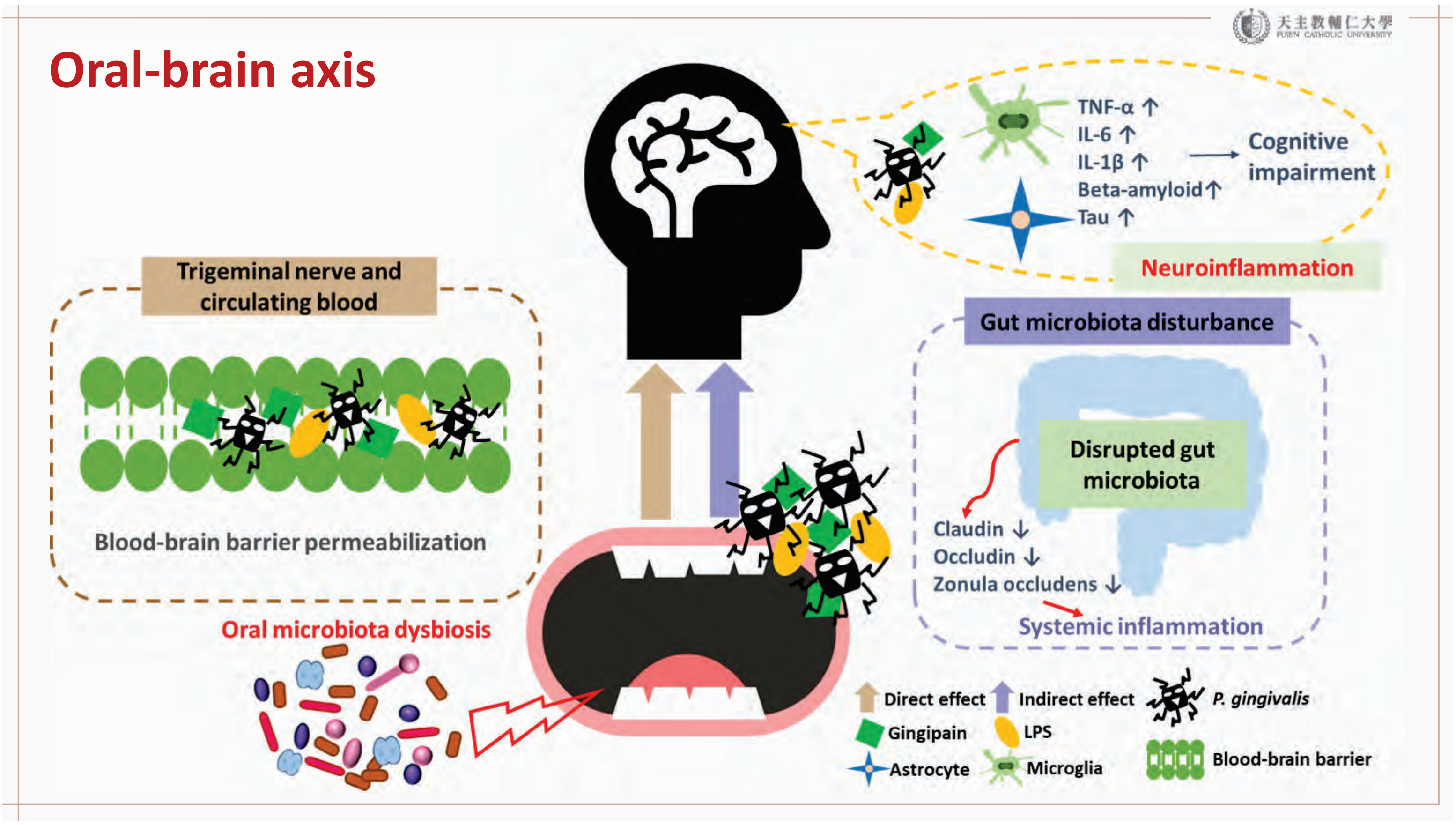
(Gross et al. 2017)



圖六、與口腔疾病相關的菌叢失衡變化。

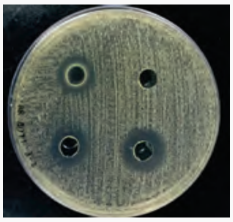
Figure 6. Dysbiosis changes associated with oral diseases. Oral diseases are associated with changes in microbiome community structure. Examples of microbiome community shifts and the main factors promoting the establishment of the dysbiotic microbiota are depicted for caries, periodontal diseases and oral candidiasis.

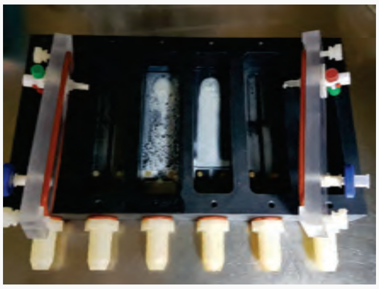
(Hoare et al. 2017)

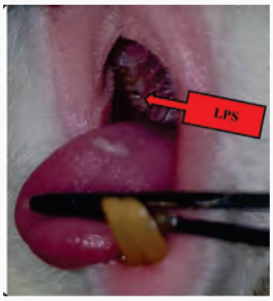


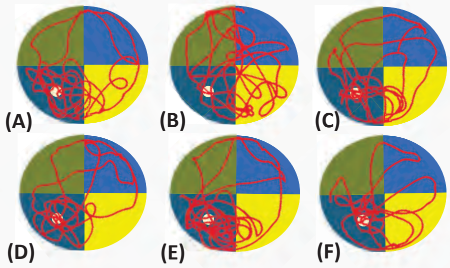
Objective

- Anti-microbial activities and anti-biofilm formation of LAB-fermented soy milk on oral pathogens.
- Anti-periodontitis and its associated cognitive impairment of LAB-fermented soy milk on lipopolysaccharide (LPS)-induced periodontal disease in rats.









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Research rationale


animals MDPI
Article
In Vitro Antibacterial Effect of the Methanolic Extract of the Korean Soybean Fermented Product Doenjang against *Staphylococcus aureus*
Klara Lalouckova [1,2], Lucie Mala [1,2], Petr Marsik [3] and Eva Skrivanova [1,2,*]


LWT - Food Science and Technology
Contents lists available at ScienceDirect
LWT - Food Science and Technology
journal homepage: www.elsevier.com/locate/lwt
ELSEVIER
Characterization of antimicrobial efficacy of soy isoflavones against pathogenic biofilms
Rekha Priyadarshini Albert Dhayakaran [a], Suresh Neethirajan [a,*], Jun Xue [b], John Shi [b]


REVIEW
Linking mechanisms of periodontitis to Alzheimer's disease
Mahtab Sadrameli[a], Praveen Bathini[a], and Lavinia Alberi[a,b]

- Isoflavones has shown antibacterial activities against *Staphylococcus aureus* and *Vibrio harveyi* in the *in vitro* studies.
  (Lalouckova et al. 2021)
- Soy isoflavones can inhibit *Listeria monocytogenes* and *Escherichia coli* biofilms formation at 10 mg/mL and 100 mg/mL concentration levels.
  (Albert Dhayakaran et al. 2015)
- In the past decade, a growing number of clinical reports have linked periodontitis to the development of dementia.
  (Sadrameli et al. 2020)

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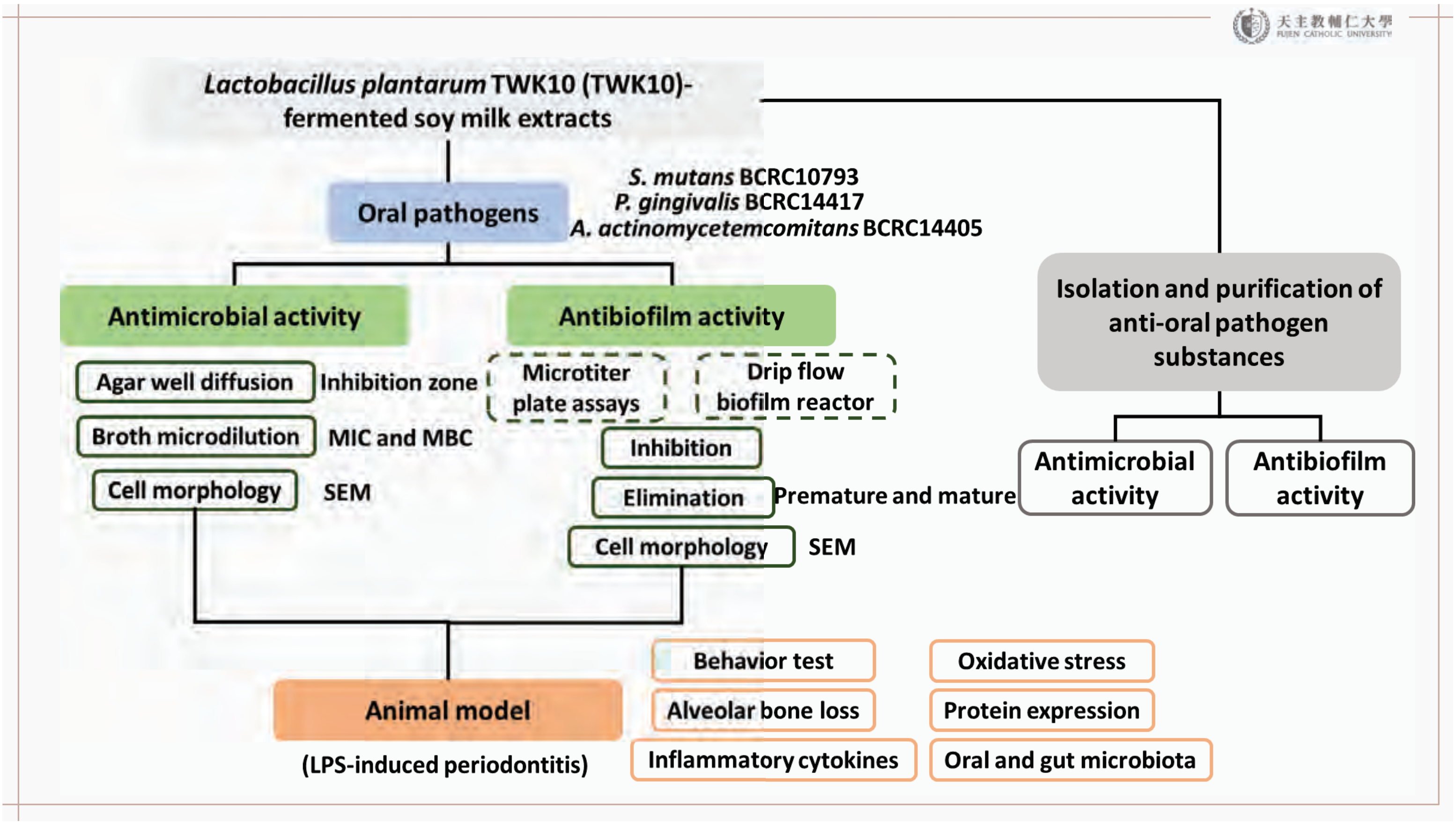

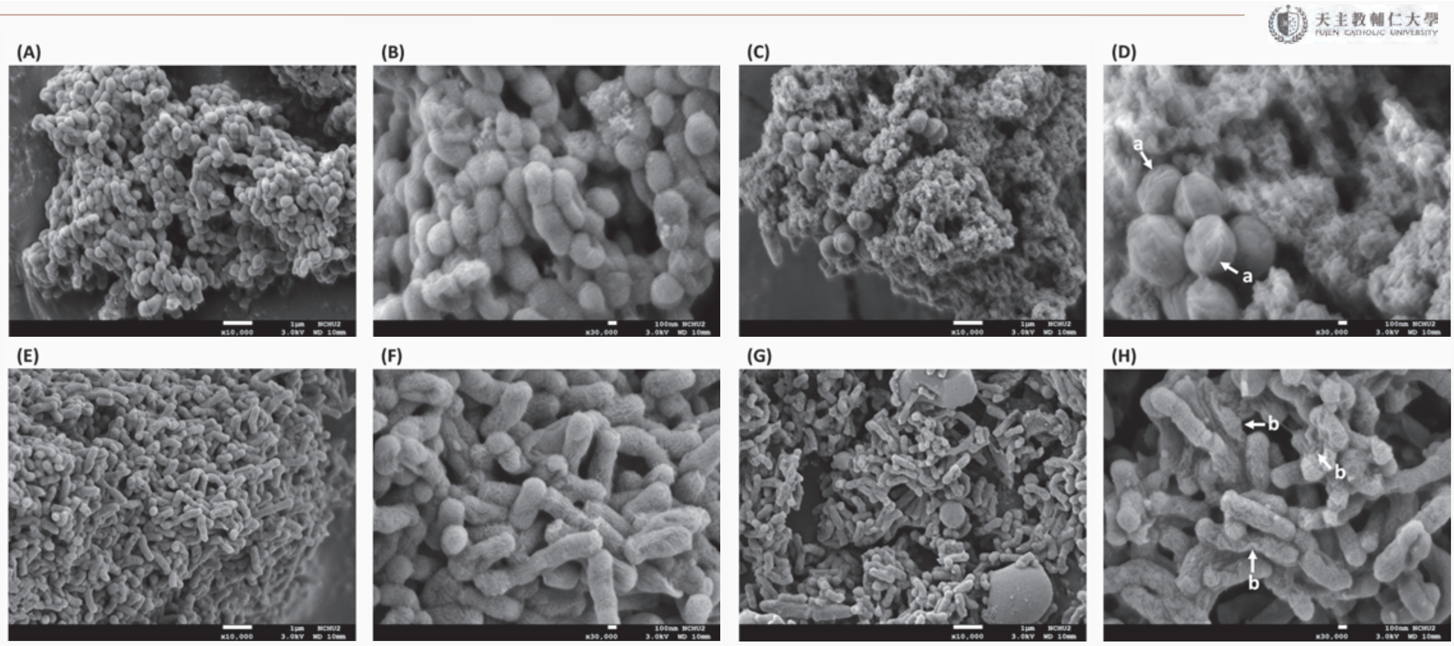

圖十、以熱場發射掃描式電子顯微鏡鏡檢經 TWK10 醱酵豆奶乙醇萃取物處理對 (A、B、C、D) *P. gingivalis* BCRC 14417 與 (EFGH) *A. actinomycetemcomitans* BCRC 14405 之影響。

Figure 10. Thermal field emission scanning electron microphotographs of *P. gingivalis* BCRC 14417 (A, B, C, D) and *A. actinomycetemcomitans* BCRC 14405 (E, F, G, H) cells being treated with ethanol extracts from TWK10-fermented soymilk at ×10,000 and ×30,000. (A, B, E, F) control; (C, D, G, H) ethanol extracts from TWK10-fermented. a – cracks; b - shrinking with irregularly deformed.

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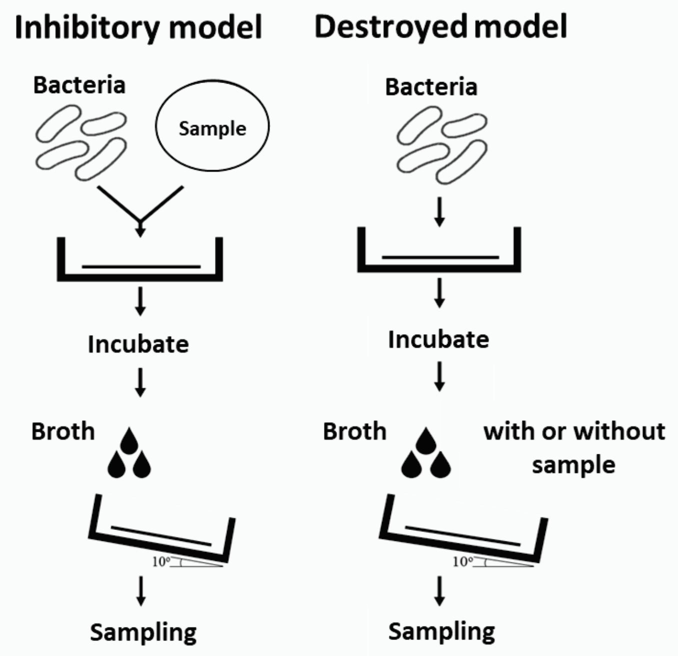
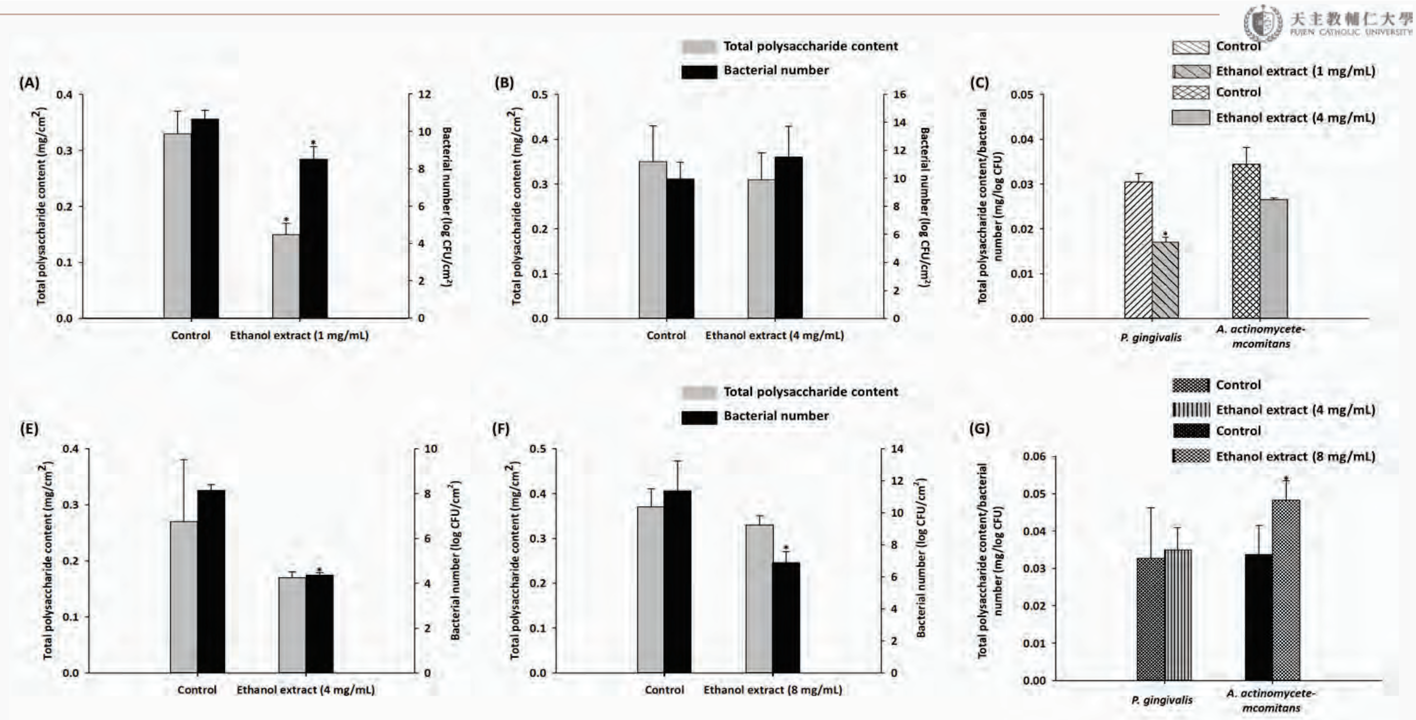


圖十二、滴流式生物膜反應器之試驗模型。

Figure 12. Experiment models on drip flow biofilm reactor .



圖十三、於生物膜反應器下 TWK10 醱酵豆奶乙醇萃取物對牙周致病菌之菌數、總多醣含量及生物膜中每單位牙周病致病菌之多醣產量之影響。

Figure 13. Effects of ethanol extract from TWK10-fermented soymilk on viable cell and total polysaccharide content of (A, E) *P. gingivalis* BCRC 14417 or (B, F) *A. actinomycetemcomitans* BCRC 14405 biofilm and (C, G) the production of polysaccharides per unit of periodontal pathogens in the biofilm with continuous flow. Results of A, B and C were pre-treatment with MIC of TWK10-fermented soymilk ethanol extract, and the results of E, F and G were post-treatment with MBC of TWK10-fermented soymilk ethanol extract. The data are presented as means ± SD (n = 3). *means significantly different from the control group in the same experimental item by Student's t-test ($p < 0.05$).

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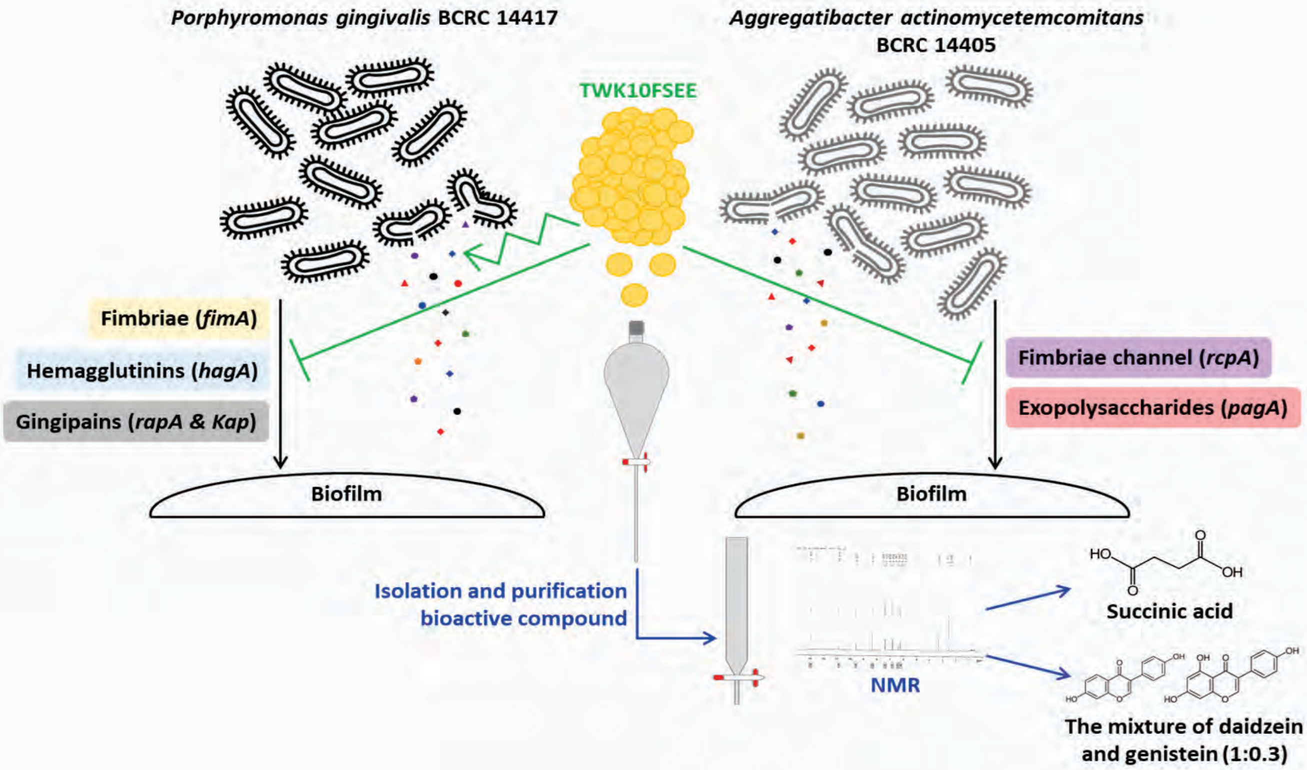

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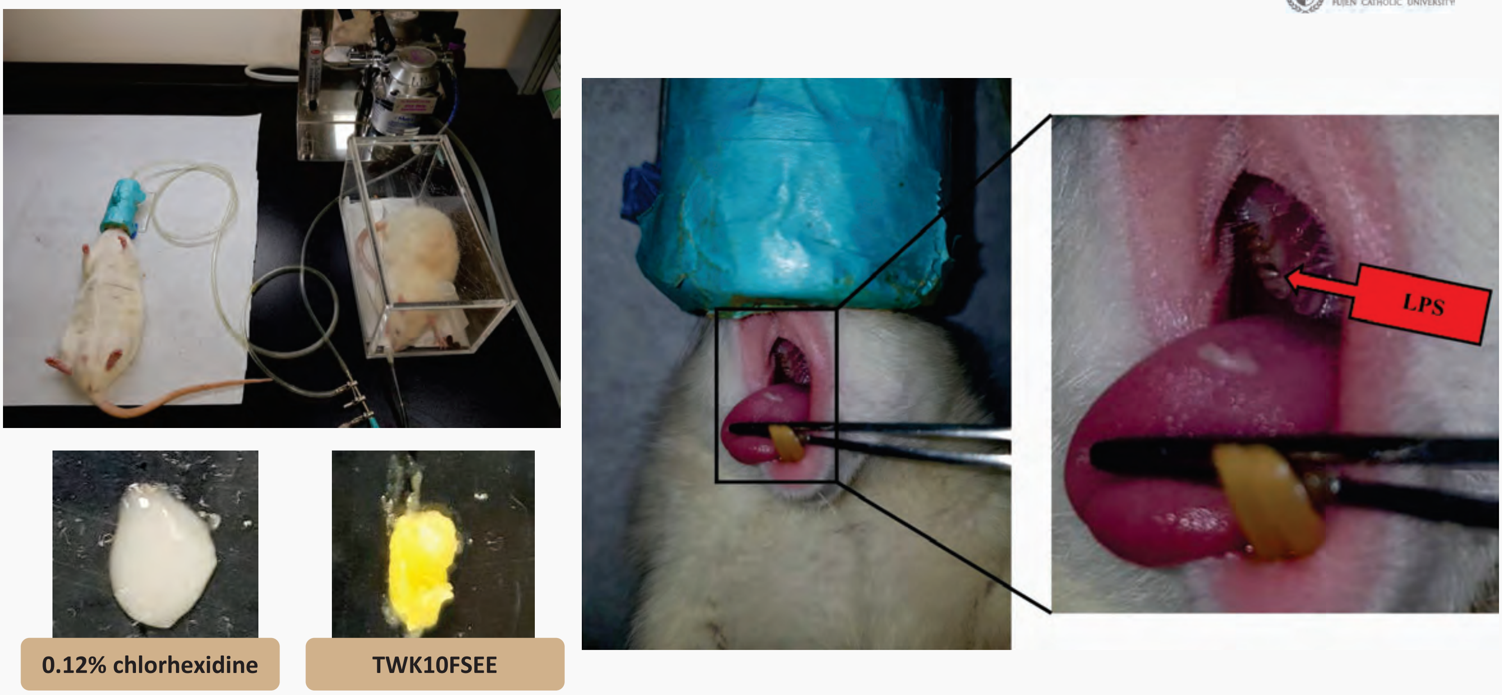
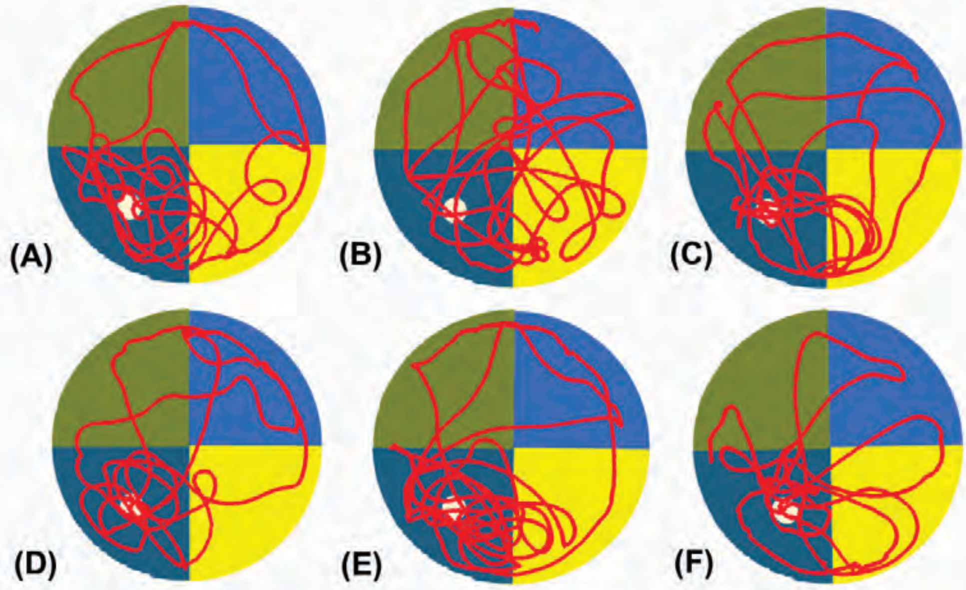


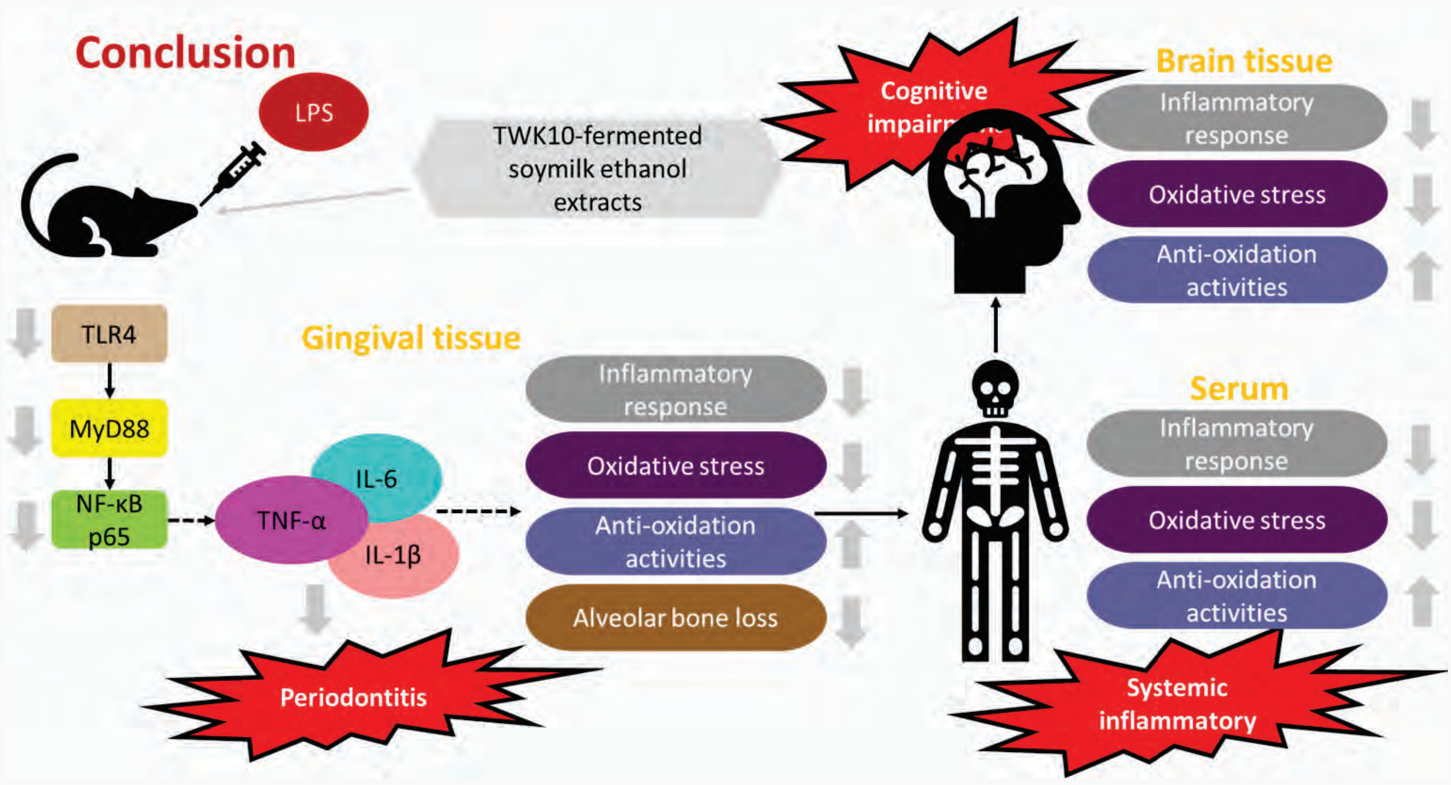
圖十七、注射脂多醣誘發大鼠牙周病之動物模式建立。

Figure 17. Establishment of LPS-induced periodontitis experimental rats animal model. LPS: lipopolysaccharide; TWK10FSEE: TWK10-fermented soy milk ethanol extracts.



圖十九、塗抹 TWK10 醱酵豆奶乙醇萃取物對經脂多醣誘導牙周病及其引發認知功能障礙大鼠於莫斯里水迷宮試驗中空間性探測試驗之游泳路徑圖。

Figure 19. Effects of spreading TWK10-fermented soymilk ethanol extracts on swimming pathways in Morris water maze in LPS induced periodontitis and its associated cognitive impairment rats (A) NC, (B) L, (C) PC, (D) LE, (E) ME, (F) HE. NC: normal control group; L: lipopolysaccharide-induced periodontitis group; PC: lipopolysaccharide-induced periodontitis positive control group with 0.12% chlorhexidine with CMC; LE: lipopolysaccharide-induced periodontitis with 0.036 g/kg bw of *L. plantarum* TWK10-fermented soymilk ethanol extract with CMC; ME: lipopolysaccharide-induced periodontitis with 0.072 g/kg bw of *L. plantarum* TWK10-fermented soymilk ethanol extract with CMC; HE: lipopolysaccharide-induced periodontitis with 0.144 g/kg bw of *L. plantarum* TWK10-fermented soymilk ethanol extract with CMC.



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Conclusion

- 老齡化社會結構以致慢性病發生率增加，保健食品的可為維護健康的選擇，並可減少醫療資源的支出
  - Population aging society causes a rise in prevalence of chronic diseases. The healthy functional foods are one of the candidate for stay healthy and reduce the medical expenditure.
- 進行有區隔性功效的產品開發可刺激新研究領域的發展並將低成本的農產品賦予新的經濟價值
  - The segmentation for development products will induce the motivation and marketing of novel products and raise the value added of traditional agriculture products.
- 深耕保健食品的功能與作用機制的探討，可使開發之保健食品功效指標化、產品科學化的立論基礎
  - Study on the efficiency and mechanisms of healthy functional foods will lead to the development of functional foods that is based on the biomarker and sciences.

簡歷

學歷

B.Sc. (1991-1995) 台大農化系

M.Sc.& Ph.D. (1999-2004) 東京大學應用生命化學系

研究經歷

2004-2008: 東京大學生物生產工學研究中心博士後研究員

2008迄今:台大生物科技研究所專任教師

2021迄今:台大農化系合聘教師

研究興趣

Symbiosis (Microbe-Plant interactions)

Environmental Microbiology

Agricultural Biotechnology

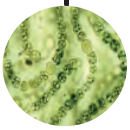
2

光合菌 Photosynthetic bacteria（PSB）

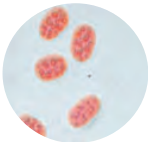
National Taiwan University

(1)產氧之光合細菌 Oxygenic photosynthetic bacteria：

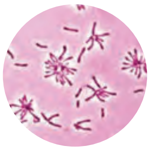
Cyanobacteria 藍綠菌



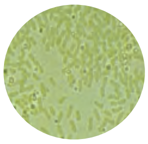
(2)不產氧之光合細菌 Anoxygenic photosynthetic bacteria：
purple and green bacteria



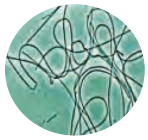
Chromatium



R. palustris



Chlorobiaceae



Chloroflexi

■廣泛分布於水田、河川、海洋和土壤中
■能將光能轉變成生長所需能量
■具有多樣的代謝路徑，可進行**固氮**、**固碳**、**硫化物氧化**等，與自然界中的**氮**、**磷**、**硫**循環有著密切的關係

(Hirashi et al., 1984; Oda et al., 2002; Hunter et al., 2008; Larimer et al., 2004) 3

光合菌在產業上之應用-1

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Fisheries industry 水產養殖業

- decrease NH_3 or NH_4^+, BOD; increase the rate of dissolved oxygen to modify the waste environment of aquaculture

Livestock industry 畜禽飼養業

- remove the waste to improve the feeding environment; as additional nutrients for fodder

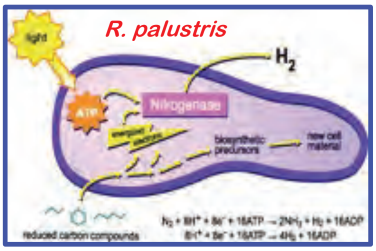
(Kaintachote et al., 2005; Tim. et al., 2013; Banerjee et al., 1999; Ponsano et al., 2011; Saejung & Apaiwong, 2015) 4

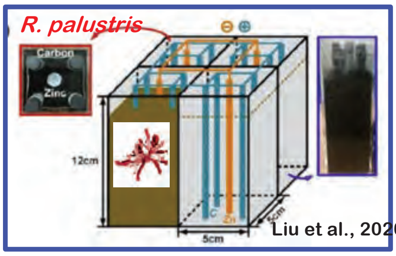
光合菌在產業上之應用-2

Bioremediation and sewage treatment 生物復育與廢水處理

- eliminate the polluting wastes, such as organic wastes, nitroaromatic compounds and hydrogen sulfide compounds

Production of hydrogen gas/ electricity as biofuel 生質能源





(Hardwood and Gibson 1988, Marvin-Sikkema and de Bont, 1994; Kim et al. 2004; Gosse et al. 2007; Liu.et al., 2015; Akbar et al. 2016, Liu et al., 2020)

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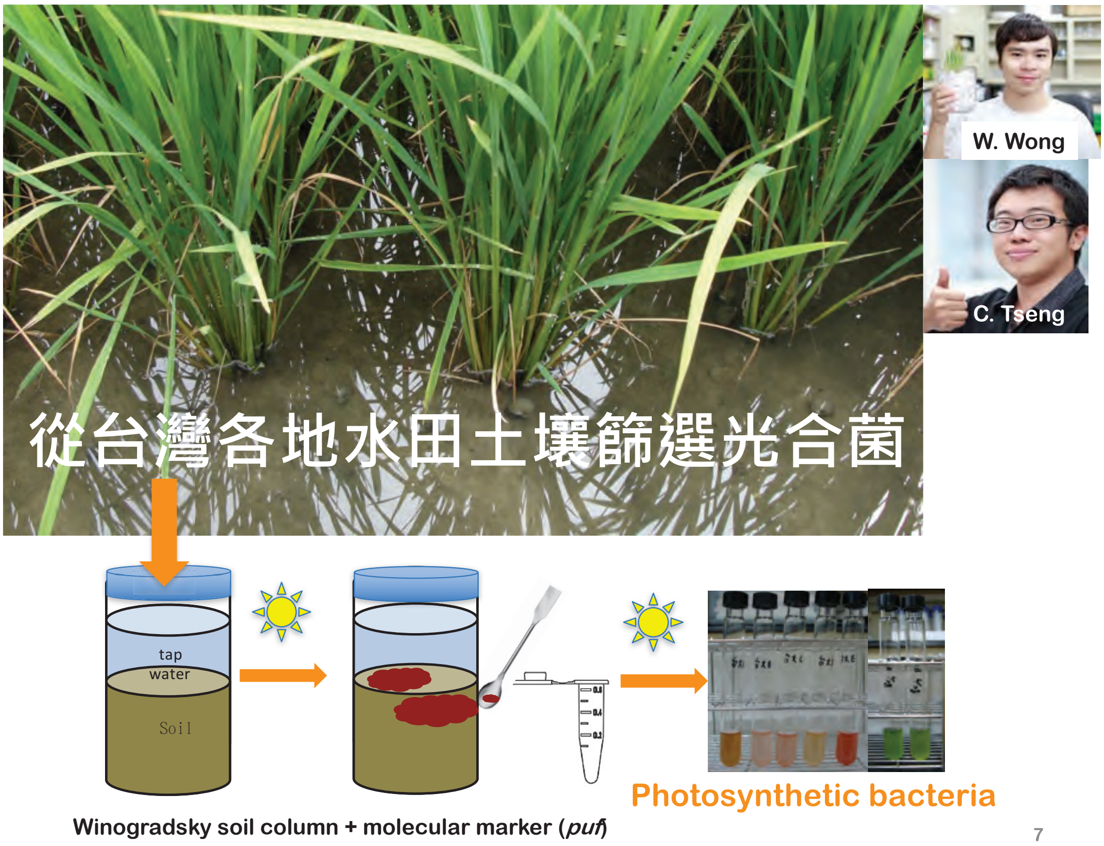
光合菌在高經濟作物上的應用

防止落果 Prevent "fruit drop"- avoid the formation of abscission layer,
e.g. Mango, Litchi, Betel palm

增加甜度與色澤 Enhance color, sweetness
e.g. Wax apple

延長開花期限 Extend flowering period, increase colors of flower, prevent blossom drop
e.g. Orchid

6



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大綱

1 應用光合菌促進作物生長與土壤肥力

2 應用光合菌減少農業溫室氣體排放

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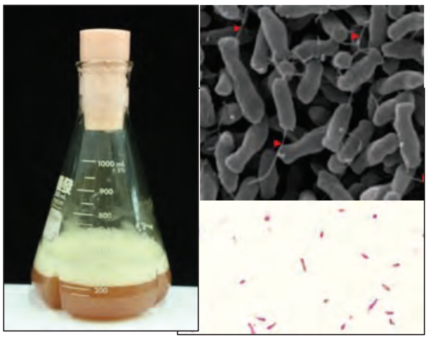
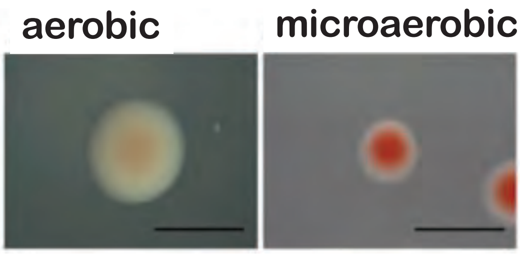
PS3 光合菌潛力菌株

National Taiwan University





- α-proteobacteria
- *Rhodopseudomonas palustris* 沼澤紅假單胞菌
- Phototrophic purple non-sulfur bacteria
- ~1um short rod, quick-moving
- Produce bacterial auxins (IAA)
- Fix nitrogen

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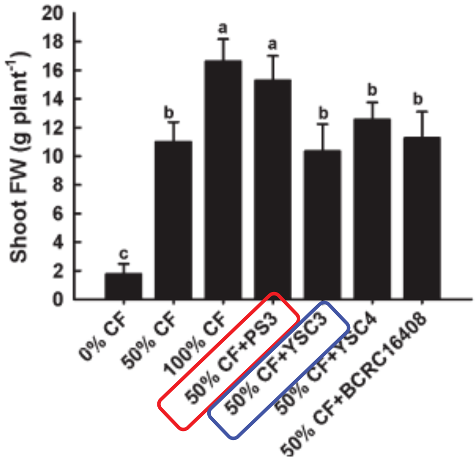
PS3 光合菌促進植物生長



100% CF, full amount of chemical fertilizer
50% CF, half amount of chemical fertilizer

Wong, et al. Microb Ecol, 2014

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農委會公告「已被鑑定為安全之微生物肥料菌種」(Safety bacterial strains for bio-fertilizer)

National Taiwan University

行政院農業委員會
COUNCIL OF AGRICULTURE, EXECUTIVE YUAN

附表 已被鑑定為安全之微生物肥料菌種

菌種種類及編號	菌種名稱（中文名稱）	台灣物種名錄物種 編號
1. 細菌類		
1-1	*Bacillus coagulans* （凝結芽孢桿菌）	110245
1-2	*Bacillus licheniformis* （地衣桿菌）	110246
1-3	*Bradyrhizobium japonicum* （ *Rhizobium japonicum* ）	110280
1-4	*Mesorhizobium loti* （ *Rhizobium loti* ）	110283
1-5	*Rhizobium leguminosarum*	110285
1-6	*Rhodopseudomonas palustris* （沼澤紅假單孢菌）	110281
1-7	*Sinorhizobium fredii* （ *Ensifer fredii, Rhizobium fredii* ）	110286
1-8	*Streptococcus thermophilus* （嗜熱鏈球菌）	110274
2. 真菌類		

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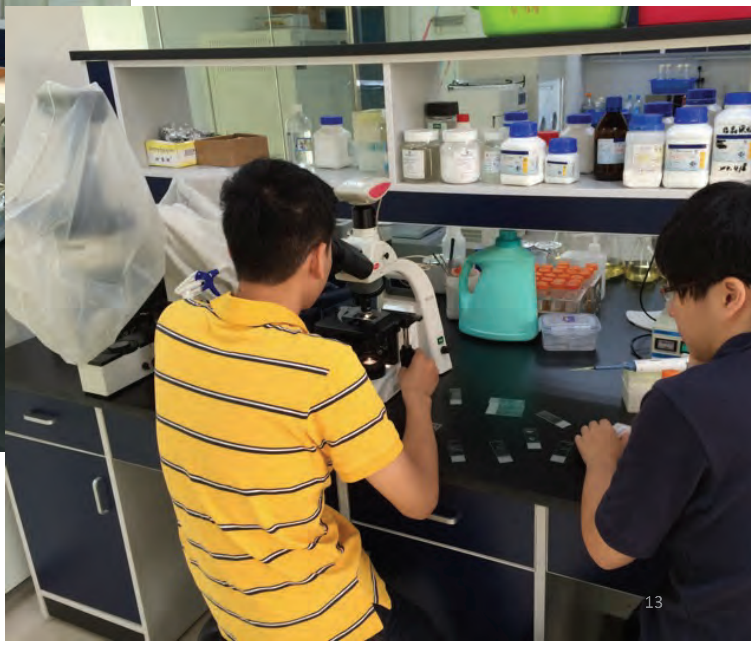
SIMTECH 興邦科技

National Taiwan University



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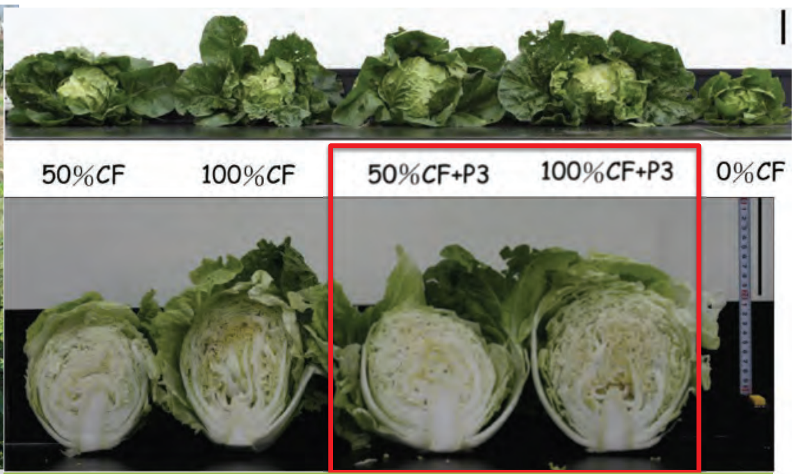
Conventional Farming
慣行農法



結球白菜葉球較大且內葉緊密 Ballhead cabbage with larger head and more tightly packed leaves

Yield (Kg/ 0.1ha)

50% CF	100% CF	50%CF +PS3	100%CF +PS3
2,374.2	2,679.3	3,303.6	3,723.4 ~39%↑

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慣行農法
Conventional Farming

National Taiwan University

Crops	Treatments	Yield (Kg/ 0.1ha)
Chinese flowering cabbage (Choi Sum)	100% CF	1,835.8
	100% CF +PS3	2,328.4
Pepper leaves	100% CF	3402.9
	100% CF +PS3	4298.5

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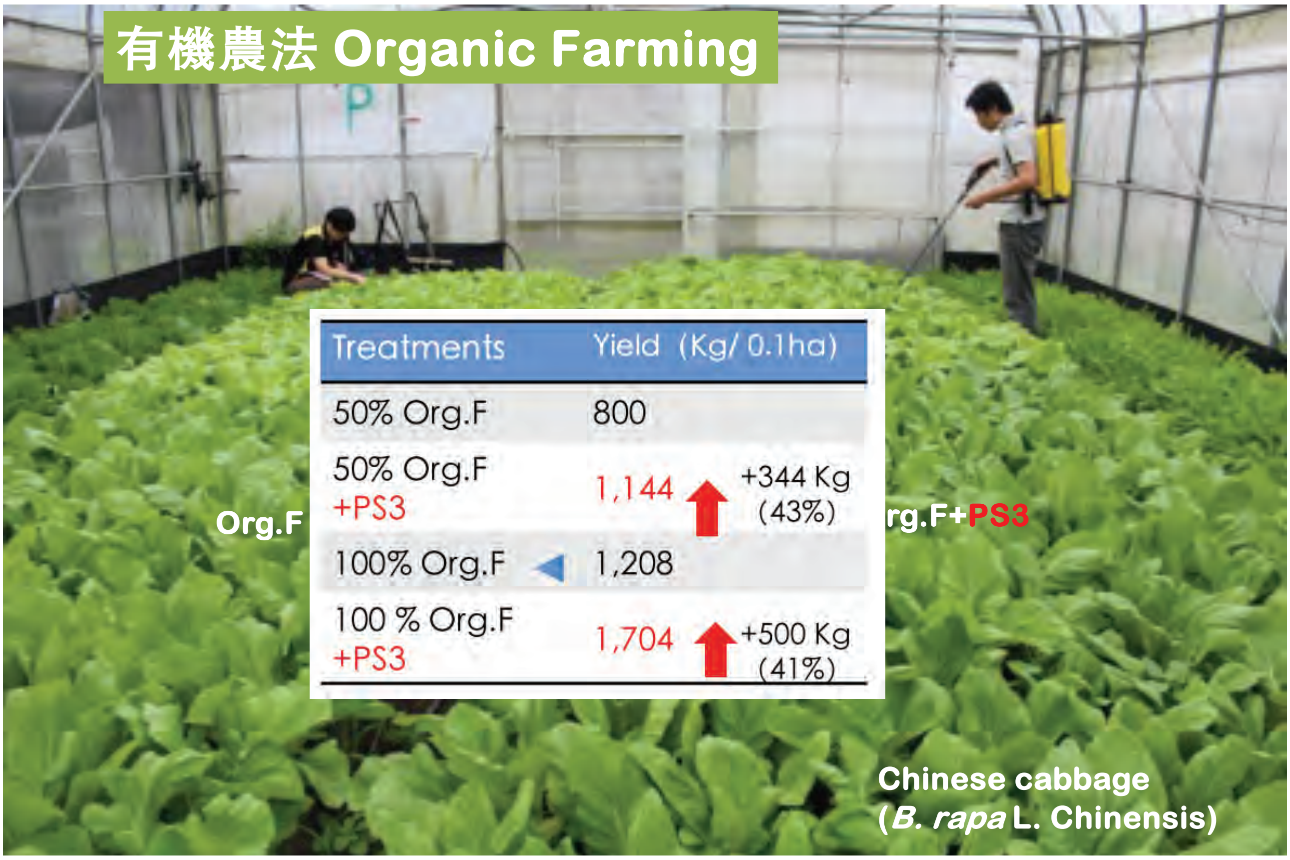
有機農法 Organic Farming



Treatments	Yield (Kg/ 0.1ha)	
50% Org.F	800	
50% Org.F +PS3	1,144 ↑	+344 Kg (43%)
100% Org.F ◀	1,208	
100 % Org.F +PS3	1,704 ↑	+500 Kg (41%)

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接種 PS3 光合菌之植體內總氮與氮素利用效率(NUE) 顯著提升

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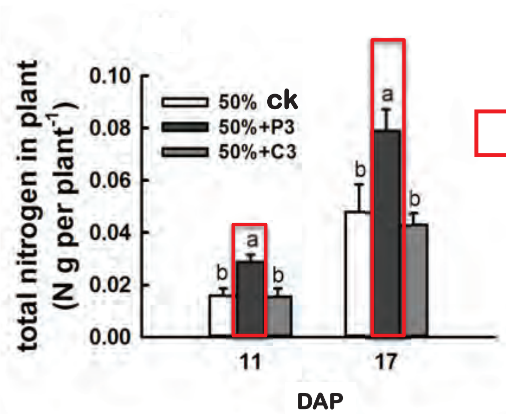
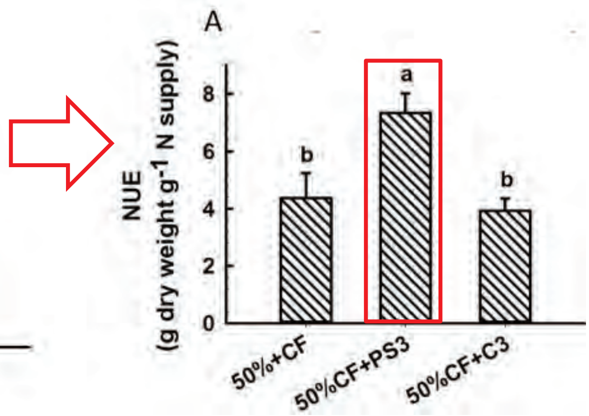
N-content in whole plant ↑



N use efficiency (NUE)



$$NUE = \frac{\text{Plant dry mass (g)}}{\text{Total N supply}}$$

Hsu et al. Front Plant Sci, 2021

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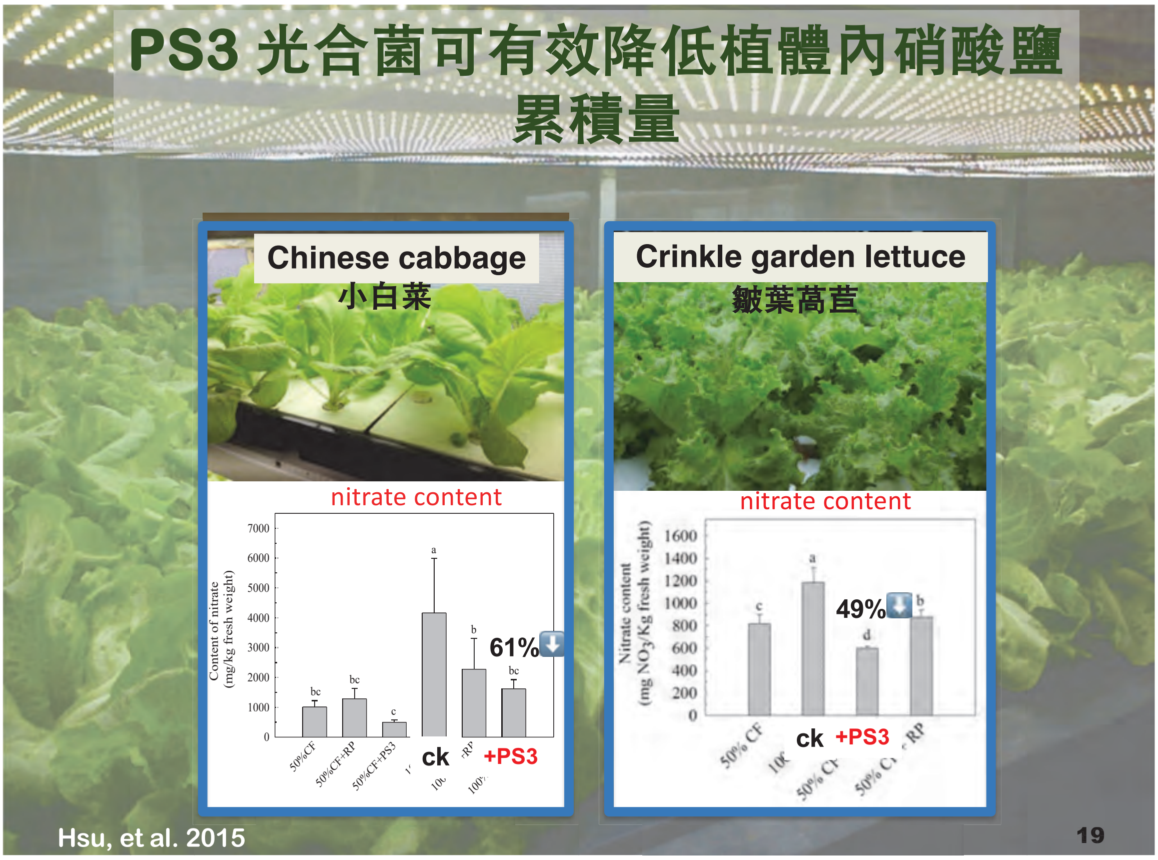

US010015935B2

(12) **United States Patent**
Liu et al.

(10) **Patent No.: US 10,015,935 B2**
(45) **Date of Patent: Jul. 10, 2018**

(54) **METHOD OF REDUCING NITRATE CONTENT IN A PLANT**

(71) Applicant: **National Taiwan University**, Taipei (TW)

(72) Inventors: **Chi-Te Liu**, Taipei (TW); **Huu-Sheng Lur**, Taipei (TW); **Kai-Jiun Lo**, Taipei (TW); **Shu-Hua Hsu**, Taipei (TW)

(73) Assignee: **NATIONAL TAIWAN UNIVERSITY**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 451 days.

(21) Appl. No.: **14/732,380**

(22) Filed: **Jun. 5, 2015**

(65) **Prior Publication Data**

US 2016/0242362 A1 Aug. 25, 2016

(30) **Foreign Application Priority Data**

Feb. 24, 2015 (TW) .... 104105867 A

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,175,258 B2 * 11/2015 Bywater-Ekegard C12N 1/12

FOREIGN PATENT DOCUMENTS

TW I464260 12/2014

OTHER PUBLICATIONS

Wong et al. "Promoting Effects of a Single Rhodopseudomonas palustris Inoculant on Plant Growth by *Brassica rapa* chinensis under Low Fertilizer Input". Microbes Environ. vol. 29, No. 3, 303-313, 2014.*

Shu-Hwa Hsu et al, "利用光合菌微生物肥料降低水耕葉菜類中的硝酸鹽含量/Nitrate content in hydroponic lettuce reduced by phototrophic bacteria", Corp, Environment & Bioinformatics, vol. 12, Mar. 2015.

* cited by examiner

Primary Examiner — Vera Afremova
(74) *Attorney, Agent, or Firm* — WPAT, PC

(57) **ABSTRACT**

The present invention provides a method of reducing nitrate

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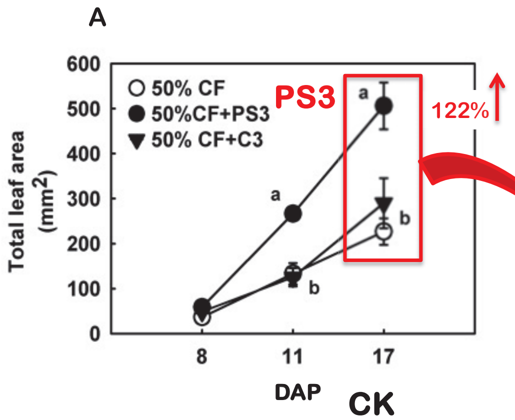
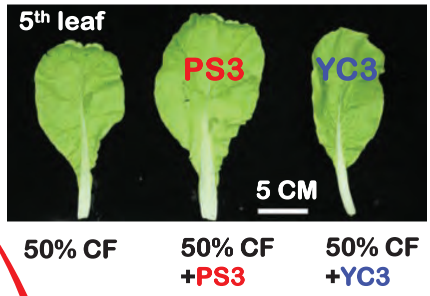
PS3 光合菌促進新葉葉面積顯著增大





	CK 50% CF	PS3 50% CF+PS3	YC3 50% CF+C3
1st leaf	18.42 ± 4.27 a	20.36 ± 5.37 a	18.90 ± 4.48 a
2nd leaf	29.15 ± 5.10 a	39.96 ± 7.93 a	45.83 ± 10.89 a
3rd leaf	60.13 ± 9.19 b	109.42 ± 6.53 a	76.25 ± 17.40 ab
4th leaf	57.95 ± 3.85 b	122.64 ± 11.05 a	80.74 ± 13.15 b
5th leaf	43.98 ± 12.15 b	112.46 ± 21.18 a	49.65 ± 8.04 b
6th leaf	26.72 ± 15.37 a	70.70 ± 15.53 a	28.55 ± 7.54 a
Total laef area plant^{-1}	227.44 ± 29.34 b	506.41 ± 51.94 a	290.40 ± 55.62 b

Young

young , fully expanded leaves

Hsu et al. Front Plant Sci, 2021

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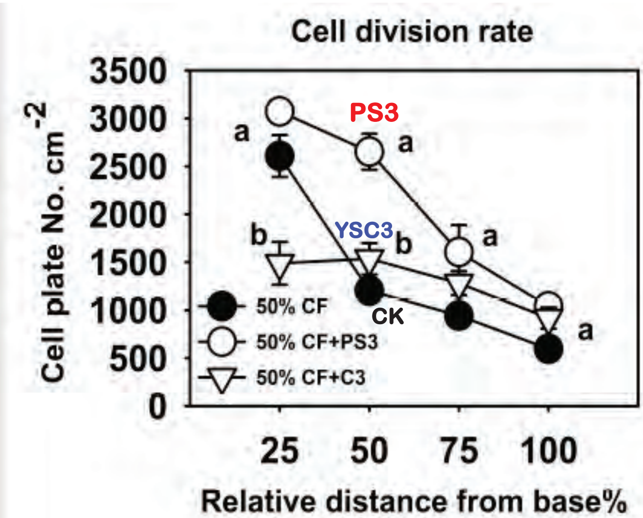
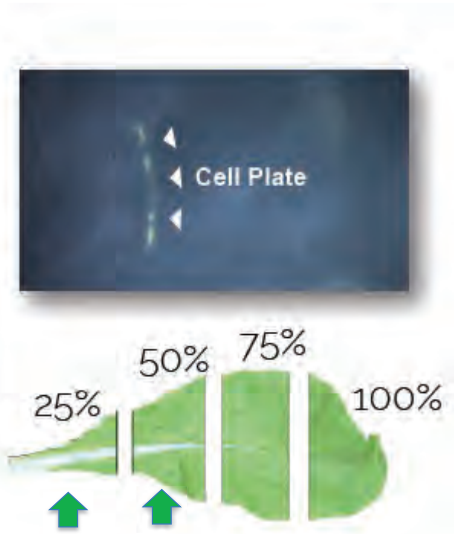
PS3光合菌提升葉基部細胞之分裂活性





Hsu et al. Front Plant Sci, 2021

PS3 prolonged the cell division activity in the leaf base

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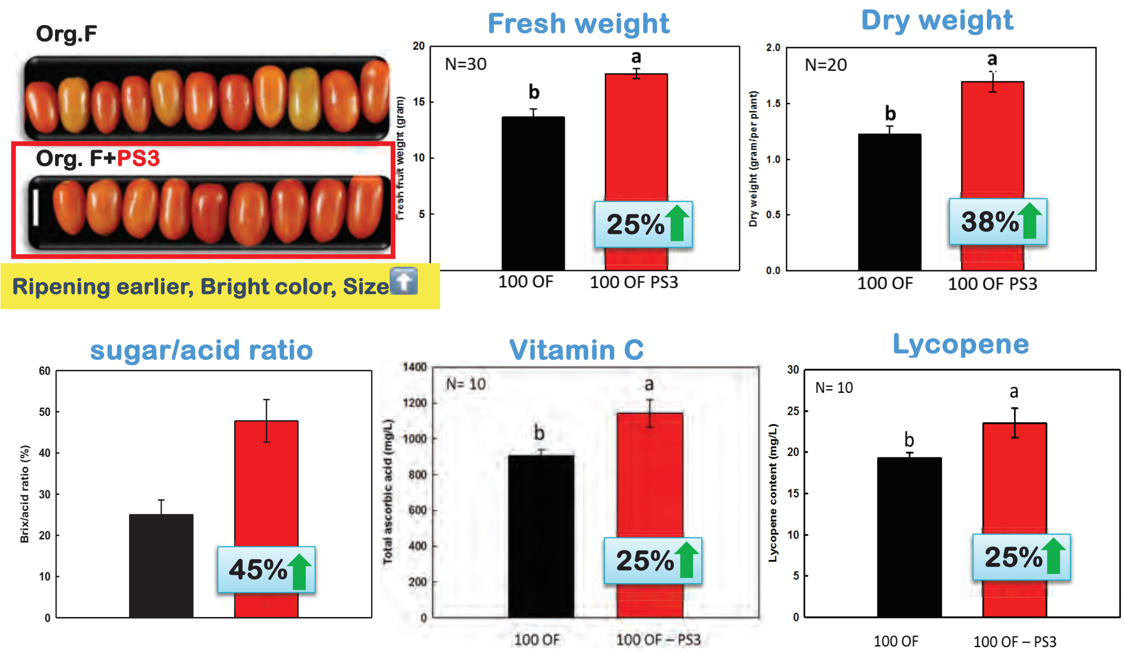
PS3 光合菌提升有機番茄的產量與品質

National Taiwan University



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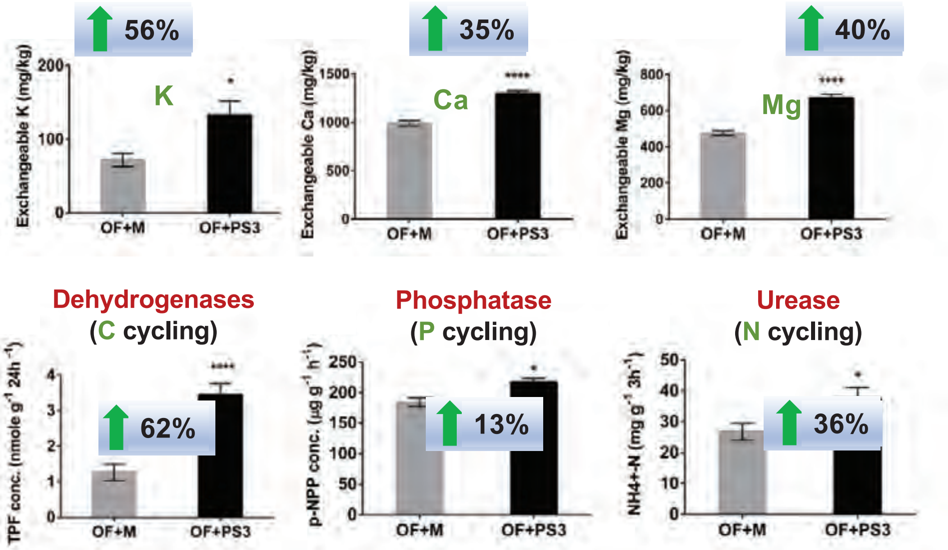
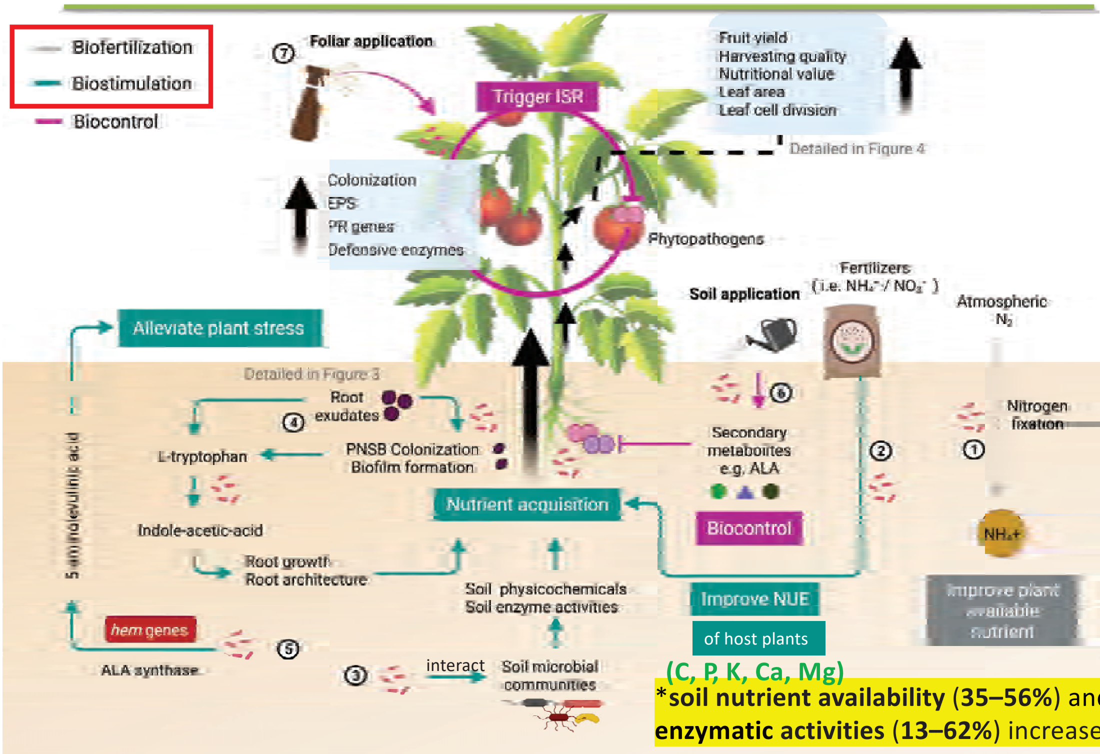
PS3提升土壤養分有效性和土壤酵素活性



✓ PS3 Inoculation enhanced the C-P-N cycling related enzyme activities

Lee et al., Front. Microbiol, 2022

Summary-1 PS3光合菌有利於植物生長的主要機制



(C, P, K, Ca, Mg)
*soil nutrient availability (35–56%) and enzymatic activities (13–62%) increased by PS3

大綱

1 應用光合菌促進作物生長與土壤肥力

2 應用光合菌減少農業溫室氣體排放

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溫室氣體 Greenhouse gases (GHG)

3 major GHG

- carbon dioxide (CO_2)
- 甲烷 methane (CH_4)
- nitrous oxide (N_2O) 氧化亞氮

CH_4 and N_2O are stronger contributors to global warming than CO_2 emissions

21 times the potential global warming impact than CO_2 *

310 times the potential global warming impact than CO_2 *

*全球暖化潛勢 global warming potential (GWP) within 100 year time horizon

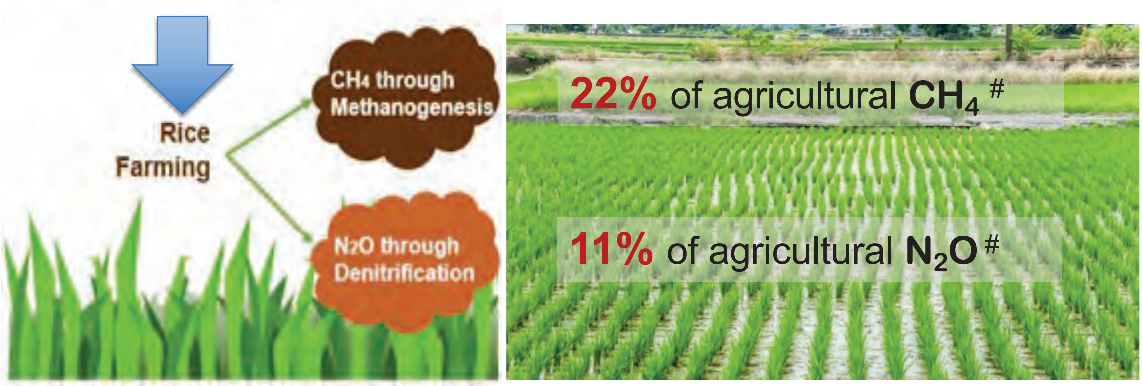
United Nations Climate Change

National Taiwan University

水稻田是CH_4 和 N_2O 的重要排放源

Agricultural practices emit over **50%** of global non-carbon dioxide GHG emissions

經由**農業活動**所排放的溫室氣體佔全球非二氧化碳溫室氣體排放量的 **50%** 以上



AgResults INNOVATION IN RESEARCH AND DELIVERY

Qian et al., Nature Reviews Earth & Environment, 2023

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在水稻田可增加碳封存以及減少碳排的手段

Emission reduction measures

Less and no tillage	Material recycling	New fertilizer
Straw disposal	→ Biological control	Deep placement of N
Green manure	Integrated farming	Biochar
Water saving irrigation	Multiple cropping rotation	Low-emission crop variety planiting
Intermittent irrigation	Conservation or reduced tillage	High-yield cultivation

Adapted from Ji et al., Front. Sustain. Food Syst. 2024

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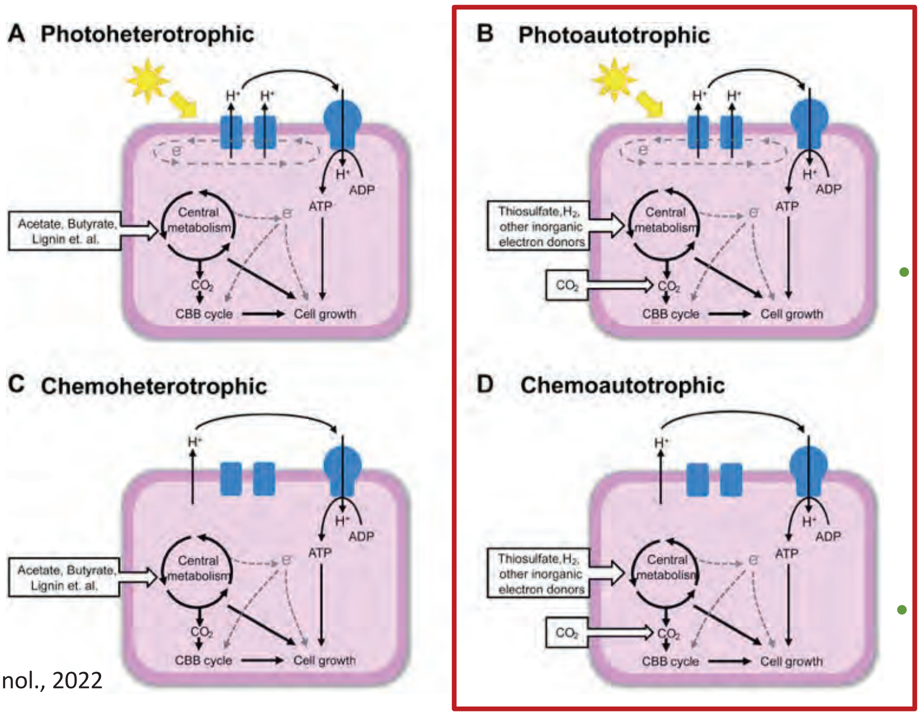
R. palustris 具多元代謝路徑

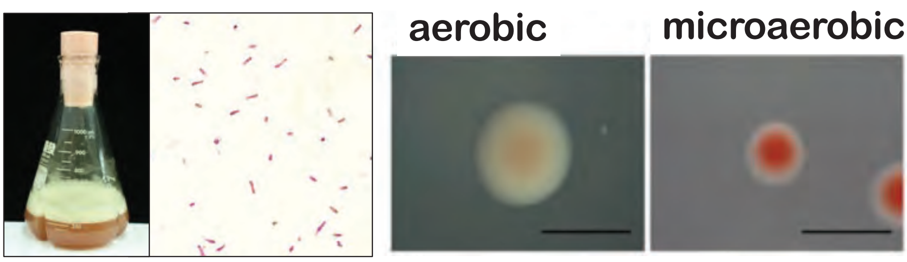


- Fix CO_2
- Fix CO_2

Li et al., Front. Bioeng. Biotechnol., 2022

National Taiwan University

Rhodopseudomonas palustris strain PS3



- Purple non-sulfur bacteria (PNSB)
- ~1um short rod, quick-moving
- Produce bacterial auxin
- Fix nitrogen
- Fix CO_2

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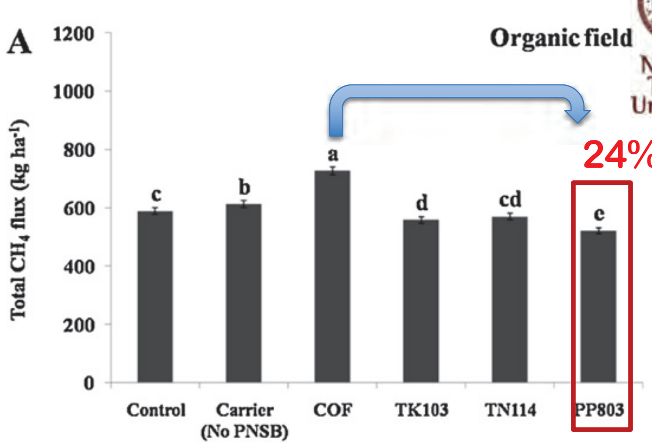
Applied Soil Ecology 100 (2016) 154–161
Contents lists available at ScienceDirect
Applied Soil Ecology
journal homepage: www.elsevier.com/locate/apsoil

Biofertilizers from *Rhodopseudomonas palustris* strains to enhance rice yields and reduce methane emissions

Duangporn Kantachote[a,b,*], Tomorn Nunkaew[c], Thanawan Kantha[a], Sumate Chaiprapat[b,d]



Benefits of application

- *R. palustris* PP803 was the most effective to reduce CH_4 emission in both organic and saline flooded rice fields.
- PP803 which was 24% and 28% lower than commercial organic fertilizer (COF), in organic and saline paddy fields, respectively

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建構低氮負碳的農耕模式

- reducing N-fertilizer input
- reducing CH_4 emissions
- CO_2 fixation

R. palustris PS3 inoculant

N_2 fixation → NH_4^+ ⇧

CO_2 fixation → Soil carbon storage

CO_2 capture

Reduce CH_4

(inhibit methanogen)

Goals

4 per 1000 initiative

水稻試驗場域

National Taiwan University

Rice paddy fields

台大農場

NTU exp. farm

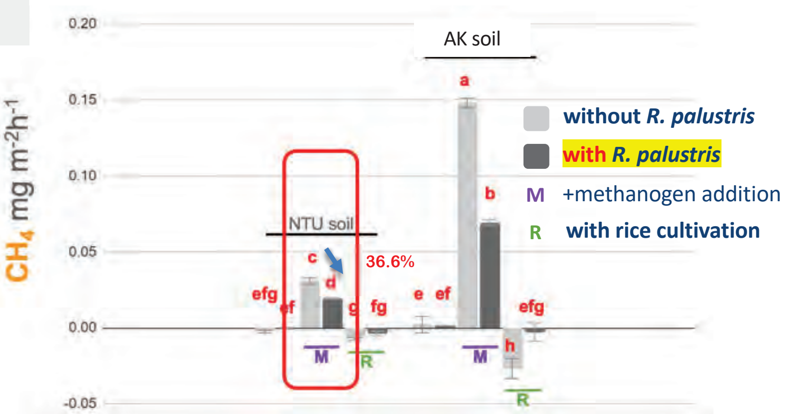
安康分場

Ankang farm

Pot experiments-for CH_4

National Taiwan University

Transparent chamber for CH_4 and N_2O measurement

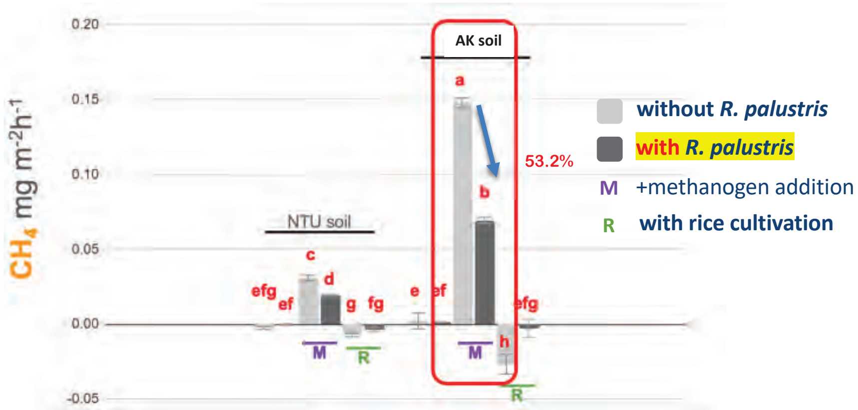


R. palustris could decrease the CH_4 flux in emitted from the NTU farm soil by about **36.6%**

36

National Taiwan University

Pot experiments-for CH_4

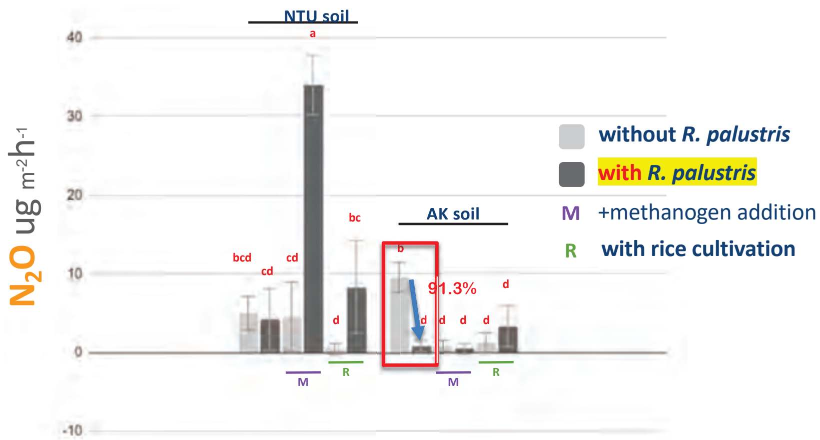


R. palustris could decrease the CH_4 flux emitted from the Ankang farm soil by about 53.2%

37

National Taiwan University

Pot experiments-for N_2O



R. palustris could decrease the N_2O flux by about 91.3% in the Ankang farm soil

38

Field experiment @

The Ankeng Branch of NTU's Farm

39

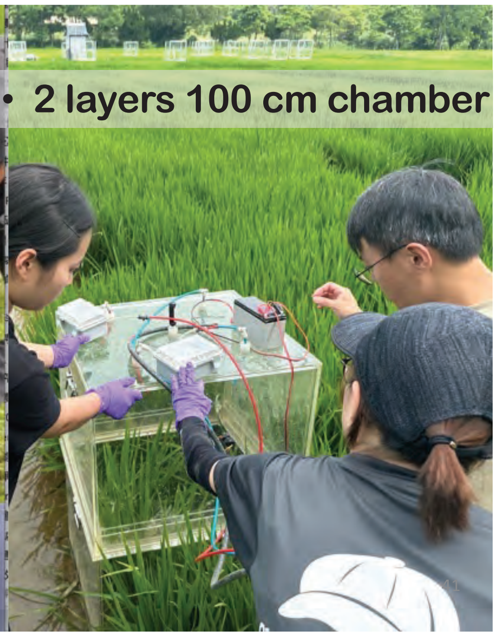
- 50 cm closed chamber

LI-COR Trace Gas Analyzers for CH_4, and N_2O measurements

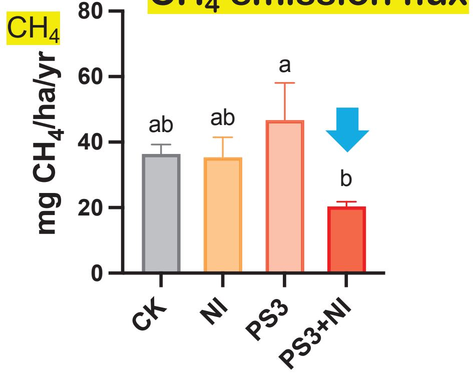
National Taiwan University

微量(痕量)氣體分析儀

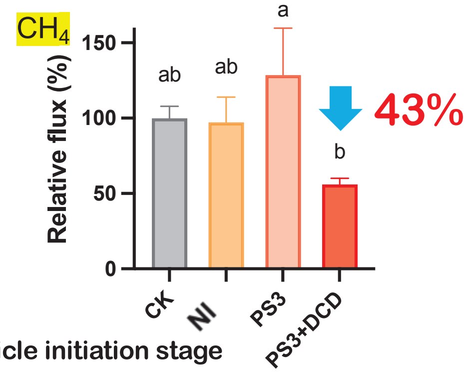
LI-7810 (CH_4 / CO_2) & LI-7820 (N_2O)



CH_4 emission flux

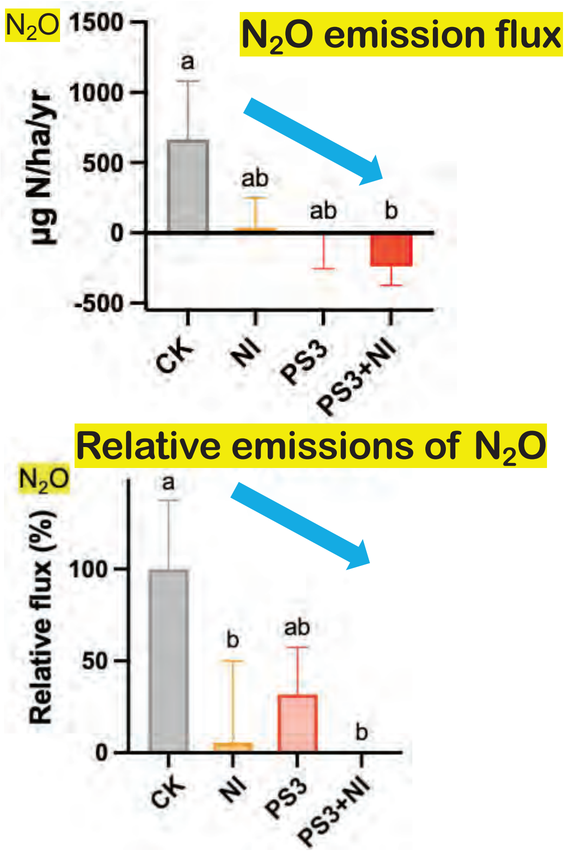


Relative emissions of CH_4



@ panicle initiation stage

National Taiwan University


N2O emission flux
N2O
μg N/ha/yr
1500
1000
500
0
-500
a
ab
ab
b
CK
NI
PS3
PS3+NI
Relative emissions of N2O
N2O
Relative flux (%)
100
50
0
a
b
ab
b
CK
NI
PS3
PS3+NI


NI、PS3或NI+PS3處理皆能有效抑制N2O
排放
National
Taiwan
University


Take-home message
• PS3光合菌可透過 biofertilization和biostimulation 作用來促進植物生長
• 接種 PS3光合菌可以提高土壤養分利用效率和土壤酵素活性
• PS3光合菌具有減少溫室氣體排放的優異潛力

1 Acknowledgements

Chi-Te Liu's Lab

Collaborators

Prof. HS Lur | Dr. CH Kuo | Prof. ZY Hseu | Prof. W Fang | Prof. WC Yang

Prof. SS Lin | Prof. JC Chen | Dr. MS Chiang | Mr. MK Chen | Prof. LT Chang

NSTC 國科會

大勝 | SIMTECH 興邦科技 | 星广地农业 | 城南有機農場 | nugreen

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2 Acknowledgements

Chi-Te Liu's Lab

Collaborators

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Assist. Prof. YJ Shiau | Assoc. Prof. SY Pan

- Mr. LC Cheng
- Mr. CF Kao
- ……

NSTC 國科會

農業零碳技術與管理
創新研究中心

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謝謝聆聽
Thanks for your attention

劉啟德 Chi-Te Liu
Microbial Ecology & Functional Engineering Lab
chiteliu@ntu.edu.tw

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Winpact INNOVATIVE CULTIVATION SOLUTIONS

研究到生產 ：醱酵代工
From research to production: Fermentation Service

major science Co., Ltd.
產品開發技術服務課 林泰宏經理
leo.lin@majorsci.com
2025/03/13

2025/03/07

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醱酵放大的定義 | Definition of Fermentation Scale-Up

醱酵放大是將實驗室中的醱酵過程擴大到工業規模的關鍵技術。
Fermentation **scale-up** is the key technology for expanding laboratory fermentation to industrial scale.

這一過程涉及多種生物與工程**參數**的調控，以確保微生物生長、代謝產物生成與生產效率的穩定性。
This process requires the regulation of multiple biological and engineering **parameters** to ensure microbial growth, metabolite production, and production efficiency. This article discusses the key parameters in fermentation process scale-up and their applications.

03/07/2025 2 https://www.sciencedirect.com/science/article/abs/pii/S1369703X02000165

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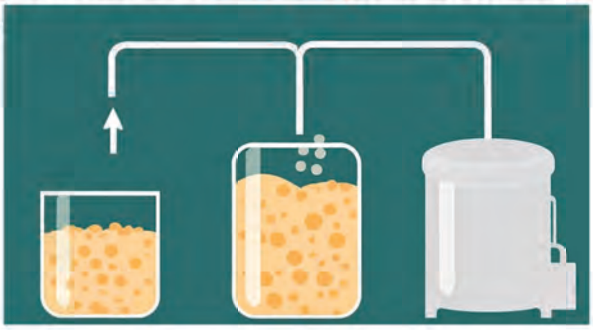
醱酵放大的流程 | Process of Fermentation Scale-Up

醱酵放大通常包括三個階段：實驗室規模、試量產規模和量產（工業）規模。
Fermentation scale-up typically involves three stages: **laboratory**(research) scale, **pilot** scale, and **production**(industrial) scale.



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實驗室規模醱酵 | Laboratory(research)-Scale Fermentation

在實驗室中優化培養基、溫度和其他條件，以獲得最佳的醱酵結果。
In the lab, media, temperature, and other conditions are **optimized** for the best fermentation results.

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試量產規模醱酵 | Pilot-Scale Fermentation

將實驗室條件轉移到試量產規模，測試可行性和經濟性。
Lab conditions are scaled to pilot-scale to test feasibility and economic viability.

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量產（工業）規模醱酵 | Production(industrial)-Scale Fermentation

最終將醱酵擴展到大型生物反應器，生產商業化產品。
Finally, fermentation is scaled up to large bioreactors for commercial production.

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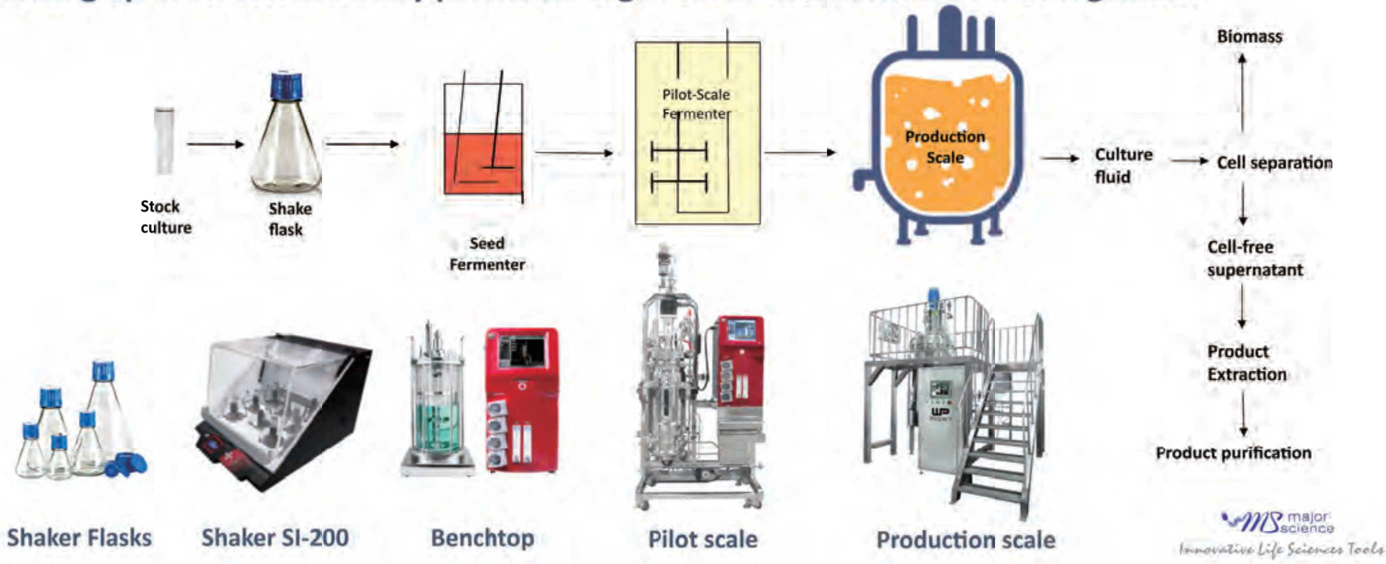
Flowchart shows you how to Scale up

Scaling up of an commercially profitable organism or metabolites of that organism.



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醱酵放大的關鍵參數 | Key Parameters in Fermentation Scale-Up

- **反應器幾何形狀**（ **Vessel Geometry** ）：確保不同規模的幾何設計的相似性，以保持一致的混合與傳質特性。
- **攪拌與曝氣**（ **Agitation & Aeration** ）：1. 攪拌確保養分均勻分佈並提升氧氣傳輸效率。 2. 放大時需調整剪切力與氧轉移率，以匹配小規模試驗條件。
- **氧氣傳輸速率**（ **OTR, Oxygen Transfer Rate** ）：對好氧醱酵來說， OTR 是關鍵因素。隨著體積增加，表面積與體積比率改變。
- **流變特性**（ **Rheological Properties** ）：醱酵液的黏度在不同規模下可能改變，影響混合與傳質，需要監測與調整。
- **養分補給模式**（ **Feeding Profiles** ）：在批次醱酵（ Fed-batch ）中，需控制養分添加的時間與速率，避免基質抑制或缺乏影響產率。

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現代醱酵技術 | Modern Fermentation Technologies

現代醱酵技術利用基因工程、智慧控制和新型生物反應器等方式提升效率。
Modern fermentation uses genetic engineering, intelligent control, and novel bioreactors for improved efficiency.

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基因工程 | Genetic Engineering

通過基因編輯技術改造微生物以提高目標產物的產量。
Genetic editing modifies microorganisms to enhance target product yields.

精準醱酵是一種先進的生物技術方法，透過基因改造微生物（如細菌、酵母或真菌）來生產特定分子，例如蛋白質、脂質和生物活性化合物。
Precision fermentation is an advanced biotechnological approach that enables the production of specific molecules, such as proteins, lipids, and bioactive compounds, using genetically engineered microorganisms.

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基因工程 | Genetic Engineering

開發出能夠生產關鍵酪蛋白的酵母菌株後，如今無需乳牛就可以製作出有彈性的乳酪。
Stretchy dairy cheese could now be made without any cows by the development of yeast strains that produce crucial casein proteins. (https://dairyx.com/)

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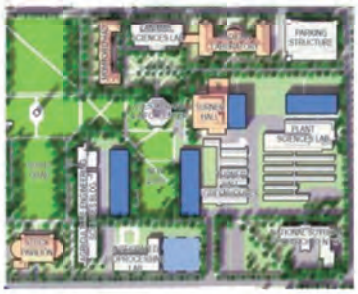
基因工程 | Genetic Engineering

精準醱酵的市場機會：2022 年至 2048 年，預計產業價值將成長 16 億美元 → 118 億美元。
Market Opportunity in Precision Fermentation : Industry Growth in Value, from 2022 to 2048. (https://ifabtechhub.research.illinois.edu/)

iFAB
Illinois Fermentation and Agriculture Biomanufacturing Hub



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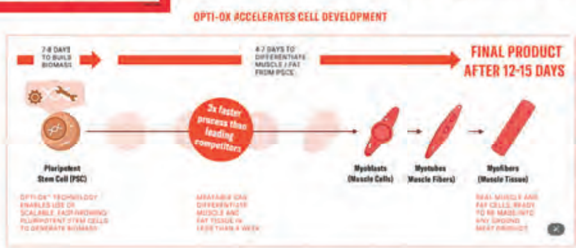
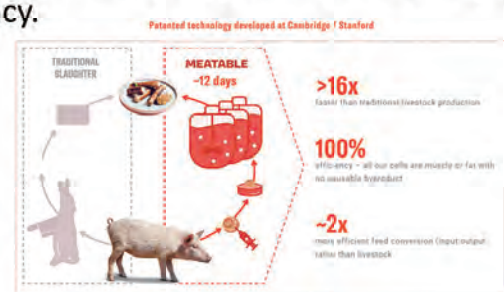
基因工程 | Genetic Engineering

Meatable 使用專利技術 opti-ox™。這是唯一一種能夠以快速且 100% 效率從多功能性幹細胞（ PSCs ）培育真實肌肉和脂肪細胞的方法。
Meatable works with patented technology, opti-ox™. It is the only method to grow real muscle and fat cells from pluripotent stem cells (PSCs) at speed, and at 100% efficiency.





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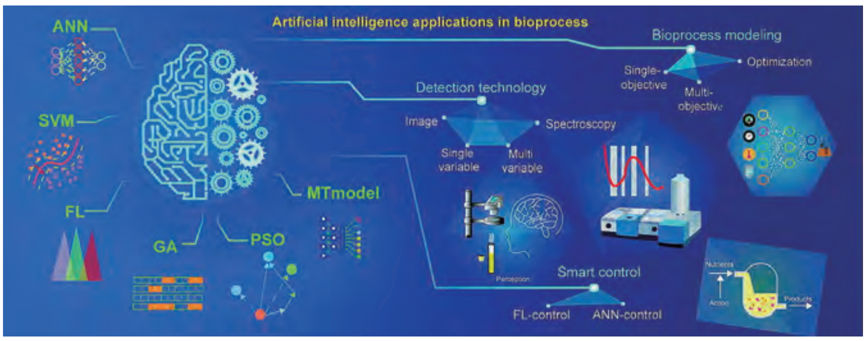
https://www.meatable.com/

Winpact INNOVATIVE CULTIVATION SOLUTIONS

智慧控制技術 | Intelligent Control

使用傳感器和 AI 技術即時監控和優化醱酵過程。
Sensors and AI technologies monitor and optimize fermentation processes in real-time.



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https://linkinghub.elsevier.com/retrieve/pii/S0960852422017849

Winpact INNOVATIVE CULTIVATION SOLUTIONS

智慧控制技術 | Intelligent Control

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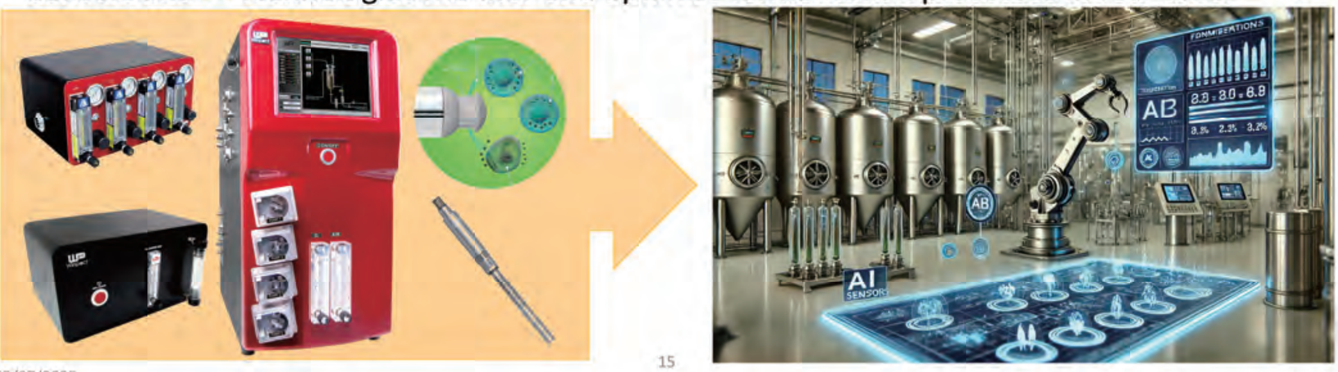

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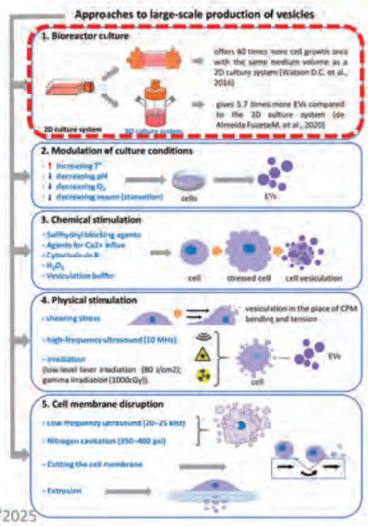
Winpact INNOVATIVE CULTIVATION SOLUTIONS

新型生物反應器 | Novel Bioreactors



大規模生產細胞外囊泡的方法

Methods of the Large-Scale Production of Extracellular Vesicles.

03/07/2025 16

Int. J. Mol. Sci. 2022, 23(18), 10522; https://doi.org/10.3390/ijms231810522

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INNOVATIVE CULTIVATION SOLUTIONS

新型生物反應器 | Novel Bioreactors

開發**新型反應器**以提高生產效率並減少能源消耗。
Novel bioreactors enhance production efficiency and reduce energy consumption.

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新型生物反應器 | Novel Bioreactors

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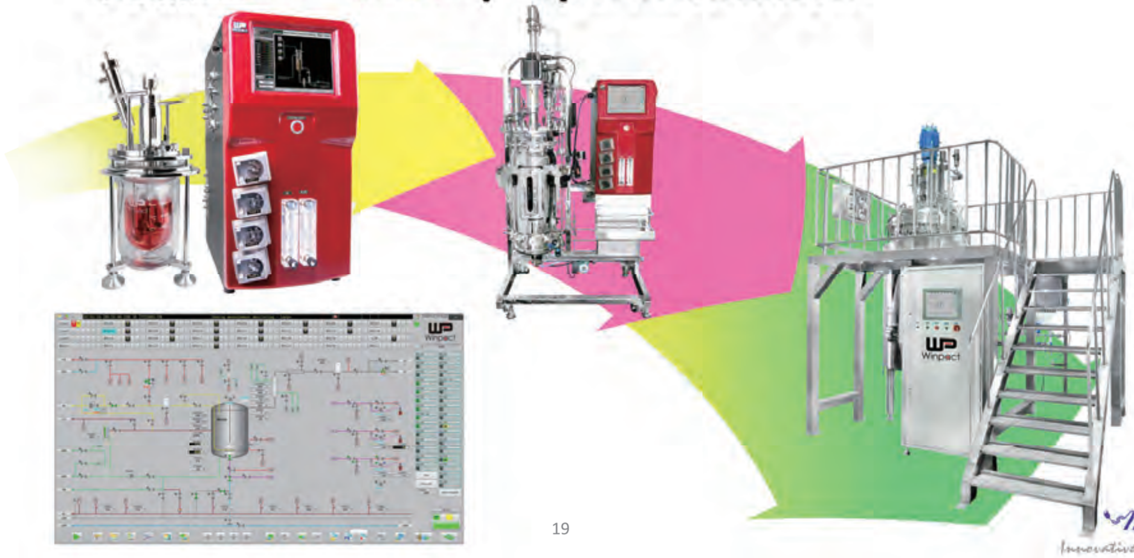
Winpact INNOVATIVE CULTIVATION SOLUTIONS

實驗室代工服務 | Experimentation-Service



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Winpact INNOVATIVE CULTIVATION SOLUTIONS

實驗室代工服務 | Experimentation-Service

生物醱酵實驗服務為研究機構與產業提供專業的醱酵設備、技術與專業知識，以進行小規模與中試規模的醱酵研究。。

Bio fermentation experimentation services provide researchers and industries with specialized facilities, expertise, and equipment to conduct small-scale and pilot-scale fermentation studies.

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Winpact 能提供什麼服務 | What can Winpact provide

Winpact 的專業團隊，可以提供以下醱酵實驗服務的項目 -
Winpact's professional team can provide the following fermentation experiment services:

- **醱酵技術諮詢** ：提供有關醱酵技術的專業建議和支持。
- **Fermentation Technology Consulting** : Offer professional advice and support regarding fermentation technology.

- 醱酵實驗設計 ：根據研究需求設計醱酵實驗的參數。
- **Fermentation Experiment Design** : Design the parameters of the fermentation experiment based on research needs.

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Winpact
INNOVATIVE CULTIVATION SOLUTIONS

Winpact 能提供什麼服務 | What can Winpact provide

Winpact 的專業團隊，可以提供以下醱酵實驗服務的項目 -
Winpact's professional team can provide the following fermentation experiment services:

- **原物料選擇** ：提供不同類型原料的選擇建議，如糖類、蛋白質和氨基酸等。
- **Material Selection** : Provide recommendations for different types of materials, such as carbohydrates, proteins, and amino acids.

- **醱酵條件優化** ：調整溫度、 pH 、氧氣濃度等條件以提高產量和效率。
- **Fermentation Condition Optimization** : Adjust conditions such as temperature, pH, and oxygen concentration to improve yield and efficiency.

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Winpact 能提供什麼服務 | What can Winpact provide

Winpact 的專業團隊，可以提供以下醱酵實驗服務的項目 -
Winpact's professional team can provide the following fermentation experiment services:

- **試量產放大** ： 配合 Wipnact 50L 的醱酵設備進行試量產生產。
- **Pilot Scale Production** : Using Winpact's 50L fermentation equipment ot pilot scale production

- **量產放大** ： 與合作工廠的噸級醱酵設備進行放大生產。
- **Scale-Up Production** : Using production scale fermentation equipment with co-partner facility to scale up production.

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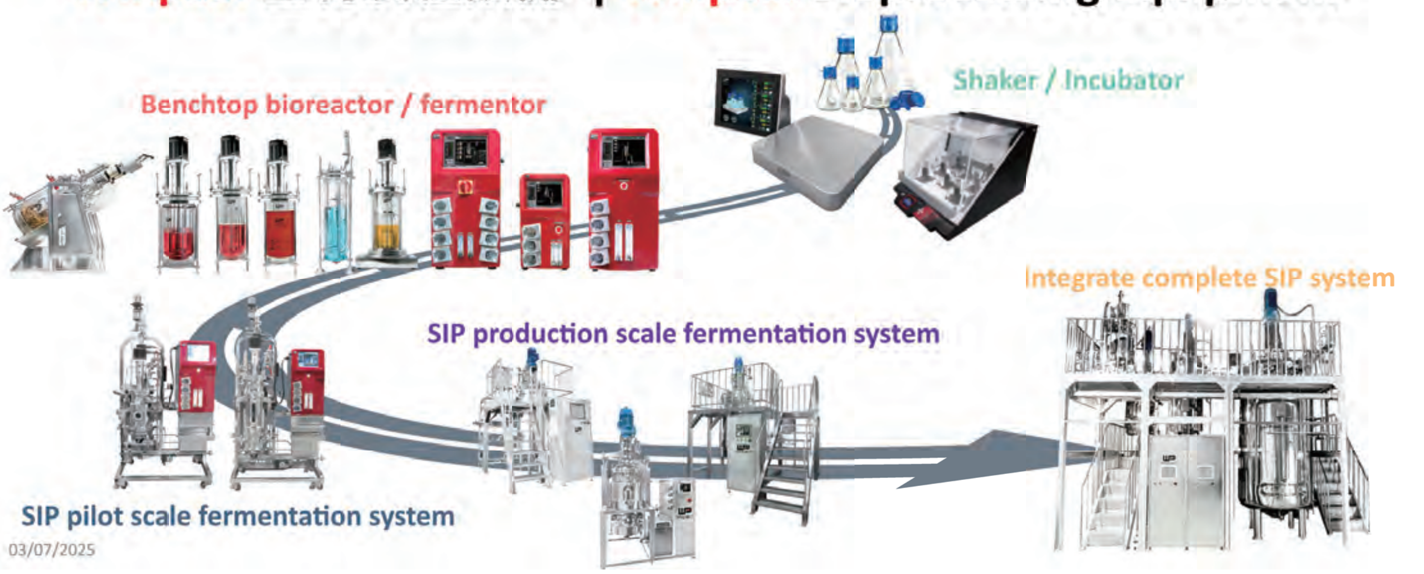
Winpact 生物製程設備 | Winpact Bioprocessing equipment



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Winpact industry-academia collaboration | Winpact 產學合作

Winpact 產學合作的項目 -
Winpact industry-academia collaboration :

- **技術轉移**：學術界的研究成果轉移至企業。
- **Technology Transfer** : Academic research outcomes are transferred to companies.

- **創新基地**：加入創新中心或孵化器。
- **Innovation Base** : Join innovation centers or incubators.

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Winpact industry-academia collaboration | Winpact 產學合作

Winpact 產學合作的項目 -
Winpact industry-academia collaboration :

- **研究合作**：學校的研究團隊與企業合作進行技術開發或產品研發。
- **Research Collaboration** : Research teams from schools work with companies to develop technologies or products.

- **小型企業創新研發計畫** ：協助推動和商業化創新和研究。
- **Small Business Innovation Research** : To help advance and commercialize innovation and research.

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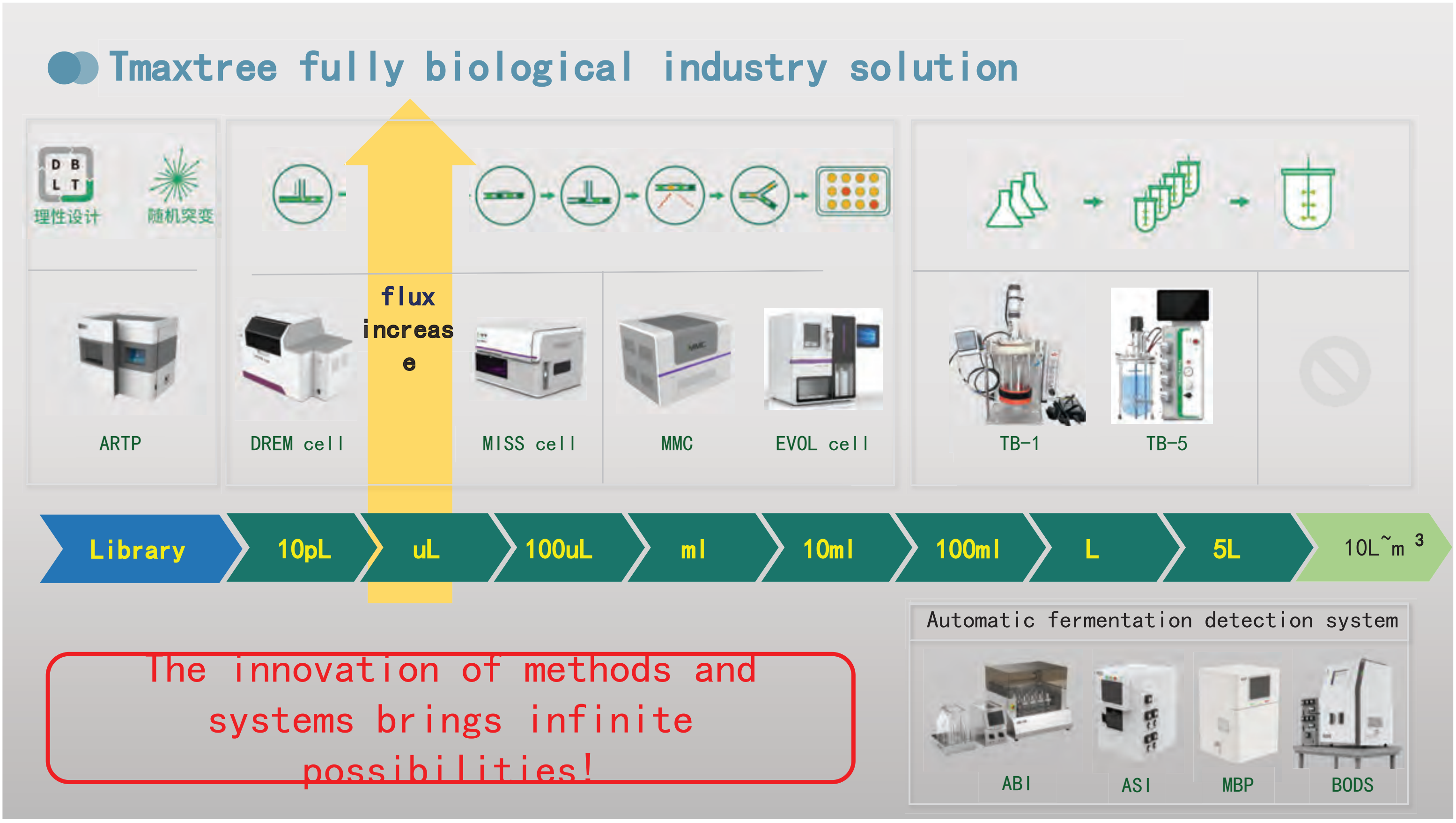
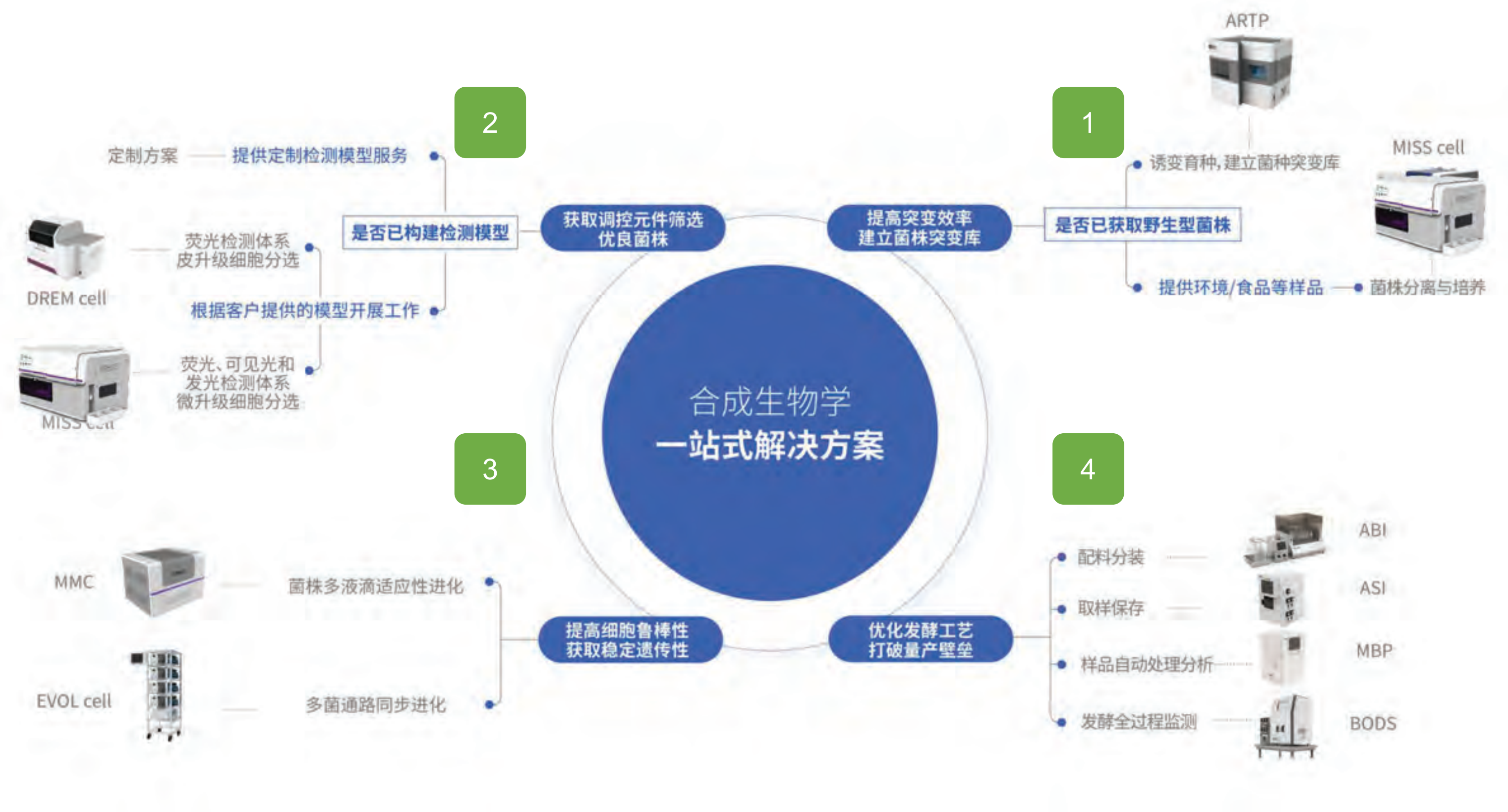
生物育種系統

清华大学无锡应用技术研究院 生物育种研究中心

TMAXTREE 天木生物

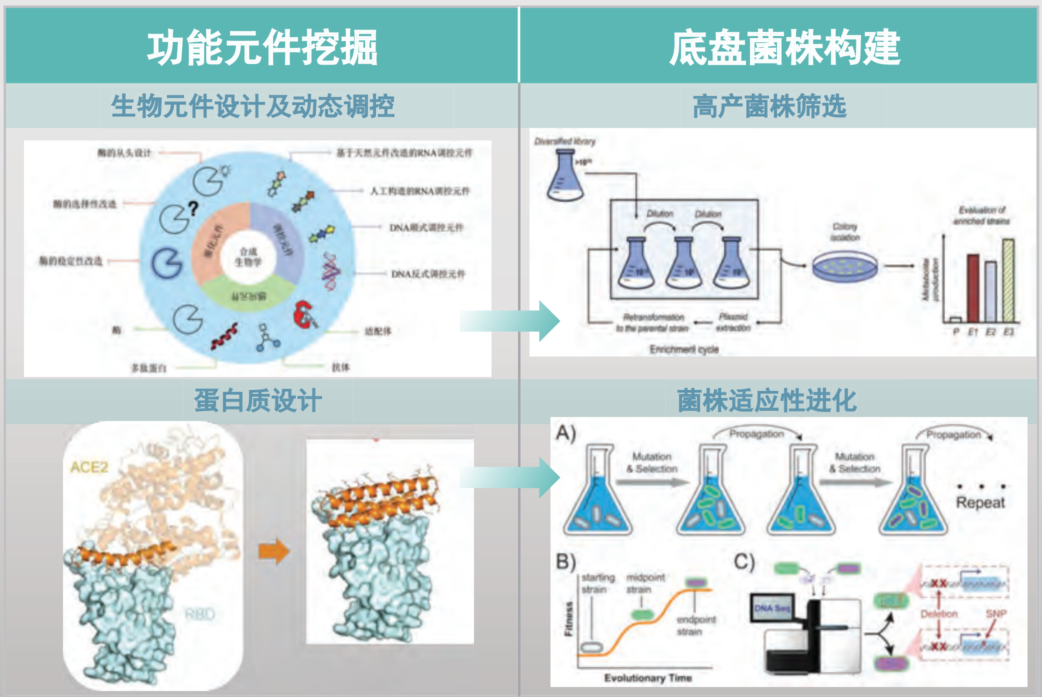
山水科技儀器有限公司 Shan Shui Technology Ltd.





合成生物学主要研究方向

合成生物学通过设计和构建自然界中不存在的人工生物系统，解决能源、材料、健康和环保等问题。主要包括两个方面，一是设计和构建新的生物零件、组件和系统；二是对现有的、天然存在的生物系统的重新设计和改造。



合成生物学主要研究方向

合成生物学产业面临挑战和技术难题

- 传统诱变手段突变效率随机
- 底盘菌株理性设计的技术门槛
- 试验成功与量产之间存在壁垒

待解决的关键问题

- 高效调控元件获取
- 蛋白质结构设计
- 高产量菌株筛选
- 菌株适应性进化

生物医药领域

CAR-T细胞治疗术开发

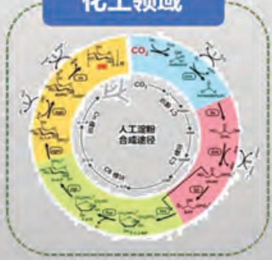
食品领域

基因工程生产植物肉

农业领域

RNA农药特异性抗病虫害

化工领域



人工合成淀粉新途径

Applications

- Food → Eat Well, Live Well. AJINOMOTO 味の素株式会社; wilmar; LESAFFRE; Asahi 朝日啤酒
- Medicine → 聯邦制藥 UNITED LABORATORIES; teva; Bacchus Bio innovation
- Argiculture → CORTEVA agriscience; KAGOME 可果美; APHEA bio
- Enzyme → novozymes; 溢多利 VTR; WuXi Biologics Global Solution Provider
- Synthetic biology → DTU; 清华大学 Tsinghua University; NUS National University of Singapore; 神戸大学
- Biochemical engineering → CONAGEN; kaneka; DUPONT
- Cosmetics → DSM; CLARIANT; EVONIK INDUSTRIES

合成生物学一站式解决方案

提高突变效率
建立菌株突变库

↓

获取调控元件
筛选优良菌株

↓

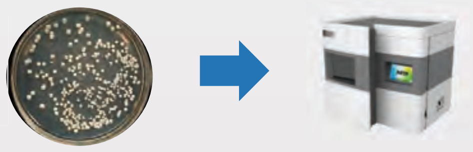
提高细胞鲁棒性
获取稳定遗传性

↓

优化发酵工艺
打破量产壁垒

ARTP常压室温等离子体诱变育种

- 条件温和可控、活性粒子丰富
- 提高突变率，获得大量突变菌株



DREM cell/MISS cell高通量液滴单细胞分选系统

- 筛选高效调控元件
- 单细胞单液滴培养系统
- 高通量筛选性能优良菌株

MMC/EVOL cell全自动微生物进化仪

- 菌株适应性进化

ABI/ASI自动配料装液/取样系统
BODS/MBP发酵自动化检测/分析

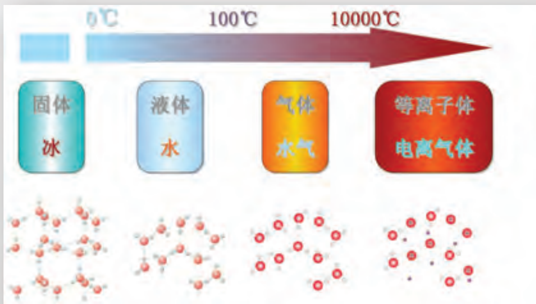
- 发酵工艺优化及放大

构建突变库

等离子体定义

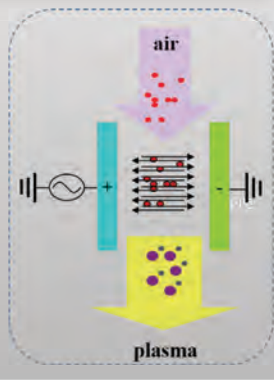
等离子体（Plasma）是与物质的固态、液态和气态并存的物质第四态（1879, 英, W. Crooks），是一种正离子和电子的密度大致相等的电离气体（1928, 美, *I. Langmuir*），整体呈电中性。

加热只是气态变成等离子体状态的一种方式，另一种方式就是通过外加能量进行激发，ARTP就是采用后者，将99.999%的高纯氦气激发为等离子体状态。



	nm	ev	KJ/mol
UVA	400-315	3.1-3.9	297-374
UVB	315-280	3.9-4.4	374-422
UVC	280-190	4.4-6.5	422-624
	260	4.77	458
He*	62.7	19.77	1900
	50.5	24.57	2360

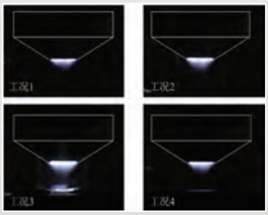
成键原子	键长(pm)	键能(KJ/mol)
C=C	134	611
C-C	154	348
C-N	148	305
C=N	135	615
C-O	143	326
C=O	120	728



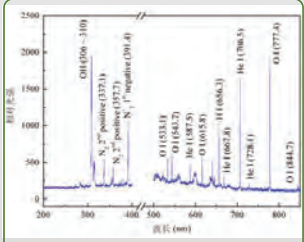
构建突变库

底盘菌株构建—高效构建多样性突变库

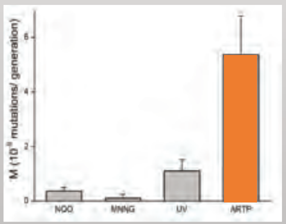
菌株诱变筛选高产菌株



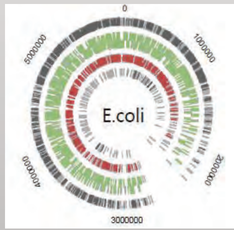
条件温和、可控性强



活性粒子种类丰富

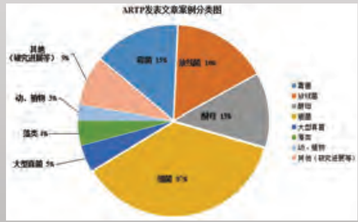


突变效果好



突变谱广

截止到2024年5月，ARTP相关文献共计**1283篇**，其中中文文献468篇，英文文献209篇，专利367篇，学位论文239篇

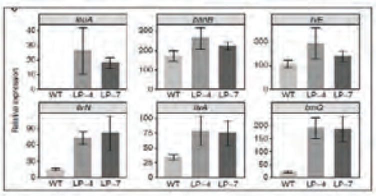


构建突变库

生物育种应用—高效构建多样性突变库

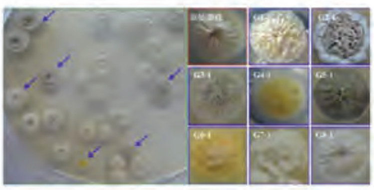
表型多样性显著增加

细菌领域成果多、效果显著



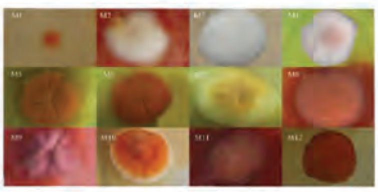
筛选到高产L-亮氨酸突变株，产量达到18.55mg/g，比出发菌株提高2.91倍。（Nature communications,9（2018））

放线菌抗生素产量显著提高



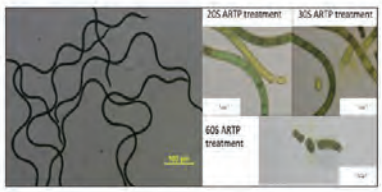
突变率、正突变率分别为30%、21%，获得一株阿维菌素B1a产量提高23%。（常压室温等离子体对微生物的作用机理及其应用研究[D].王立言.清华大学2009）

霉菌产色素能力大幅度提升



突变菌株产橙、黄色素能力比出发菌株分别提高136%、43%。（核农学报，2016,30（4）：654-661）

藻类正突变率高、突变库表型丰富

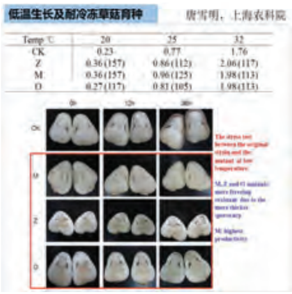


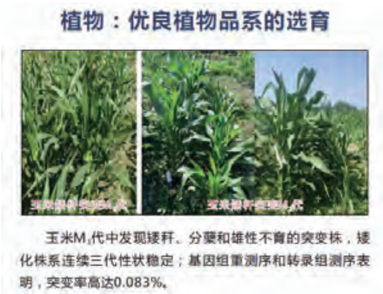
总突变频率和阳性突变频率在特异增长率上分别达到45%和25%，并且突变库中表型丰富。（PLOS ONE，2013,8（10）：1-12）

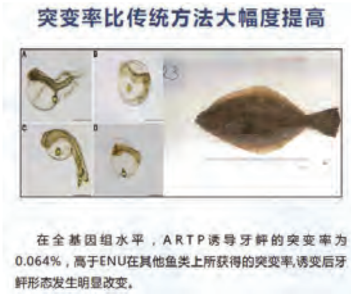
构建突变库

生物育种应用---高效构建多样性突变库

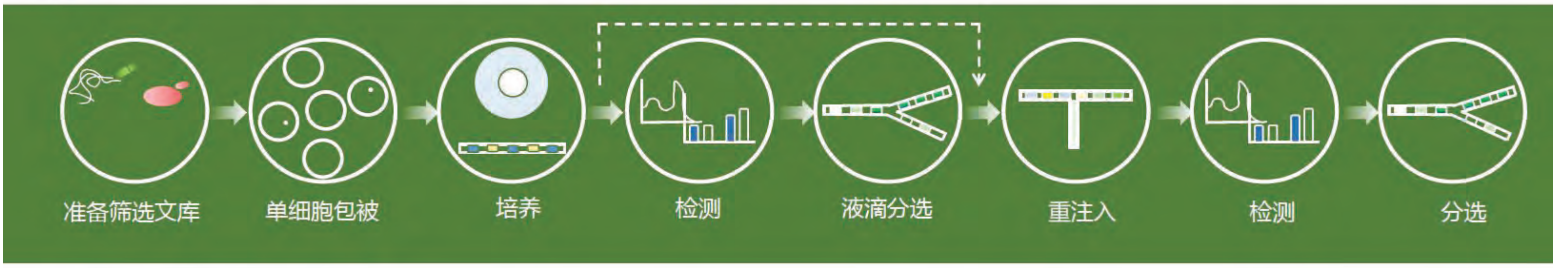
表型多样性显著增加



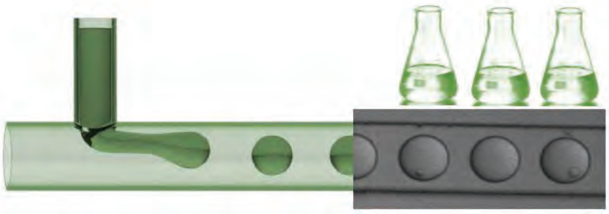




微流控技术——实现筛选通量量级提升



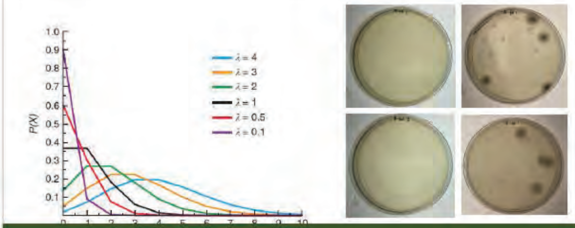
皮升~微升体系



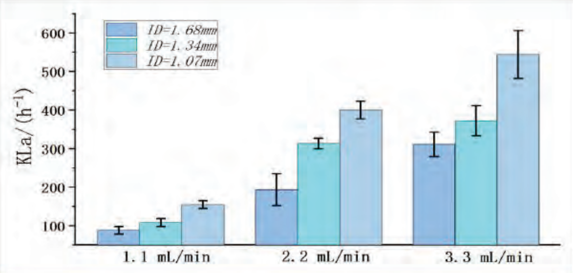
- 仪器和耗材价格更便宜
- 设备高度集成、自动化程度高
- 应用领域广泛
- 适用于单细胞

微流控技术体系优点明显

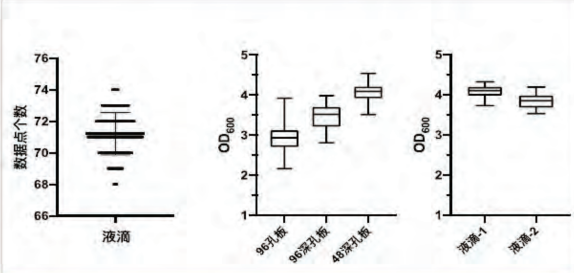
独创的"液滴体系+管式培养"



稳定实现单细胞包裹和培养



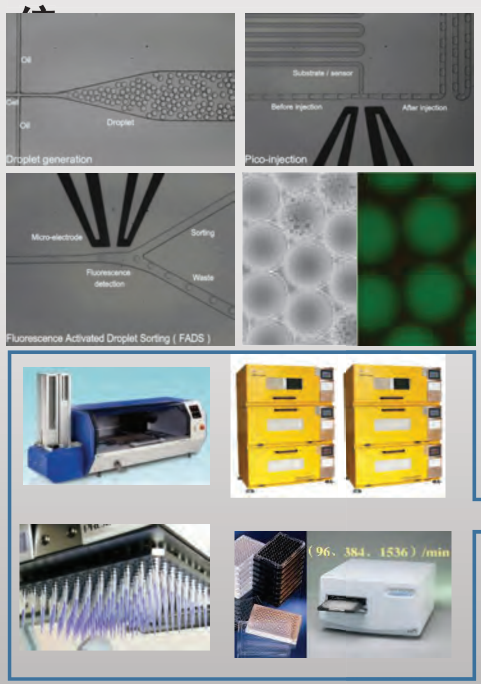
控氧效果更好，传质效率更高



体系误差和培养误差，显著优于孔板体

高通量筛选

DREM cell/MISS cell 高通量液滴单细胞分选系统



初筛

- 筛选通量可达10^{7-8}个/天
- 相比传统筛选体系，该系统筛选速率提高10^4倍，试剂消耗量下降至$1/10^6$
- 可广泛应用于微生物筛选、(胞内、胞外)酶筛选、抗体筛选、药物筛选等领域

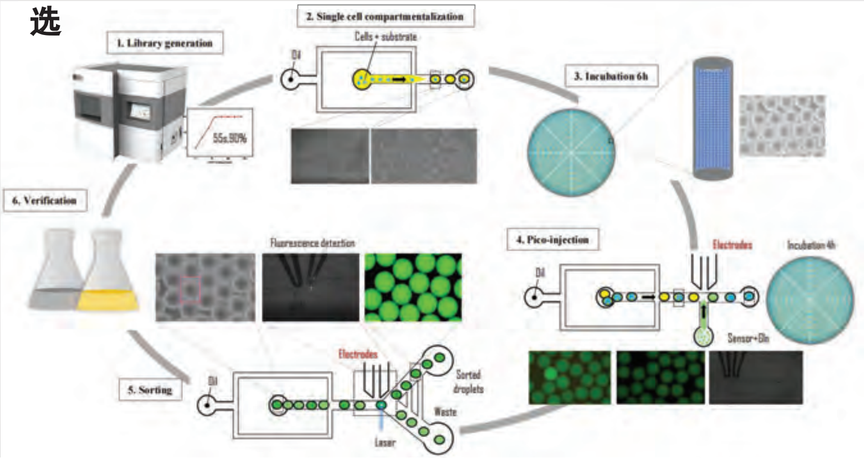
进一步筛选

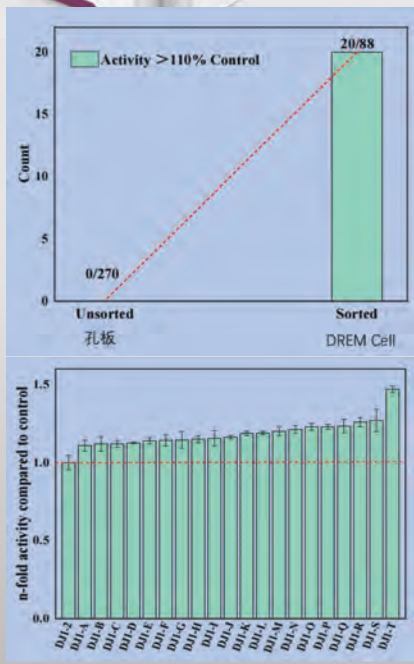
- 筛选通量可达10^3个/天
- 相比传统筛选体系，该系统筛选速率提高10倍，试剂消耗量下降至$1/10^4$
- 适用于多种检测体系和多种培养环境

高通量筛选

底盘菌株构建--高产菌株诱变筛选

高产谷氨酰胺酶解淀粉芽孢杆菌筛选



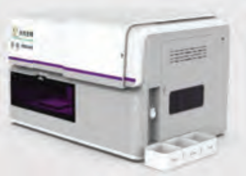


DREM Cell： 10万CFU/天（9小时），培养基0.5ml，检测试剂0.2mL，矿物油0.3mL

孔板： 1000CFU/天，需100天，培养基消耗60L，检测试剂10L，耗材？

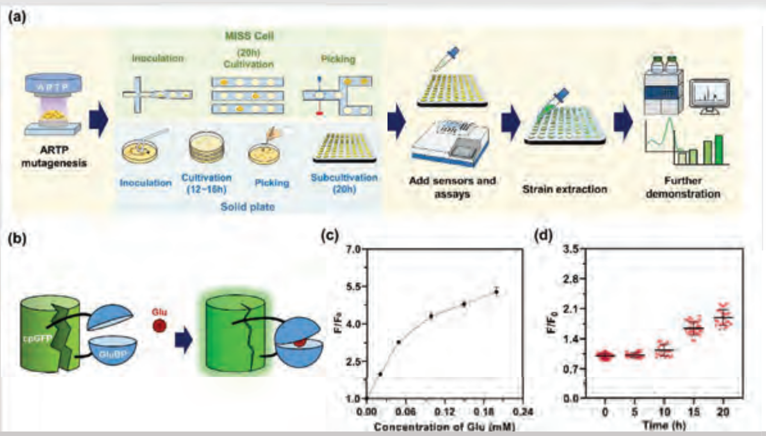
降低筛选成本，提高筛选通量，提升筛选效果！

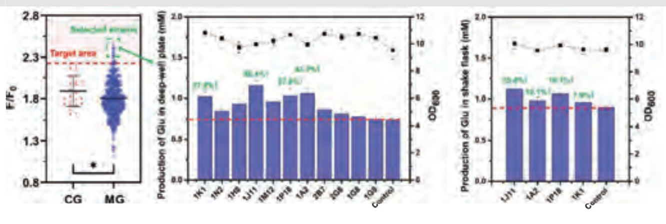
高通量筛选模型构建



底盘菌株构建--高产菌株诱变筛选

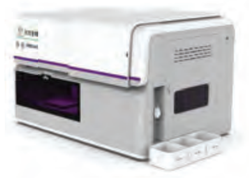
高产谷氨酸突变株筛选





- 基于谷氨酸感应荧光传感器（iGluSnFr），使用**MISS cell在3500个液滴中分选502个单克隆**，选取11株进行后续验证。最终验证得到的1J11和1P18突变体，摇瓶培养的谷氨酸**产量分别提升了25.8%和19.1%**

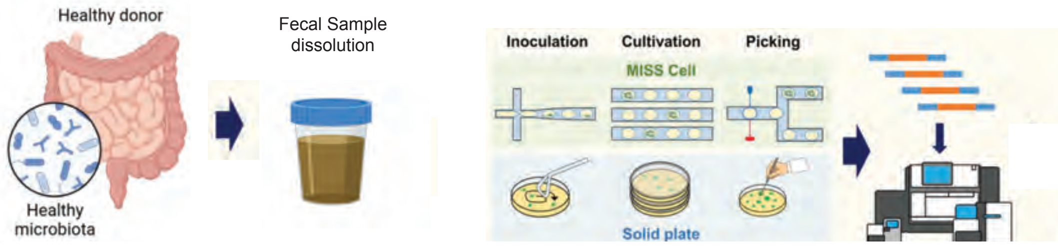
Biotechnology and Bioengineering, 2022



高通量筛选

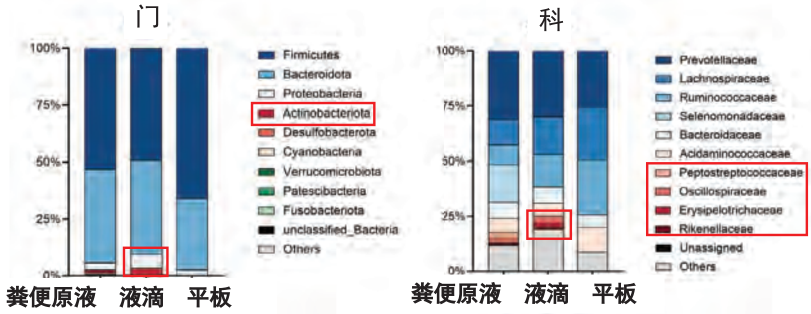
粪便样品微生物分离--肠道菌群资源挖掘

液滴微流控平台揭示人类肠道菌群多样性



健康人粪便取样　粪便样本处理　单克隆培养及筛选　扩增及检测

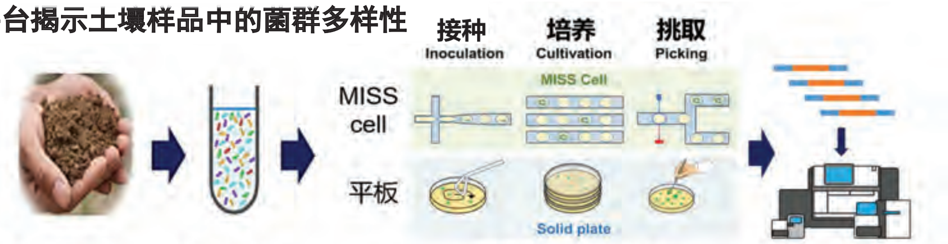
与平板筛选相比，MISS cell 富集细菌种类提升60%



高通量筛选

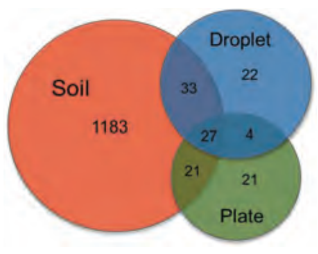
环境微生物分离--土壤微生物资源挖掘

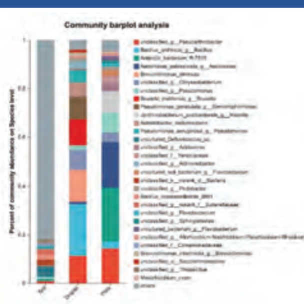
液滴微流控平台揭示土壤样品中的菌群多样性

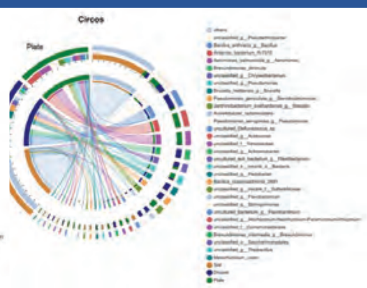


土壤样本取样　样本处理　单克隆培养及筛选　扩增及检测

在种水平，与平板筛选相比MISS cell 获得微生物种类提高17.8%

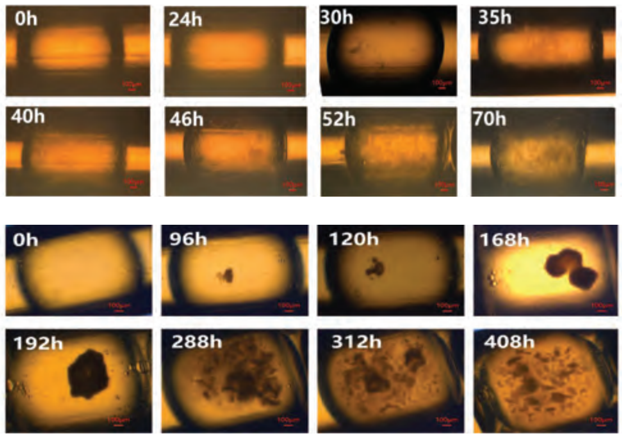






高通量筛选

VS



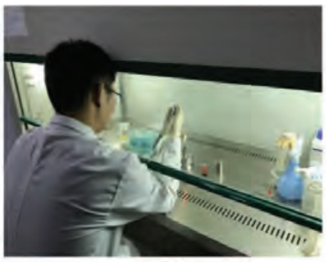
黑曲霉

放线菌

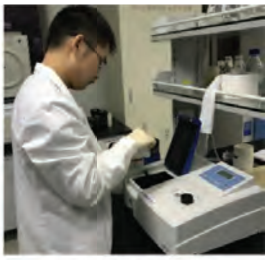
细胞（孢子）包裹与液滴中，形成独立的培养单元有效避免菌株间交叉污染

适应性进化

培养



取样



检测

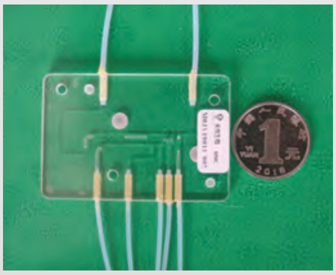
传代培养

化学因子梯度添加

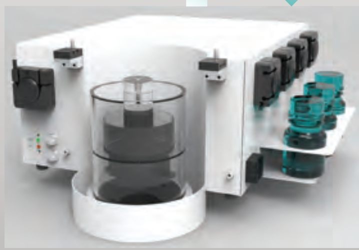
利用微流控微液滴技术替代传统的摇瓶培养，实现自动化自适应传代体系。可以长时间自动培养和驯化菌株，并且提供不同环境的适应性压力，减少人工操作出现的误差，实现高效的菌株驯化和培养。

适应性进化

MMC/EVOL cell全自动微生物进化仪

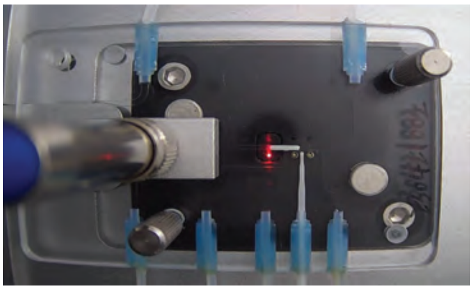


- 全自动化操作；微升体系连续传代进化；
- 多种检测参数；实时在线化；
- 多类型培养驯化体系；
- 工作效率提高10倍以上；
- 可用于菌种初筛；生长状态测定；细胞适应性进化；药物筛选等领域。

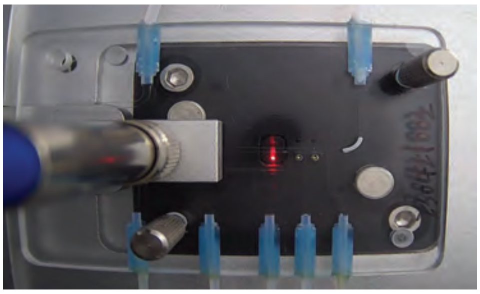


- 全自动化操作；毫升体系连续传代进化；
- 多种检测参数（光学）；实时在线化；
- 支持取样、留样检测；
- 工作效率提高10倍以上；
- 可用于细胞适应性进化。

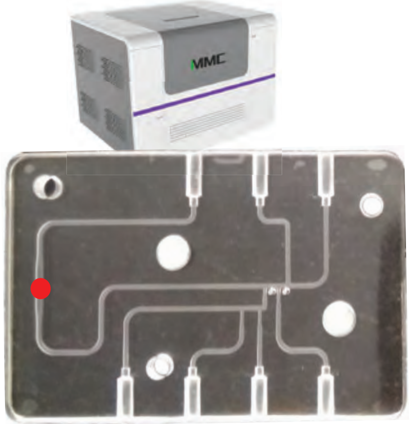
适应性进化



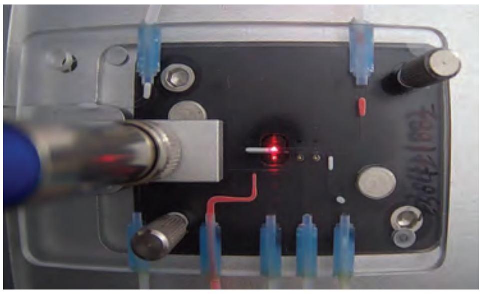
液滴生成—摇瓶装样



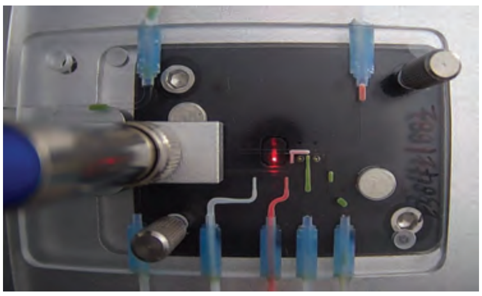
液滴往复培养—振荡培养



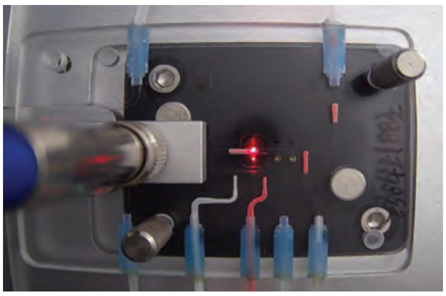
液滴检测—分光光度计检测



液滴分割融合—传代操作



化学因子梯度添加

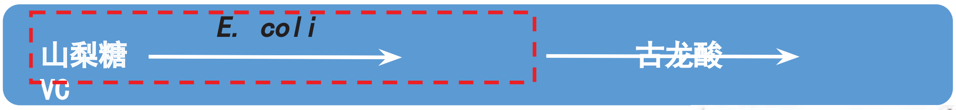


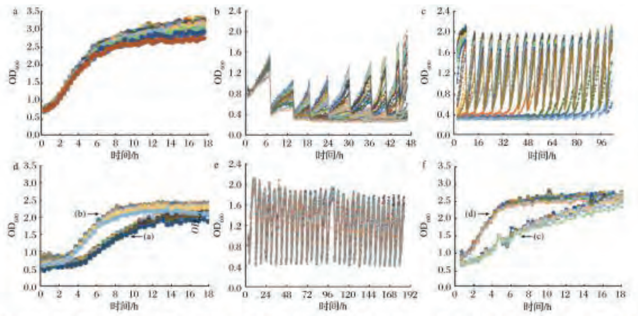
液滴提取和保存

适应性进化

提高底物耐受性，进一步提高产物产量！

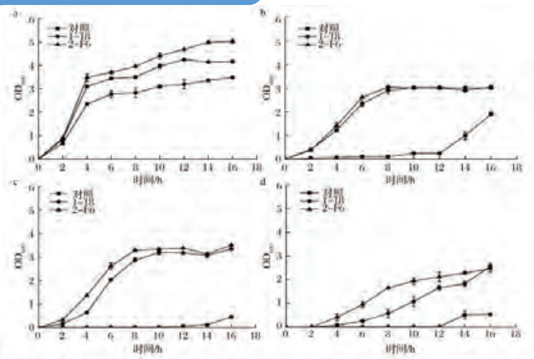
耐高浓度山梨糖大肠杆菌的筛选





a—出发菌株生长曲线；b—较低质量浓度 L—山梨糖（梯度质量浓度为10.00、13.33、16.67 和 20.00 g/L）培养基中的进化过程；c—中质量浓度 L—山梨糖（梯度质量浓度为10.00、20.00 和 30.00 g/L）培养基中的进化过程；d—出发菌株（a）和进化菌株 1-18（b）的生长对比；e—高质量浓度 L—山梨糖（梯度质量浓度为30.00、50.00、70.00 和 100.00 g/L）培养基中的进化过程；f—出发菌株（c）和进化菌株 2-F6（d）的生长对比

图 1 菌株耐高浓度 L—山梨糖的适应性进化结果



a—添加 10 g/L L—山梨糖；b—添加 30 g/L L—山梨糖；c—添加 100 g/L L—山梨糖；d—添加 200 g/L L—山梨糖

图 2 进化菌株在摇瓶中的生长状况

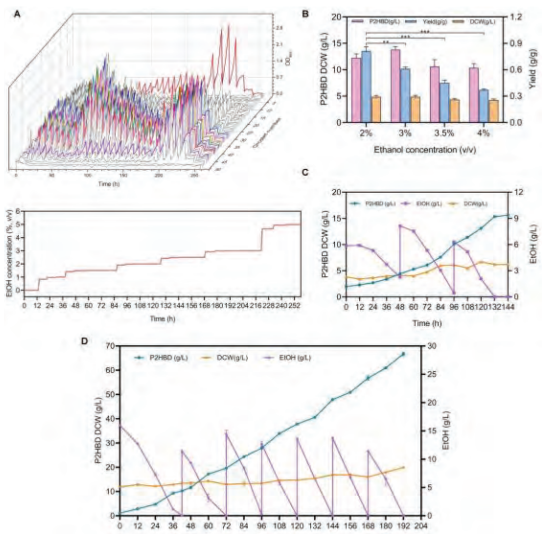
- 单轮连续培养约120h，连续传代近20次；
- 大肠杆菌山梨糖耐受性**提高了200%**。

江南大学,Trends in Biotechnology,2020（IF=14.3）,食品与发酵工

适应性进化

提高底物耐受性，进一步提高产物产量！

适应性进化策略强化乙醇利用型普鲁兰菌性能



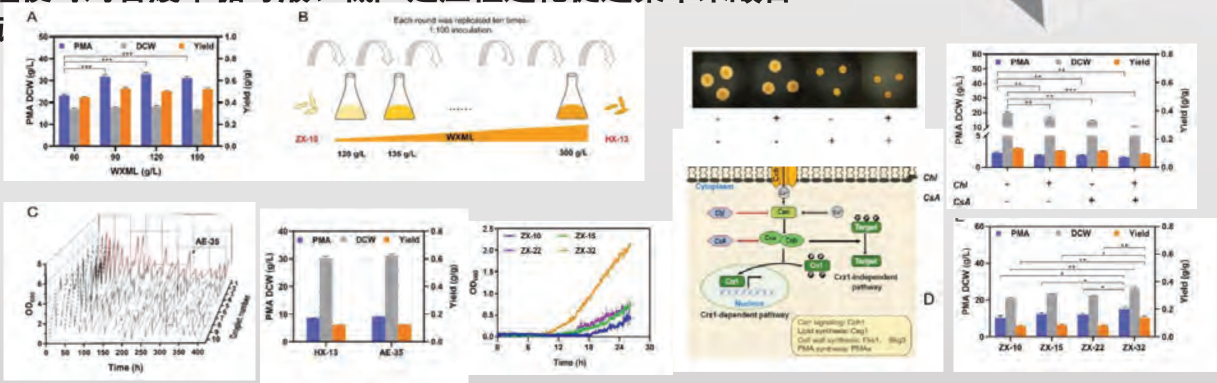
- 乙醇利用型普鲁兰菌可以在没有碳损失的情况下合成聚二氢丁二酸。
- **连续10天、25代**的进化，逐渐提高乙醇的用量，获得了一株对极端乙醇环境耐受性显著提高的普鲁兰菌。
- **随着乙醇浓度从2%增加到4%，细胞生长没有出现明显下降**，并且经启动子调控、MMC适应性进化、静息细胞培养一系列优化策略，聚二氢丁二酸的产量**提高了50.23%**。

西南大学， 邹祥教授课题组 Green Chemistry,2022（IF=11.034）

适应性进化

提高底物利用率，增加 pH耐受性，降低控制成本！

短梗霉对含废木糖母液、低pH适应性进化促进聚苹果酸合成



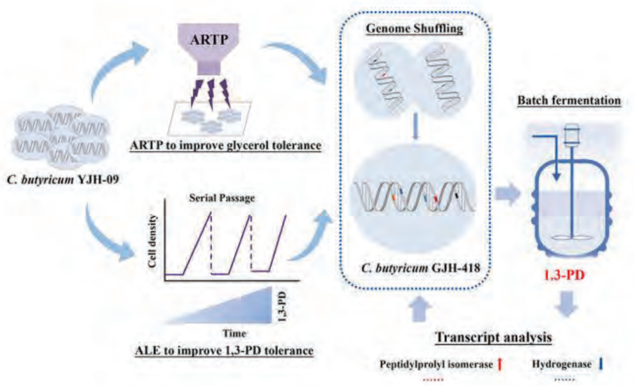
- 进行耐高浓度废木糖母液（WXML）进化，聚苹果酸（PMA）效价增加**14.24%**
- 进行耐低pH适应性进化，能够在**2.5的低pH下生长** 的菌株AE-35，自由pH控制下PMA效价达到9.23±0.02g/L，**增加5.27%**
- 引入外源白僵菌cnb基因，获得突变株AE-59，在5 L发酵罐中用Na_2CO_3进行低pH控制时，PMA效价达到**49.47±0.48g/L**，产量达到**0.33g/g**。

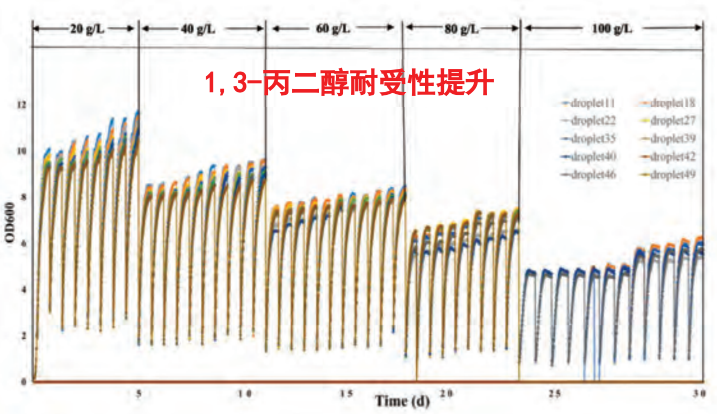
Chemical Engineering Journal, 2022.（IF=16.744）

适应性进化

提高底物和产物耐受性，进一步提高产率！

适应性进化策略提高丁酸梭菌耐受性和1,3-丙二醇产量



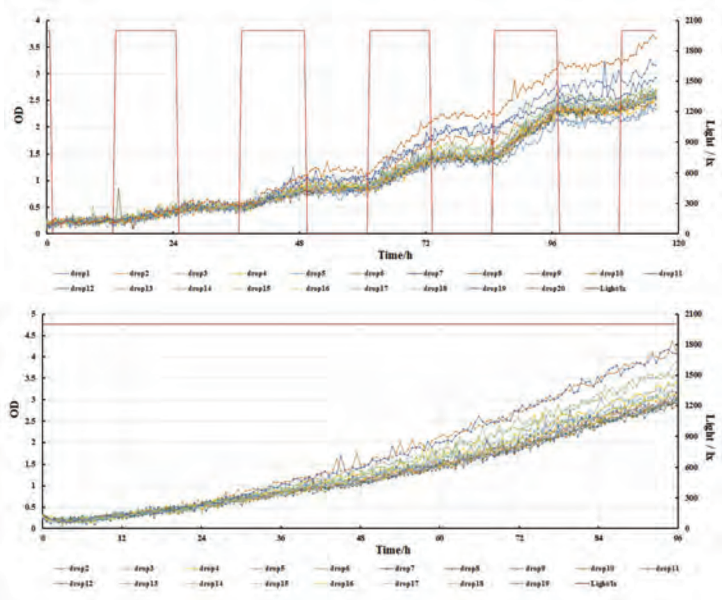


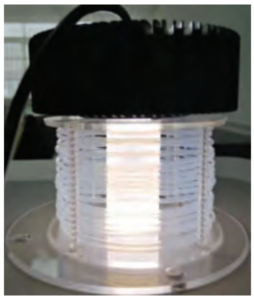
- 丁酸梭菌将甘油转化为1,3-丙二醇的生物效率受到其对各种应激源的耐受性较低的限制，特别是作为**底物的甘油**，作为最**终产物的1,3-丙二醇**，以及作为副产物的丁酸，**最终降低产率**。
- 利用**ARTP诱变**野生菌株获得了对**160 g/L甘油耐受的菌株**；
- 通过**MMC**介导的适应性实验室进化产生对**100 g/L 1,3-丙二醇耐受** 性最高的菌株；
- 最后通过两个优势菌群的基因组洗牌产生了最终菌株GJH-418，**1,3-丙二醇产量为60.12 g/L**。

Bioresource Technology, 2022（IF=11.889）

适应性进化

个性化定制解决方案





增加**藻光灯配置**，为培养管路提供光照，用于藻类培养

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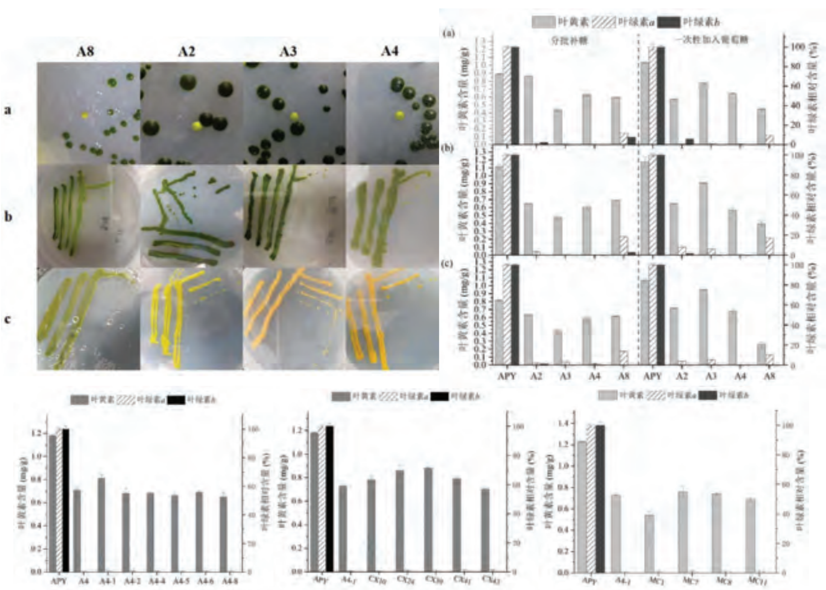
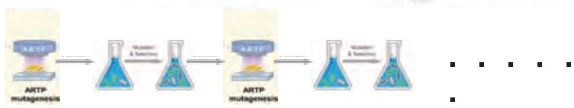
适应性进化

诱变筛选理想型突变株，降低工艺成本！

蛋白核小球藻叶绿素合成缺陷型突变株诱变筛选





- 基于**ARTP诱变-MMC筛选** 获得蛋白核小球藻颜色突变株，通过多轮诱变和筛选，得到叶绿素合成缺陷型突变藻株CX41和MC8，从**根本上抑制了非光依赖型的叶绿素合成**；
- 与野生型藻株相比，这两株突变株藻体呈金黄色，叶绿素a含量降低了98%以上，不含叶绿素b，有效减少了工业生产过程中低效、高成本、高污染的脱色去腥步骤，大大简化工艺流程，降低生产成本，可以用于生产高蛋白藻体和蛋白粉，为替代蛋白的发酵生产提供了产能高、品质好的优质发酵藻种。

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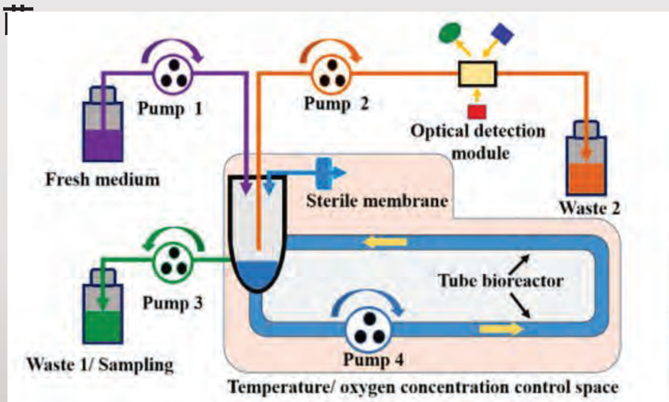
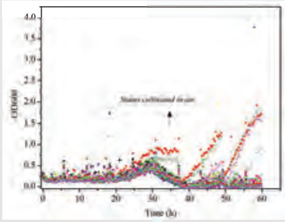
适应性进化

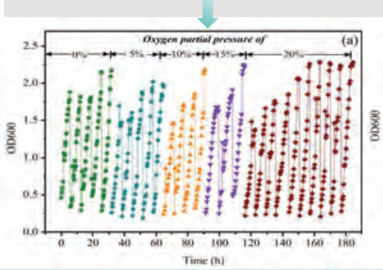
提高氧耐受能力，降低控制成本！

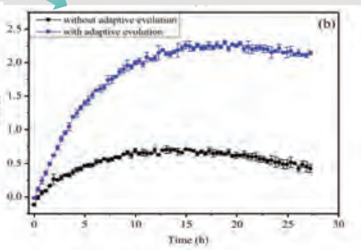
适应性进化策略选育氧耐受力提高的植物乳杆菌





氧气环境中植物乳杆菌的生长受到严重抑制





- 采用EVOL cell对植物乳杆菌（厌氧菌）进行**8天**连续传代培养驯化，以提高菌株对氧气的耐受性；
- 进化后的植物乳杆菌在**氧分压为20%**的情况下，生长情况可以**达到与完全无氧环境相当**；
- 与野生型相比，进化菌株的**生长速度**和最终OD600**显著增加**，在固定阶段**增加了130-150%**。

Biochemical Engineering Journal, 2023

发酵工艺优化放大

- **依赖人工操作**
- **工作量大**
- **效率低**
- **平行性差**
- **数据时效性不足**

自动化样品获得、处理和检测等是发展方向！

发酵工艺优化放大

- 培养基配制、分装
- 细菌培养及检测

- 培养基配制、分装
- 细菌培养及检测

- 小型发酵罐
- 发酵过程监控

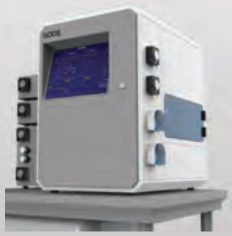
- 发酵罐
- 发酵过程监控

- 发酵生产车间
- 发酵过程监控

ABI
自动配料装液系统

MBP
样品自动化处理与检测分析系统

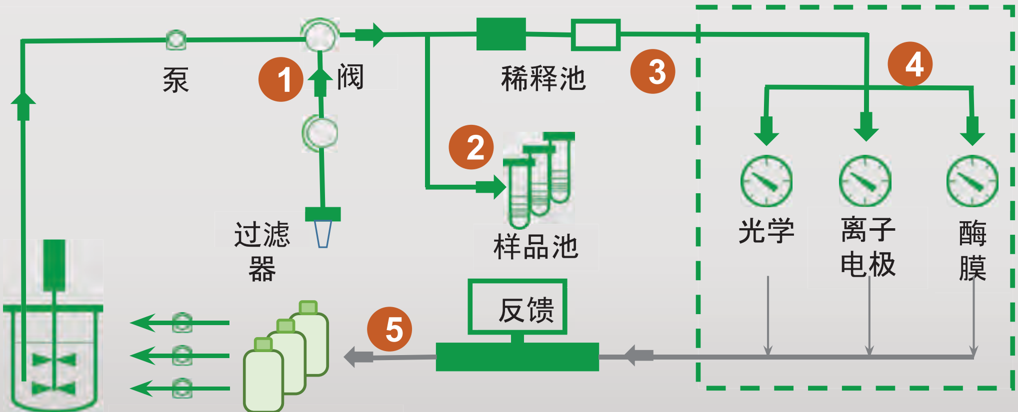
ASI
自动取样留样系统



BODS
生物反应在线自动检测系统

发酵工艺优化放大

高时效性、多参数、灵活配置、多反应器



1 **取样** 时效高；死体积小

2 **留样**

3 **样品处理** 全自动样品处理 精确样品稀释

4 **多种检测**
光学+离子+酶膜
参数多，速度快
量程大，精度高

5 **反馈控制**
支持多种补料策略
根据检测结果自动修正

可见光(OD)、荧光、NH_4^+、Na^+、K^+、Ca^{2+}、葡萄糖、木糖、乳酸、赖氨酸、谷氨酸、乙醇、甘油 ...

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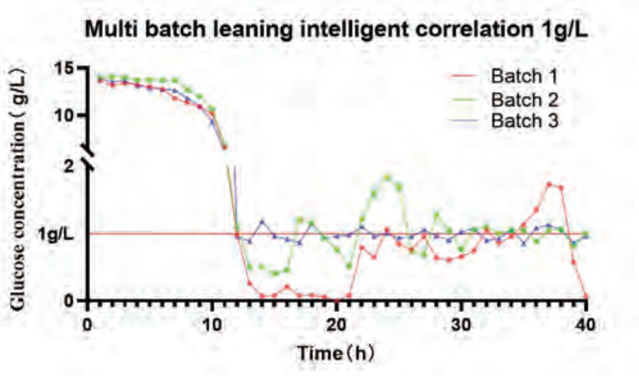
发酵工艺优化放大

智能AI补料反馈控制

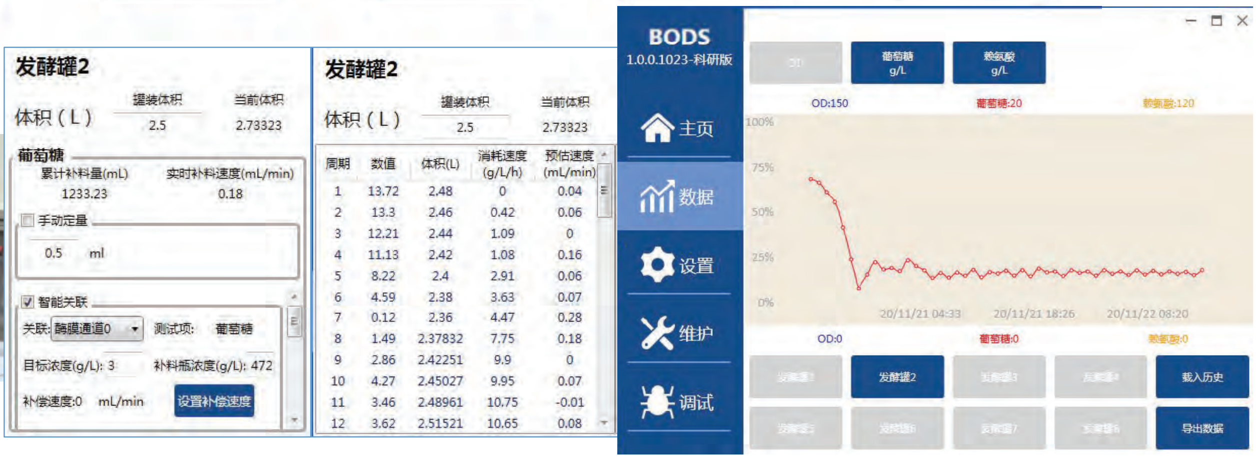


首批发酵通过AI评估菌株发酵过程葡萄糖消耗情况，生成补料反馈控制策略；后续批次发酵过程不断修正补料模型，经过3批次的AI自我学习，BODS控糖精度从**±1.0g/L提升到±0.15g/L**！！！

发酵工艺优化放大

智能AI补料反馈控制

糖浓度在线检测 → 糖消耗速率计算 → 补料速度预测 → 补料速度校正 → 低糖浓度精确调控



- 多策略、双通道 补料反馈控制
- 智能关联策略可精确控制 补料时机与补料速度，实现低浓度恒糖 发酵

生物育种一站式解决方案

● 高性能菌株筛选平台

- 大容量菌株突变库构建
- 高通量菌株筛选

- 高产菌株筛选:抑菌物质、功能糖、生物酶、氨基酸、蛋白质、多糖、抗体;
- 高灵敏度胞内生物传感器筛选
- 关键基因挖掘

● 稀有功能菌株资源挖掘平台

- 微生物资源挖掘
- 高通量菌株筛选

- 环境样本微生物资源挖掘(如土壤样本、水样、粪便等样品)
- 环境中微生物快速检测

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生物育种一站式解决方案

● 高鲁棒性菌株获取平台

- 大容量菌株突变库构建
- 菌株适应性进化

- 改善菌株对环境耐受性: pH、盐浓度、温度、氧气
- 解除菌株底物/产物抑制
- 优化菌株生长性能

● 发酵过程优化及放大平台

- 体系优化放大: μL→mL→L
- 发酵过程控制

- 改善菌株对环境耐受性,解除菌株底物/产物抑制
- 缩短菌株进入发酵工艺的时间,打破量产壁垒

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生物育种一站式解决方案

● 高通量生物育种和筛选新型平台解决方案

全流程解决方案
天木系统生态链

- 大容量菌株突变库构建
- 高通量菌株筛选
- 微生物资源挖掘
- 菌株适应性进化
- 发酵过程优化及放大

顶尖博士团队
技术支持对接

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生物育种一站式解决方案

发表论文

Metabolic Engineering	IF=8.829	Angewandte Chemie International Edition (GDCh)	IF=16.823
Chemical Engineering Journal	IF=16.744	Trends in Biotechnology	IF=14.3
BMC Part of Springer Nature	IF=16.837	Green Chemistry	IF=11.034
Biochemical Engineering Journal	IF=4.446	Biotechnology and Bioengineering	IF=4.395


THANKS
FOR YOUR ATTENTION

Dr. CHEN-CHE HSIEH

國立高雄科技大學
水產食品科學系
National Kaohsiung University of Science and Technology
Department of Seafood Science

Innovation in Precision Fermentation for Food Application

PRESENTED BY Dr. CHEN-CHE HSIEH

03.13.2025

1

國立高雄科技大學
水產食品科學系
National Kaohsiung University of Science and Technology
Department of Seafood Science

Dr. CHEN-CHE HSIEH

OUTLINE

Research Team Introduction

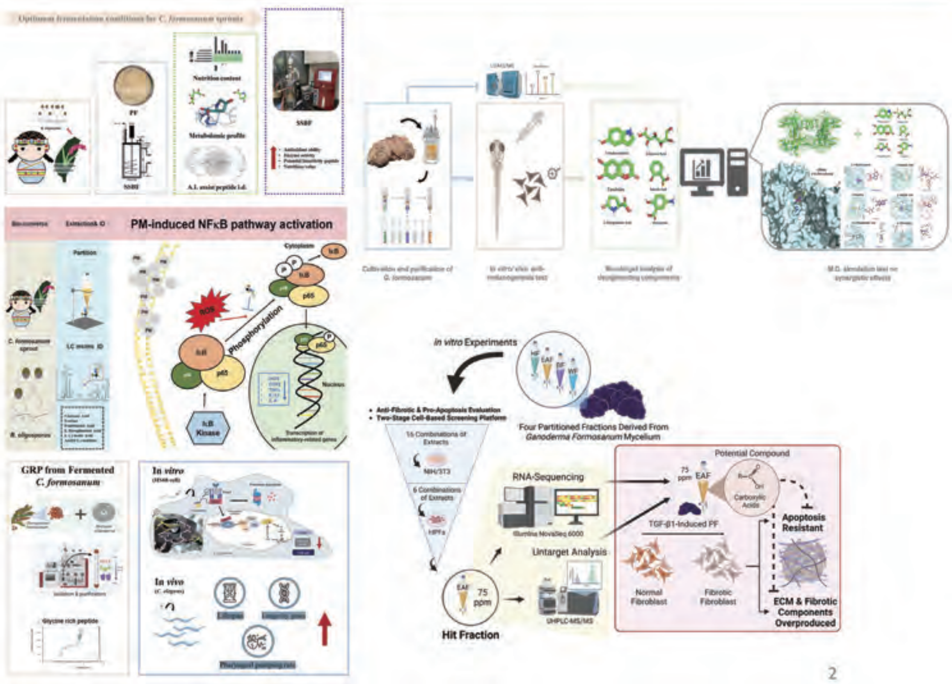
- Self Introduction
- Team Introduction

Innovative Technology

- Problem and Solution
- Bioreactor-based Technology
- Transcriptome Deep Exploration
- Global Natural Products Networking
- Precise Action at the Molecular Level

Industrial value and Publication

- From Lab to Food Industry
- Takeaway



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國立高雄科技大學
水產食品科學系
National Kaohsiung University of Science and Technology
Department of Seafood Science

Dr. CHEN-CHE HSIEH

Research Team Introduction

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國立高雄科技大學
水產食品科學系
National Kaohsiung University of Science and Technology
Department of Seafood Science

Dr. CHEN-CHE HSIEH

Self Introduction

Chen-Che, Hsieh Ph.D.

Assistant Professor, Department of Seafood Science, National Kaohsiung Univ. of Science and Technology

*Applying artificial intelligence and multi-omics methods in bioreactor engineering to develop low-carbon sustainable algae based functional foods with anti-aging potential.

Postdoc., Food Science Technology, National Taiwan Univ.

*Artificial intelligence assisted technology in the production of bioactive-peptides from fermented *Chenopodium formosanum* sprouts to restore photodamage by UV light.

Ph.D., Institute of Biotechnology, National Taiwan Univ.

*Comprehensive analysis of metabolites from solid-state fermented *Chenopodium formosanum* sprouts and evaluation of their potentials against PM2.5 -induced inflammation.

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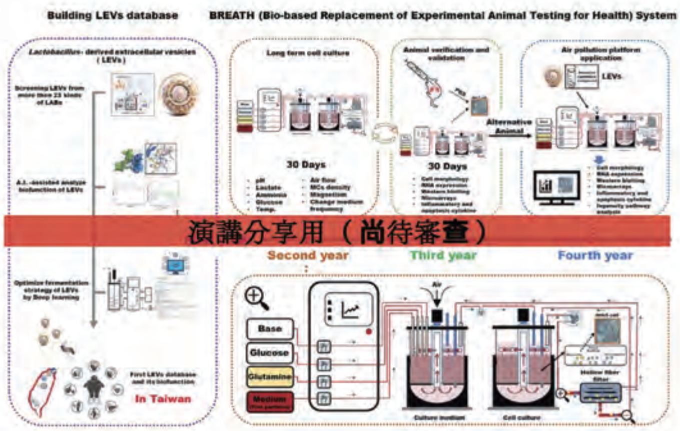
國立高雄科技大學 水產食品科學系
National Kaohsiung University of Science and Technology Department of Seafood Science

Dr. CHEN-CHE HSIEH

Current Studies (NSTC)

Applying Artificial Intelligence and Multi-Omics Methods in Bioreactor Engineering to Develop Low-Carbon Sustainable Algae-Based Functional Foods with Anti-Aging Potential

Establishing the First *Lactobacillus*-Derived Extracellular Vesicle Database in Taiwan for LEV Screening to Mitigate PM2.5-Induced Inflammation Using the ""*BREATH*"" System



Four-year complete project workflow diagram.

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Current Studies (Industry cooperation)

佳味香

Selected for Presentation at the IFT FIRST Conference 2025 in Chicago, USA

Effect of Sacha inchi (*Plukenetia volubilis*) meal addition on chicken frankfurt sausage nutritional properties and sensory evaluation

Special Aromatic Beer Brewing Process

工業技術研究院 Industrial Technology Research Institute

Development of High-Value Applications from Agricultural By-Products

DTIT PEPSICO

Selected for Presentation at the IFT FIRST Conference 2025 in Chicago, USA

Evaluate *Lactiplantibacillus plantarum*'s ability to degrade solanine and enhance bioactive compound content under varying fermentation conditions and as potential functional foods

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國立高雄科技大學
水產食品科學系
National Kaohsiung University of Science and Technology
Department of Seafood Science

Dr. CHEN-CHE HSIEH

Team Introduction

Prof.
Dr. Kuan-Chen, Cheng
IoB / FST, NTU. / IUFoST Fellow

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IoB, NTU.

Postdoc.
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Dpt. Seafood Science, NKUST

Master student
Bo-Jun, Liao
Dpt. Seafood Science, NKUST

Intern
Tzu-I, Yang
Dpt. Seafood Science, NKUST

Intern
Chien-Ching, Li
Dpt. Seafood Science, NKUST

Associate Prof.
Dr. Shin-Ping Lin
Dpt. Food Safety, TMU.

Assistant Manager
Dr. Kai-Wen, Cheng
LWHK Lab. Co.

Master student
Jing-Ru, Pan
Dpt. Seafood Science, NKUST

Undergraduate students
Wei-Chen, Hsu
Dpt. Seafood Science, NKUST

Intern
Yun-Ta, Huang
Dpt. Seafood Science, NKUST

Intern
Wan-Yu, Hong
Dpt. Seafood Science, NKUST

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國立高雄科技大學
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National Kaohsiung University of Science and Technology
Department of Seafood Science

Dr. CHEN-CHE HSIEH

Innovative Technology

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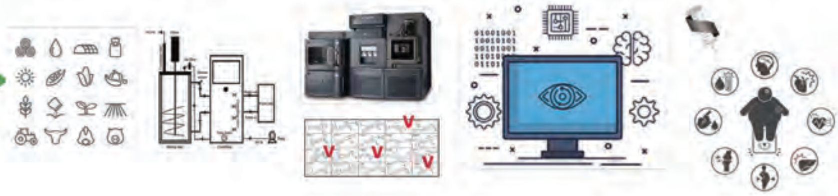
National Kaohsiung University of Science and Technology Department of Seafood Science

Dr. CHEN-CHE HSIEH

Innovative Technology: Problem and Solution

Previously researches

Future studies (with A.I. assisted)



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國立高雄科技大學 水產食品科學系
National Kaohsiung University of Science and Technology Department of Seafood Science

Dr. CHEN-CHE HSIEH

Innovative Technology: Problem and Solution

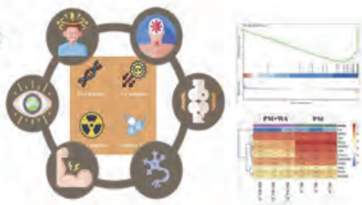
Bioreactor-based Technology

- By microbial enzymes
- Easy to mass produce
- High valuable natural products

A

Transcriptome Deep Exploration

- RNA-Seq methods for NGS
- Explore possible mechanisms
- Health food applications



B

C

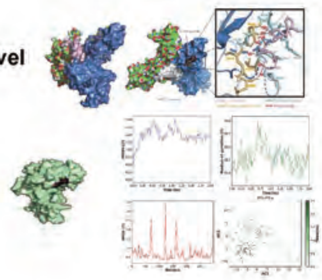
Global Natural Products Networking

- Untargeted analysis
- Novel compound discovery
- Structural analysis

D

Precise Action at the Molecular Level

- Pharmacophore identification
- Multiple ligand docking
- Molecular dynamic simulation



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National Kaohsiung University of Science and Technology Department of Seafood Science

Dr. CHEN-CHE HSIEH

Innovative Technology: Problem and Solution

Bioreactor-based Technology

- By microbial enzymes
- Easy to mass produce
- High valuable natural products

A B

C D

Precise Action at the Molecular Level

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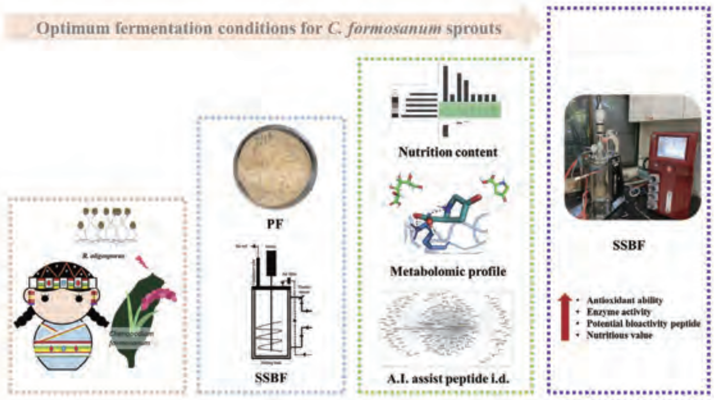
Dr. CHEN-CHE HSIEH

Product Fermented of *C. formosanum* Sprouts in a bioreactor

Production and Analysis of Metabolites From Solid-state Fermentation of *C. formosanum* (Djulis) Sprouts in a bioreactor

Food Research International
https://doi.org/10.1016/j.foodres.2023.112707



(Hsieh et al., 2023)

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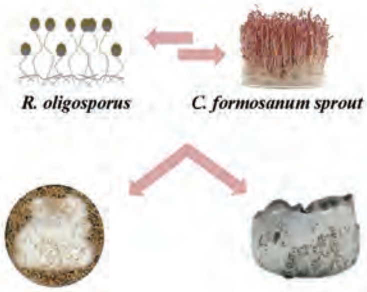
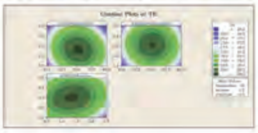
Fermentation strategy

PF



BF

Condition:
10^6 spores per 20 g of sterilized sprouts, 5% (v/w)



(簡，2019)

Condition:

10^6 spores/ mL

Aeration volume: 0.4 vvm

Rotation speed 5 rpm

(劉，2021)

PF: Traditional plate fermentation; BF: Bioreactor fermentation

(Hsieh et al., 2023)

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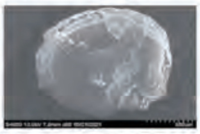
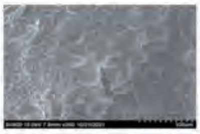
Scanning electron microscope of fermented *C. formosanum.*

(A) *C. formosanum* grain

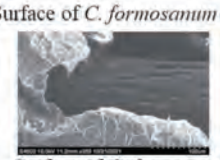


(B) Surface of *C. formosanum* grain

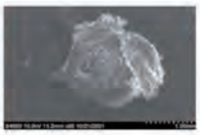


(C) *C. formosanum* sprout

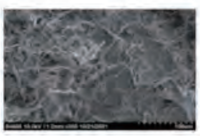
(D) Surface of *C. formosanum* spout



(E) Fermented *C. formosanum* sprout



(F) Surface of *C. formosanum* spout



1. **Fermented quinoa was covered by *R. oligosporus* mycelium, and revealed surface degradation compared to the general quinoa.**
   (Hur et al., 2018)

2. **The enzymes from bioreactor and tray (similar to PF) methods produce by *Aspergillus niger.* Bioreactor were much higher than those from the tray simply because the aeration and moisture.**
   (Mahmoodi et al., 2019)

3. **Bioreactor prevented the fermented substrates from clogging which improved heat removal efficiency through agitation.**
   (Starzyńska-Janiszewska et al., 2016; Mahmoodi et al., 2019)

PF: Traditional plate fermentation; BF: Bioreactor fermentation

(Hsieh et al., 2023)

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The antioxidant activity and free peptide content of *C. formosanum* sprouts

	Days	ABTS (mM Trolox)		DPPH (mM Trolox)		Free peptide (mg casein tryptone/g)	
		PF					
	1	23.72 ± 0.88^{b}		12.00 ± 1.30^{c}		16.17 ± 0.82^{c}	
	2	32.66 ± 2.41^{a}		20.54 ± 3.12^{a}		23.19 ± 0.65^{c}	
	3	33.49 ± 2.17^{a}	1.41 ↑	18.02 ± 2.04^{ab}	1.71 ↑	33.09 ± 2.00^{b}	2.33 ↑
PF	4	33.45 ± 2.18^{a}		16.94 ± 3.08^{ab}		37.17 ± 2.34^{a}	
	5	34.01 ± 0.92^{a}		15.79 ± 1.84^{b}		33.54 ± 0.27^{b}	
		BF					
	1	29.14 ± 0.94^{c}		12.40 ± 3.31^{b}		17.66 ± 7.49^{c}	
	2	33.55 ± 1.08^{b}		19.65 ± 3.32^{a}		31.75 ± 11.33^{c}	
BF	3	38.39 ± 1.18^{a}	1.33 ↑	17.69 ± 2.61^{ab}	1.58 ↑	57.19 ± 21.17^{b}	5.63 ↑
	4	38.76 ± 0.54^{a}		17.54 ± 3.35^{ab}		99.56 ± 7.77^{a}	
	5	37.35 ± 1.22^{a}		13.26 ± 2.10^{b}		97.14 ± 11.62^{a}	

(Hsieh et al., 2023)

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Fermented products of PF and BF (nutrition)

	PF for 4 days	BF for 4 days	
Enzyme activity (unit: U/g)			
α-amylase	1.38 ± 0.02^{b}	2.21 ± 0.01^{a}	1.60 ↑
β-glucosidase	33.45 ± 2.73^{b}	54.57 ± 10.88^{a}	1.63 ↑
Proteinase	27.60 ± 2.97^{b}	40.81 ± 6.52^{a}	1.49 ↑
Phenolic compounds (unit: mg/kg)			
Binding phenolic	43.84 ± 0.49^{a}	39.00 ± 0.23^{b}	
Free phenolic	48.56 ± 0.49^{b}	59.64 ± 1.42^{a}	1.23 ↑
Total phenolic	95.39 ± 4.06	100.63 ± 1.34	
Carotenoids	9.40 ± 0.93^{b}	12.91 ± 0.96^{a}	1.37 ↑
Chlorophyll a	14.98 ± 0.97^{b}	16.90 ± 0.95^{a}	1.13 ↑
Chlorophyll b	5.52 ± 0.35^{b}	12.91 ± 0.96^{a}	2.33 ↑
Anthocyanin	1.16 ± 0.91^{b}	2.72 ± 0.42^{a}	2.34 ↑
Flavone (QE mg/100g)			
Total flavones	119.14 ± 1.13	119.59 ± 15.07	
Isoflavone (unit: mg/100g)			
Daidzin	0.24 ± 0.03^{a}	0.07 ± 0.01^{b}	
Daidzein	0.01 ± 0.00^{b}	0.05 ± 0.00^{a}	5.00 ↑
Genistin	0.04 ± 0.01	0.06 ± 0.02	
Genistein	0.01 ± 0.00^{b}	0.04 ± 0.01^{a}	4.00 ↑
Glycitin	0.15 ± 0.02	0.17 ± 0.05	
Glycitein	N.D.	N.D.	
M-Glycitin	0.31 ± 0.08	0.40 ± 0.17	

1. The structural break down of cereal cell walls may occur due to the production of microbial enzymes during fermentation, which alter the compound profiles in the substrate

(Bei et al., 2018)

2. The removal of glycosyl group from isoflavones may enhance their biological activity

(Wang et al, 2020)

(Hsieh et al., 2023)

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Identification of compounds from PF and BF (untargeted analysis)

PF for 4 days			BF for 4 days		
Compound	MeSH Tree Classification	mzCloud Best Match	Compound	MeSH Tree Classification	mzCloud Best Match
Cortisol	Alcohol	78.4	Ecdysterone	Alcohol	92.2
Trigonelline	Alkaloids	99.5	(R,S)-Anatabine	Alkaloids	88.6
2-Naphthylamine	Amines	99.3	4-Ethylbenzaldehyde	Aldehydes	71.3
Stearamide	Amines	99.1	2-Amino-1,3,4-octadecanetriol	Amino alcohol	98.8
Choline	Amines	99.0	Linoleoyl ethanolamide	Amino alcohol	99.9
D-Sphingosine	Amines	85.8	Stearamide	Amines	99.9
Stearoyl ethanolamide	Amines	90.7	Choline	Amines	99.6
Oleoyl ethanolamide	Amines	90.6	Betahistine	Amines	98.2
α-Linolenoyl ethanolamide	Amines	90.3	Hexanoylcarnitine	Amines	91.1
Gluconic acid	Carboxylic acid	99.4	D-Sphingosine	Amines	83.8
13S-hydroxy-6Z,9Z,11E-octadecatrienoic acid	Fatty acids	94.9	N-Acetylsphingosine	Amines	78.9
Bis (4-ethylbenzylidene) sorbitol	Glucitol	97.4	2,6-Diaminotoluene	Amines	75.8
Corticosterone	Hormone	91.1	Kynurenic acid	Carboxylic acid	96.2
Indole-3-acrylic acid	Indoles	72.7	4-Acetamidobutanoic acid	Carboxylic acid	96.1
3'-Adenosine monophosphate	Nucleotide	99.7	Anacardic acid	Carboxylic acid	94.7
Guanosine	Nucleotide	99.7	2-Hydroxycinnamic acid	Carboxylic acid	92.3
2'-O-Methyladenosine	Nucleotide	99.4	Gluconic acid	Carboxylic acid	99.0
Adenosine	Nucleotide	86.9	Succinic acid	Carboxylic acid	98.7
Isoferulic acid	Phenol	98.0	Corchorifatty acid F	Carboxylic acid	88.9
4-Hydroxybenzaldehyde	Phenol	97.7	Erucic acid	Fatty acids	97.8
Ferulic acid	Phenol	95.4	9-Oxo-10(E),12(Z)-octadecadienoic acid	Fatty acids	99.6
Adenine	Purines	98.7	5-Oxo-eicosatetraenoic acid	Fatty acids	97.2
Guanine	Purines	95.8	12-Oxo phytodienoic acid	Fatty acids	96.2
Xanthine	Purines	78.2	α-Linolenoyl ethanolamide	Amines	89.6
2,4-Quinolinediol	Quinolines	98.1	(±) 9-hydroperoxy-octadecadienoic acid	Fatty acids	89.2
α, α-Trehalose	Sugar	99.6	Oleoyl ethanolamide	Amines	88
Pantothenic acid	Vitamin	97.8	13S-hydroxy-6Z,9Z,11E-octadecatrienoic acid	Fatty acids	71.9
Nicotinic acid	Vitamin	78.1	Quercetin-3β-D-glucoside	Flavonols	98.6
-	-	-	Quercetin	Flavonols	93.4
-	-	-	Rutin	Flavonols	95.9
-	-	-	Trifolin	Glycosides	72.8
-	-	-	Corticosterone	Hormones	90.7

PF for 4 days			BF for 4 days		
Compound	MeSH Tree Classification	mzCloud Best Match	Compound	MeSH Tree Classification	mzCloud Best Match
-	-	-	Indole-3-acrylic acid	Indoles	73.2
-	-	-	2'-O-Methyladenosine	Nucleotide	99.9
-	-	-	Adenosine	Nucleosides	100
-	-	-	2'-Deoxyadenosine	Nucleosides	100
-	-	-	Glycyl-L-leucine	Peptides	100
-	-	-	α-Aspartylphenylalanine	Peptides	95.3
-	-	-	4-Hydroxybenzaldehyde	Phenols	96
-	-	-	2-Aminophenol	Phenols	95
-	-	-	Pyrogallol	Phenols	87.8
-	-	-	Guanine	Purines	97.3
-	-	-	Adenine	Purines	84.4
-	-	-	Valine	Pyridines	98.5
-	-	-	2,4-Quinolinediol	Quinolones	73.7
-	-	-	α, α-Trehalose	Sugars	99.6
-	-	-	Arjungenin	Terpenes	92.7
-	-	-	Nicotinic acid	Vitamins	100
-	-	-	Acetyl-L-carnitine	Vitamins	99.9
-	-	-	Pantothenic acid	Vitamins	99.6
-	-	-	6-Hydroxynicotinic acid	Vitamins	98.8

(Hsieh et al., 2023)

α-Amylase and protease hydrolyze the covalent bonds between insoluble bound phenolics and plant cell-wall structure, releasing the phenolic substances

(Nguyen et al., 2014; Bei et al., 2018; Abdel-Aty et al., 2019)

Flavonoids, phenol, purines, and indoles, were more abundant in BF fermented products than those from PF.

There were 1 and 7 types carboxylic acids determined from PF and BF fermented products.

There were 1 and 6 types fatty acids determined from PF and BF fermented products.

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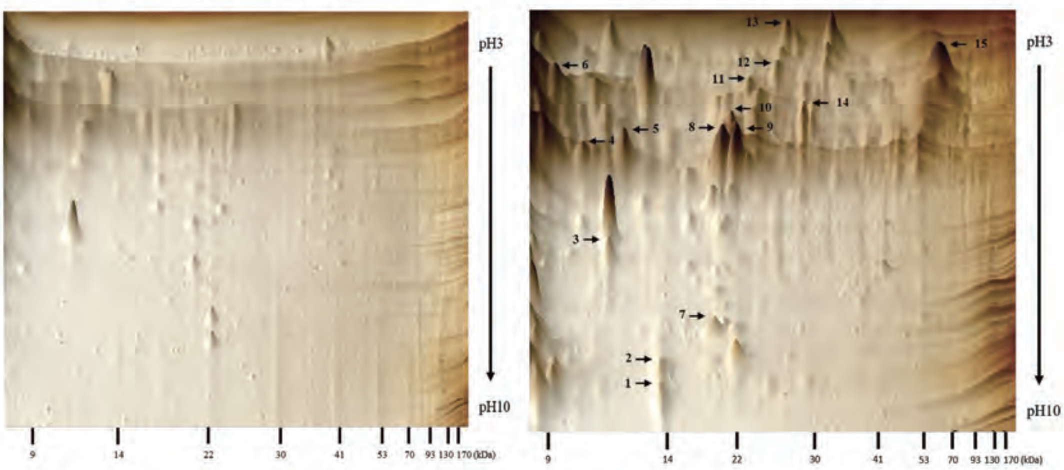
Differences in proteomics between the two fermentation methods

PF products after 4 days　　BF products after 4 days



The total of 15 spots of difference were detected, which were spread over the molecular weight ranging from 6 kDa to 70 kDa.

(Hsieh et al., 2023)

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Identification of proteomics from PF and BF

Spots	Accession No.	Protein structure	MW [kDa]	calc. pI	Identified sequence	Bioactive property prediction	
						FRS score	Potential activity
01	A0A803LCL7		11.40	11.47	TVTAMD VVYALK	0.37	DPP IV inhibitor Antioxidative ACE inhibitor Renin inhibitor DPP-III inhibitor
03	A0A803MHX2		10.50	8.40	NAAAAIS GIDYSK	0.34	ACE inhibitor DPP IV inhibitor Hypotensive DPP-III inhibitor
04	A0A803MJA2		9.80	4.49	AAELTTL LESR	0.35	DPP IV inhibitor Glucose uptake stimulating Antioxidative ACE inhibitor
05	A0A0A1MW81		13.8	4.65	DNSMLTF EGAPVQ GAAAITE K	0.41	DPP IV inhibitor Antioxidative ACE inhibitor Renin inhibitor DPP-III inhibitor
08	A0A803MZP0		20.2	5.63	IAQIPVSE AYLGRAT P	0.35	DPP IV inhibitor Antioxidative ACE inhibitor Anxiolytic Alpha-glucosidase inhibitor DPP-III inhibitor
09	A0A803MNS7		23.8	5.20	TDEYGGS IENRFMN	0.42	DPP IV inhibitor Immunomodulating ACE inhibitor Renin inhibitor DPP-III inhibitor
14	A0A0A1NW23		27.1	5.35	QWLAEN VSQEAAE K	0.30	DPP IV inhibitor Hypotensive ACE inhibitor Alpha-glucosidase inhibitor DPP-III inhibitor Ubiquitin-mediated proteolysis

After blasting using Uniports database, five quinoa and two fungus peptides were identified.

1. Deep convolutional neural networks method (AnOxPePred) and bioinformatic approaches (BIOPEP-UWM).
(Minkiewicz et al., 2019; Olsen et al., 2020)

All the amino acid sequences showed the relatively high free radical scavenging scores (from 0.30 to 0.42).

2. A, C, L, Y, I, V, K, F, H, and M amino acid residues in their sequences, which could contribute to the antioxidant activities
(Zhao et al., 2020)

The peptides present high potentials as nutraceuticals and therapeutic agents.

FRS: free radical scavenging scores

(Hsieh et al., 2023)

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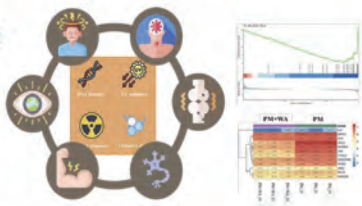
Precision Biotransformation in Food Application

A

B

Transcriptome Deep Exploration

- RNA-Seq methods for NGS
- Explore possible mechanisms
- Health food applications



C

D

Precise Action at the Molecular Level

- Pharmacophore identification
- Multiple ligand docking
- Molecular dynamic simulation

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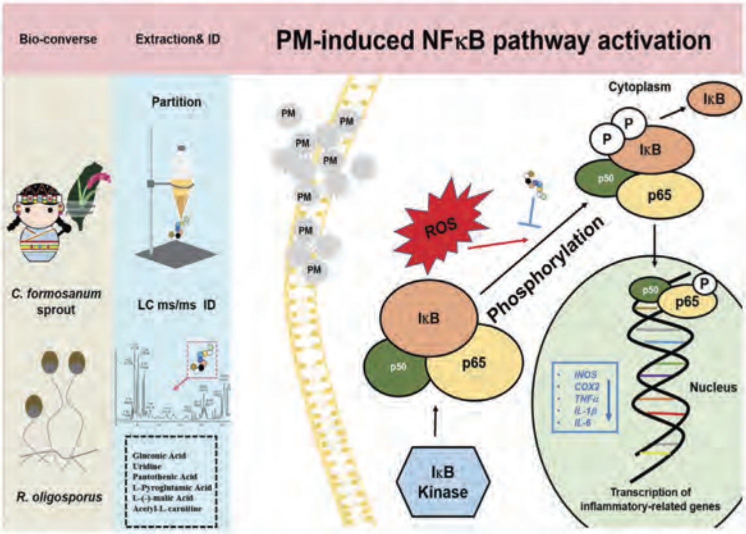
Small molecular in Fermented product extraction

Alleviation of PM2.5-induced alveolar macrophage inflammation using extract of fermented *C. formosanum* Koidz sprouts via regulation of NF-κB pathway

Journal of Ethnopharmacology



(Hsieh et al., 2024)

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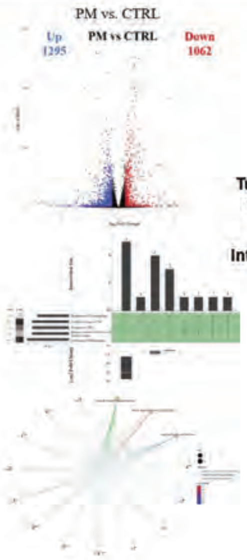
Transcriptomic changes in PM-MHS model

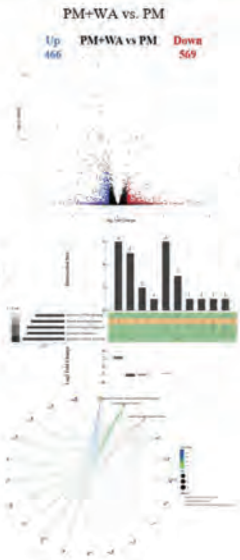


Tumor necrosis factor (TNF) → PM2.5 ← Regulation of NF-κB signaling

Interleukin 6 (IL-6) → PM2.5 ← Immune response-activating cell surface receptor

↓

IL1b, ZC3H12A, TNF, and *NFKBIA* ↑



NF-κB signaling → PM2.5+WA ← ROS metabolic

Leukocyte migration and chemotaxis → PM2.5+WA ← Upregulation of neuron projection terminus

↓

IL1b, ZC3H12A, TNF, and *NFKBIA* ↓

(Hsieh et al., 2024)

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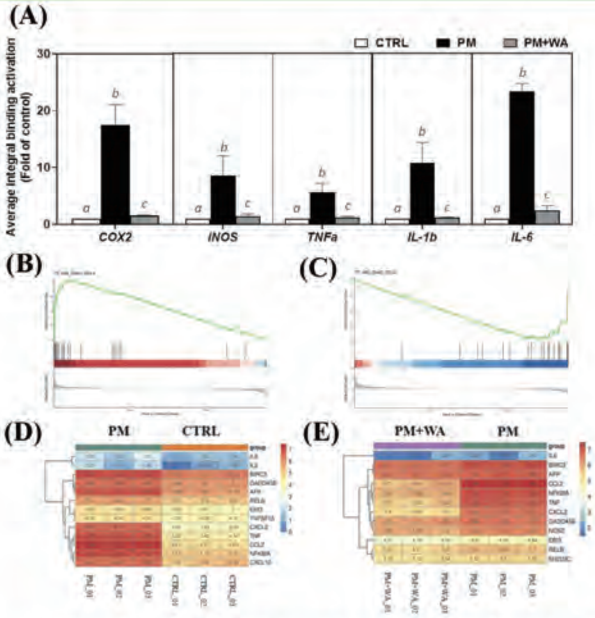
Reducing inflammatory-related nodal genes expression



Water extraction significantly downregulates RELA binding of *COX2*, *iNOS*, *TNFα*, *IL-1β*, and *IL-6* genes in the promoter regions, inhibiting ROS production and inflammation.

The Different expression genes on the Water extraction group significantly decrease with the RELA-mediated transcription genes.

(Hsieh et al., 2024)

Water-extracted FCS has anti-oxidation and anti-inflammatory properties, and possesses the ability to regulate the transcription of RELA after PM2.5 exposure.

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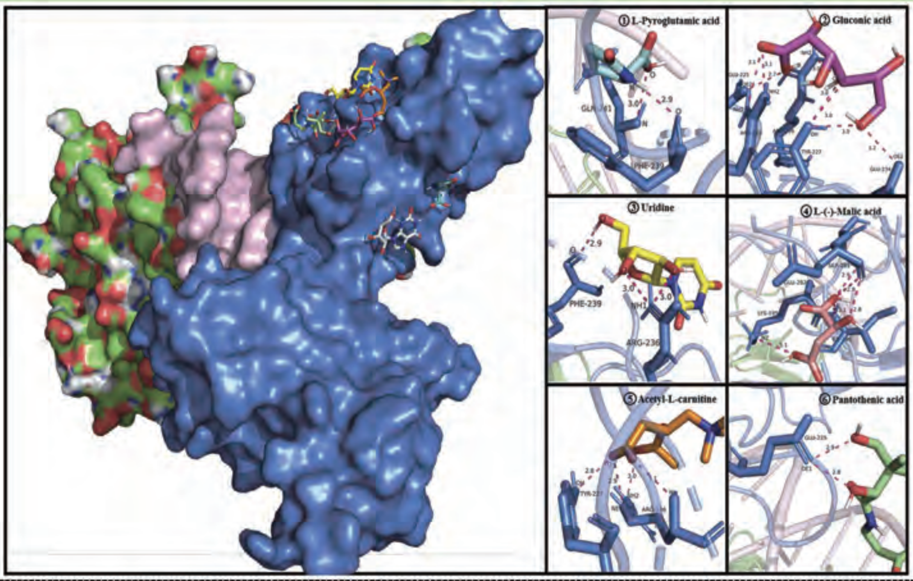
Binding sites in NF-κB with multiple docking techniques



Gluconic acid, uridine, pantothenic acid, L-pyroglutamic acid, L-(-)-malic acid, and acetyl-L-carnitine completely enters into the active pockets of RELA subunit and forms 24 hydrogen bonds.

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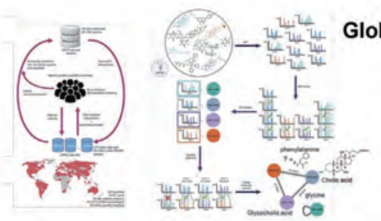
Precision Biotransformation in Food Application

C



Global Natural Products Networking

- Untargeted analysis
- Novel compound discovery
- Structural analysis

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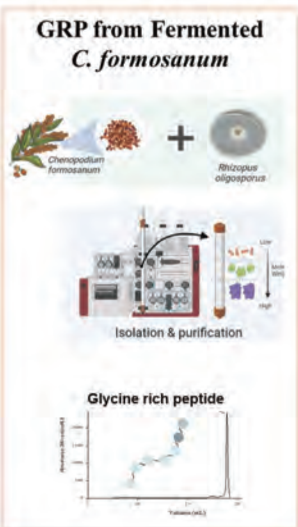
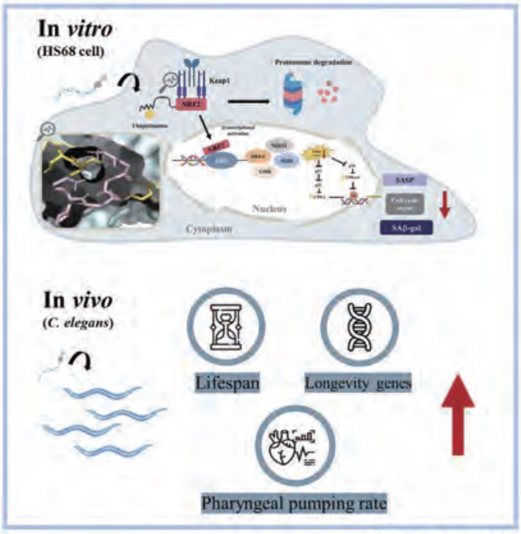
Heptapeptide in fermented *C. formosanum* products exhibit anti- Senescence Activity

Peptide from tempeh-like fermented *Chenopodium formosanum* counters senescence while enhancing antioxidant ability in non-replicative aging

LWT - Food Science and Technology
(Accept, coming soon)





(Hsieh et al., 2025)

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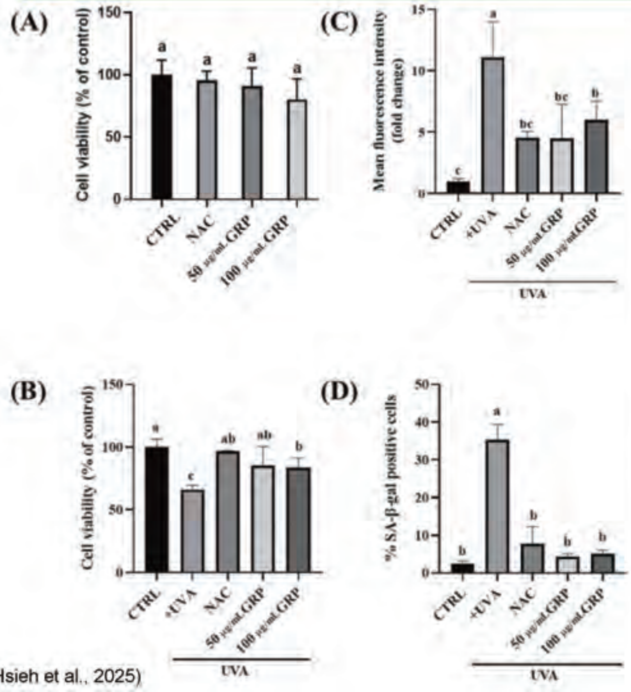
GRP modulates ROS production and prevents UVA-induced aging



(Hsieh et al., 2025)

GRP at 50 μg/mL enhances cell survival and reduces ROS levels, showing antioxidative effects comparable to NAC (1 mM).

Its glycine-rich composition suggests a role in boosting GSH activity, potentially mitigating oxidative stress and preventing cellular damage.

GRP significantly reduces SA-β-gal-positive cells, indicating its potential in slowing non-replicative aging.

The observed anti-senescence effects highlight GRP's potential application in functional foods for skin health and aging prevention.

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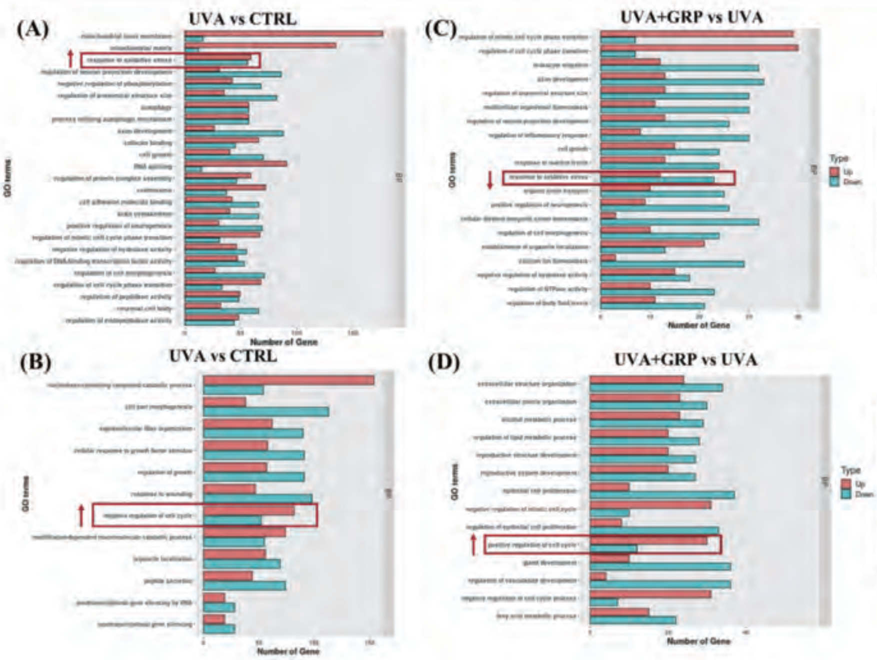
GRP Enhances Cell Cycle Regulation and Delays Cellular Aging



UVA exposure significantly upregulates oxidative stress-related genes and disrupts cell cycle regulation, accelerating cellular aging .

GRP downregulates oxidative stress response genes and promotes positive regulation of the cell cycle, suggesting its role in cellular repair and delaying aging

(Hsieh et al., 2025)

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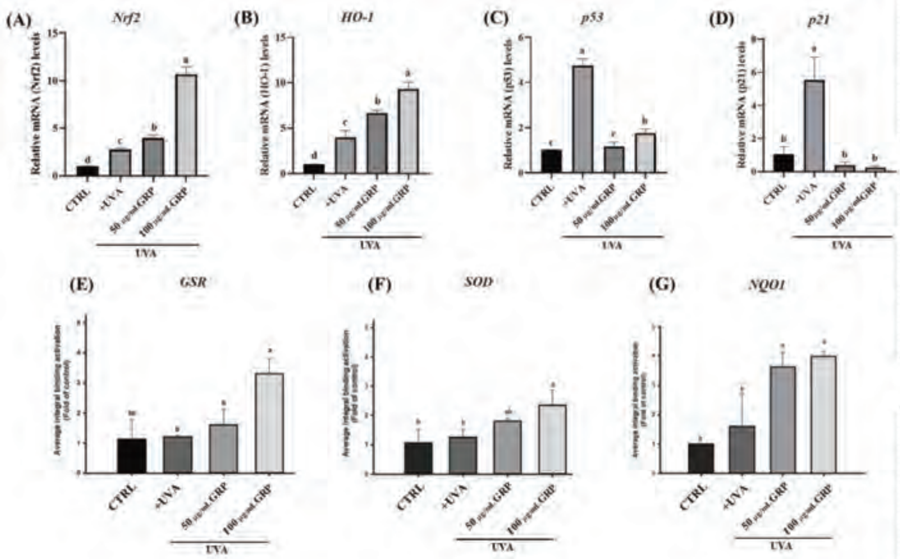
GRP Activates the Nrf2 Pathway to Reduce Oxidative Stress and Delay Cellular Aging



GRP pretreatment significantly upregulates *Nrf2* (3.86x) and *HO-1* (2.32x) expression, promoting antioxidant defense mechanisms against UVA-induced oxidative stress .

GRP suppresses *p53* and *p21* expression, reducing cellular senescence and mitigating non-replicative aging.

GRP enhances antioxidant enzyme expression, including *SOD*, *GSR*, and *NQO1*, indicating its potential role in maintaining redox homeostasis and protecting cells from oxidative damage.

(Hsieh et al., 2025)

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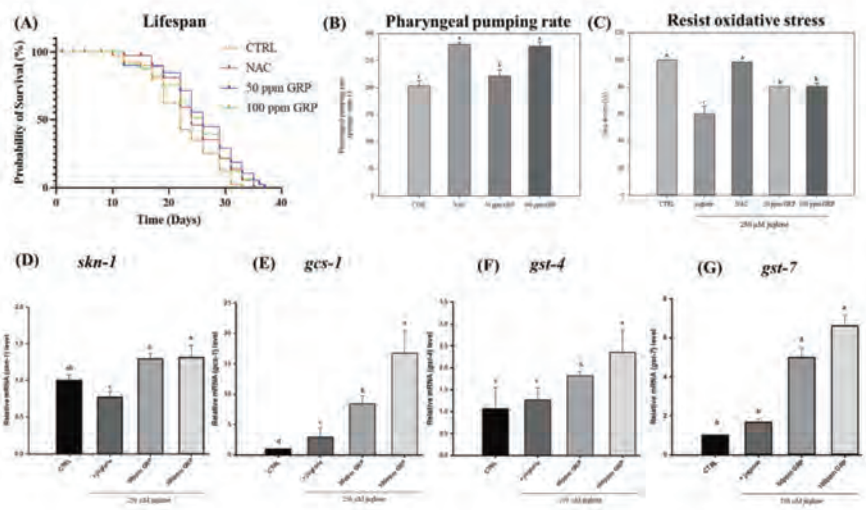
GRP Extends Lifespan and Enhances Stress Resistance in *C. elegans*



GRP treatment significantly increases lifespan in *C. elegans* by 13.4% and 11.0%, respectively, comparable to NAC supplementation.

GRP improves physiological functions, as indicated by an increased pharyngeal pumping rate, suggesting a role in maintaining metabolic health during aging.

GRP enhances oxidative stress resistance, improving worm survival under juglone-induced oxidative stress, similar to NAC's protective effects.

(Hsieh et al., 2025)

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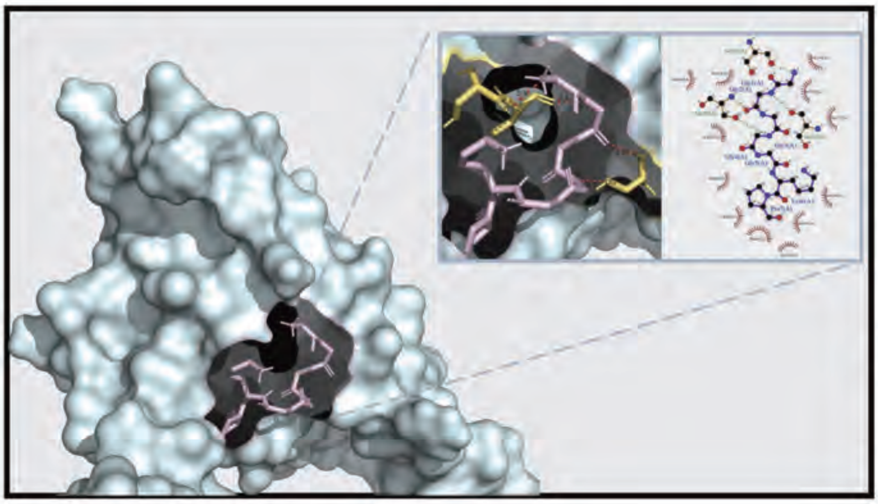
GRP May Interacts with Keap1-BTB to Enhance Nrf2 Activation



The Keap1-BTB inhibitory site regulates Nrf2 degradation by binding to Cul3, preventing Nrf2 activation. Inhibiting this site disrupts Keap1 function, allowing Nrf2 to translocate into the nucleus and activate antioxidant defense genes.

Molecular docking analysis reveals that GRP binds to the Keap1-BTB inhibitory site with a docking affinity of -5.22 kcal/mol, forming four hydrogen bonds with Ser102, Ser103, and Ser166.

GRP's glycine-rich structure facilitates covalent interactions with key residues (Ser104, Pro105, and Phe139), suggesting a potential inhibitory effect on Keap1-BTB, thereby enhancing Nrf2 translocation and antioxidative gene expression.

(Hsieh et al., 2025)

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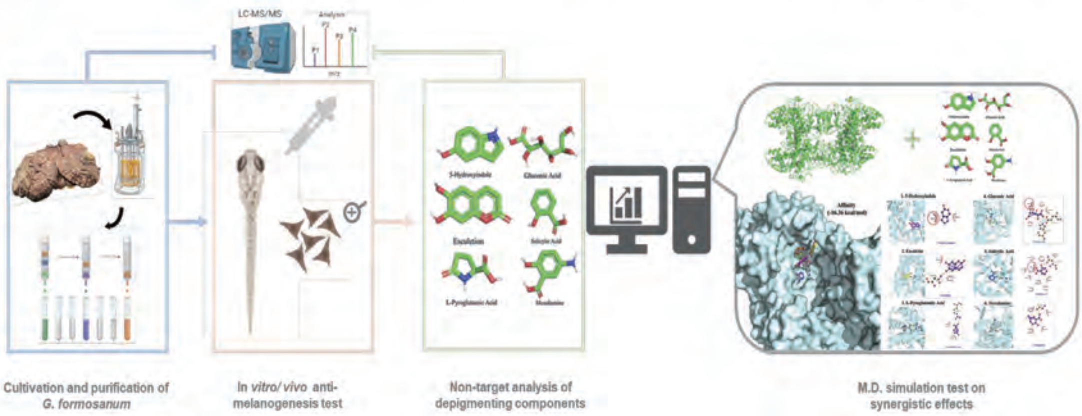
Compounds in *G. formosanum* exhibit Anti-Melanogenic Activity

Aromatic compounds and organic acids identified from *Ganoderma formosanum* exhibit synergistic anti-melanogenic effects

Journal of Food and Drug Analysis
https://doi.org/10.38212/2224-6614.3509



(Hsieh et al., 2024)

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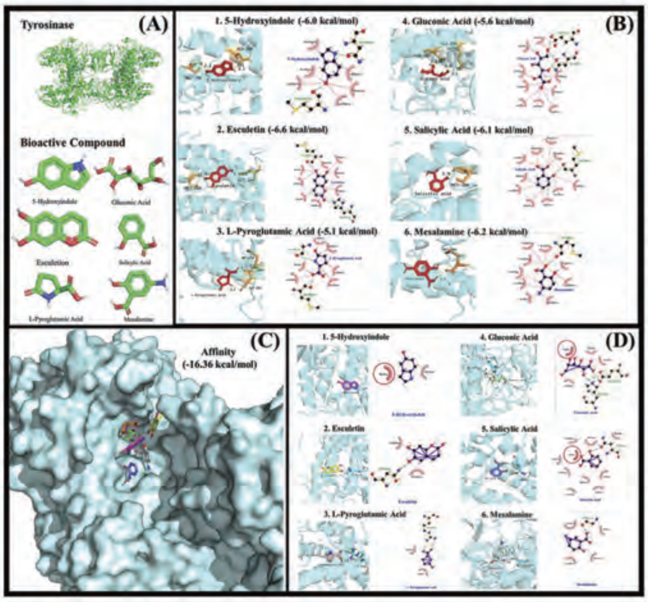
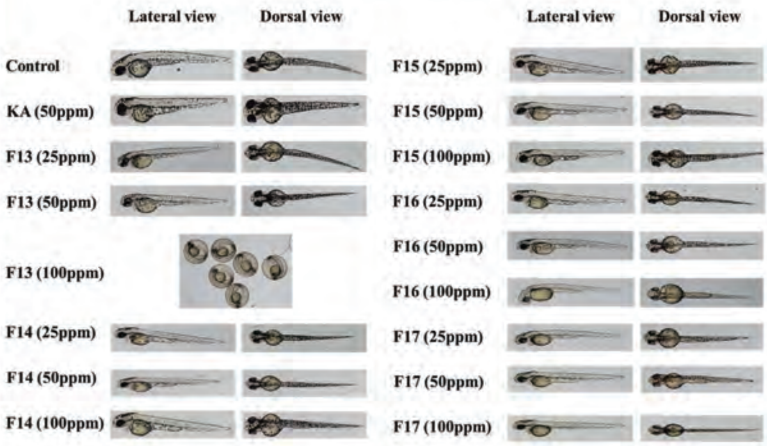
Compounds in *G. formosanum* exhibit Anti-Melanogenic Activity



In vivo validation (Zebra fish)



(Hsieh et al., 2024)

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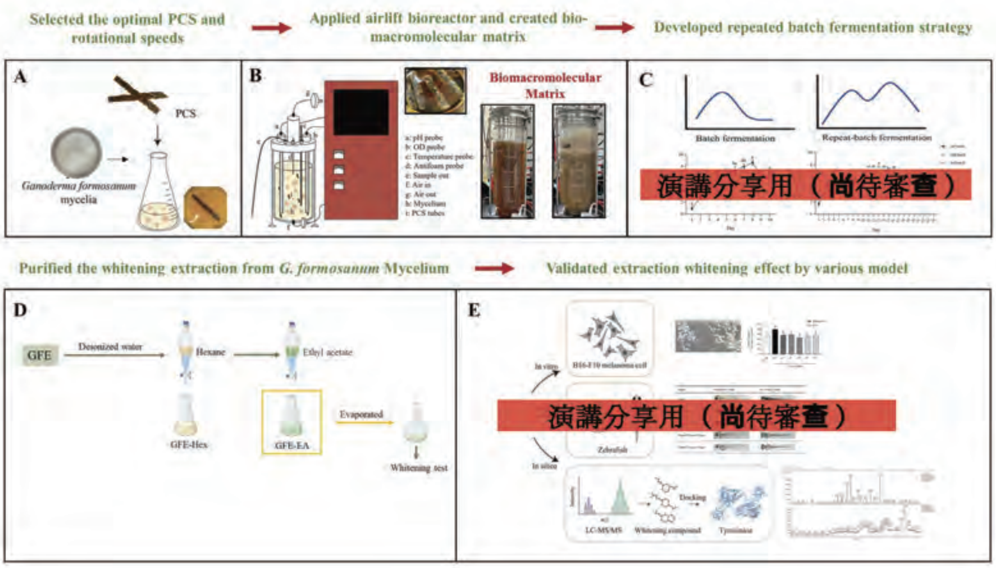
Optimized PCS-Based Fermentation for *G. formosanum* Whitening Compound Production

Sustainable Repeated Batch Fermentation of Plastic Composite Support–Immobilized *Ganoderma formosanum* Mycelium as a Biomacromolecular Matrix for the Production of Natural Whitening Compounds in an Airlift Bioreactor



(Coming Soon)

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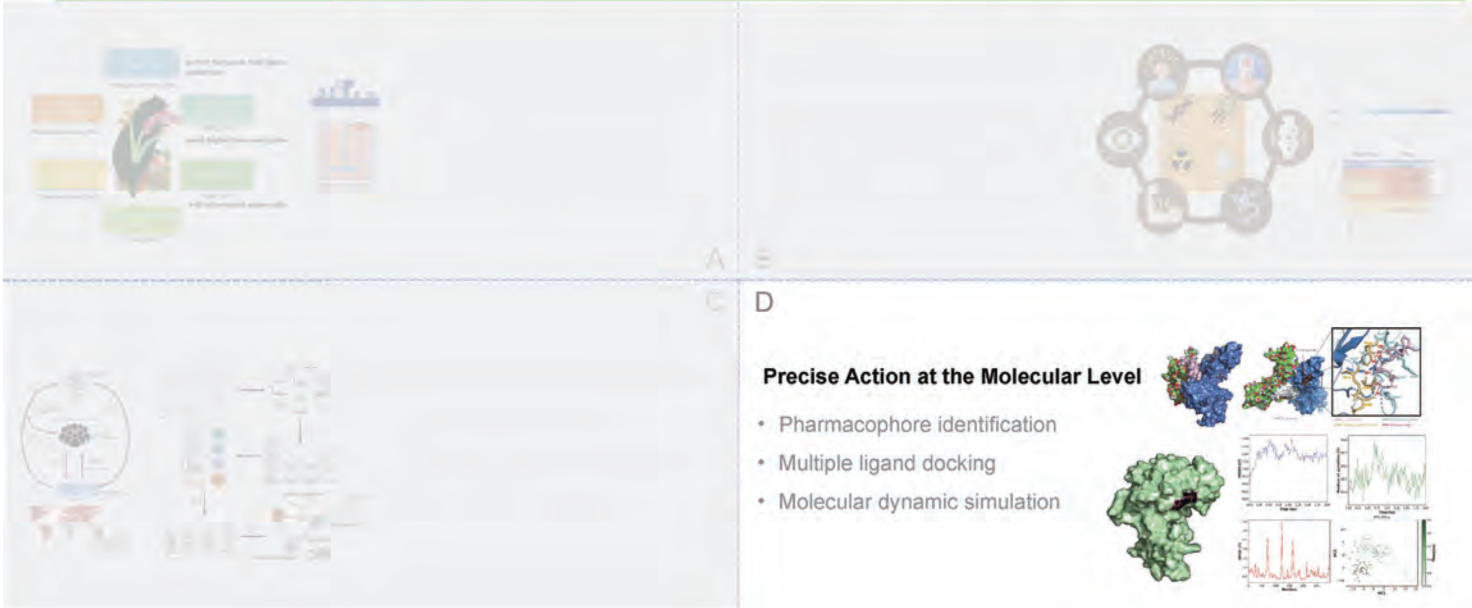
Precision Biotransformation in Food Application



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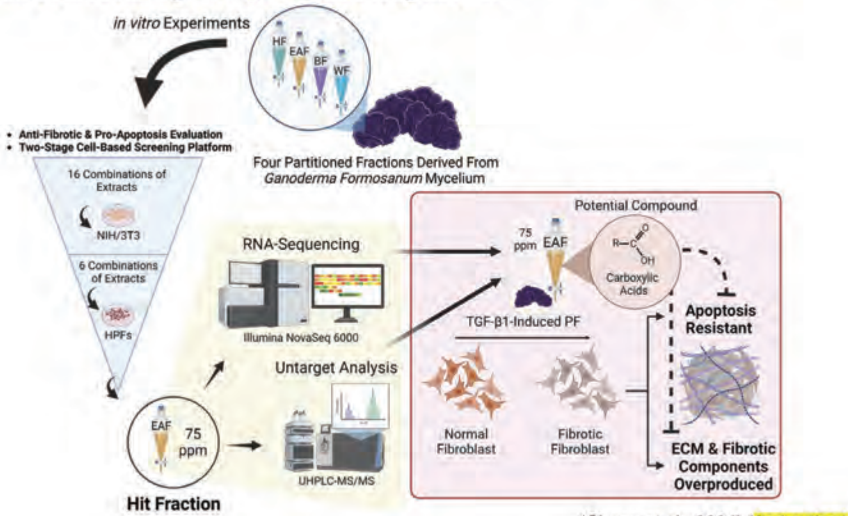
GFE suppress TGF-β1-induced lung fibrosis

Identification of anti-fibrotic and pro-apoptotic bioactive compounds from *G. formosanum* and their possible mechanisms in modulating TGF-β1-induced lung fibrosis

Journal of Ethnopharmacology



(Cheng et al., 2024) (2nd author)

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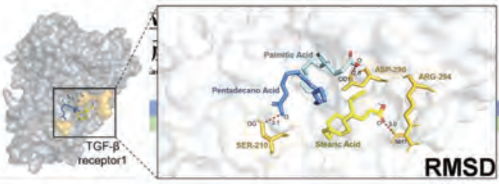
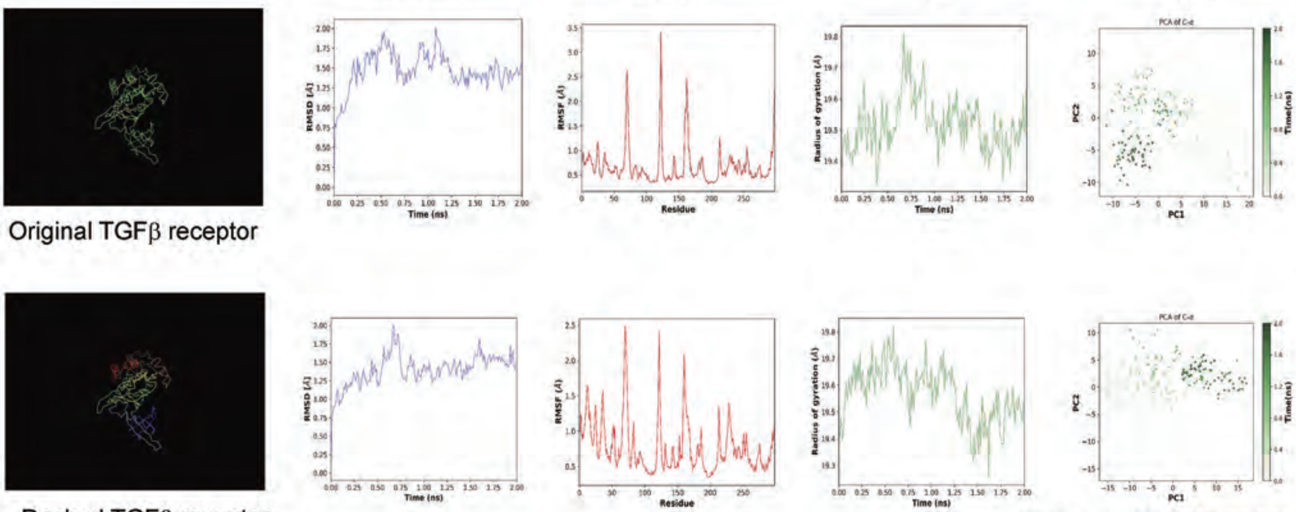


Depicts the molecular dynamics simulation conducted on both the original TGFβ receptor and the docked TGFβ receptor



(Cheng et al., 2024) (2nd author)

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Takeaway

Microbial Enzyme-Based Precision Biotransformation

- Precision fermentation leverages microbial enzymes to target specific metabolites, enabling the production of high-value natural products.

Multi-Omics Integration for Mechanistic Insights

- Precision fermentation incorporates transcriptomics (RNA-Seq), metabolomics, and untargeted mass spectrometry analysis to elucidate the functional metabolic pathways.

Targeted Regulation with Molecular Simulations

- Molecular docking and molecular dynamics simulations are employed in precision fermentation to accurately predict and optimize interactions between microbial metabolites and target proteins.

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Takeaway

Scalability of Fermentation Systems for Industrial Applications

- Precision fermentation emphasizes scalability, transitioning from small-scale trials to industrial production.

Development and Application of High-Value Functional Foods

- Precision fermentation strategies have led to the development of products such as fermented soy-based foods rich in antioxidant peptides.

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Industrial value and Publication

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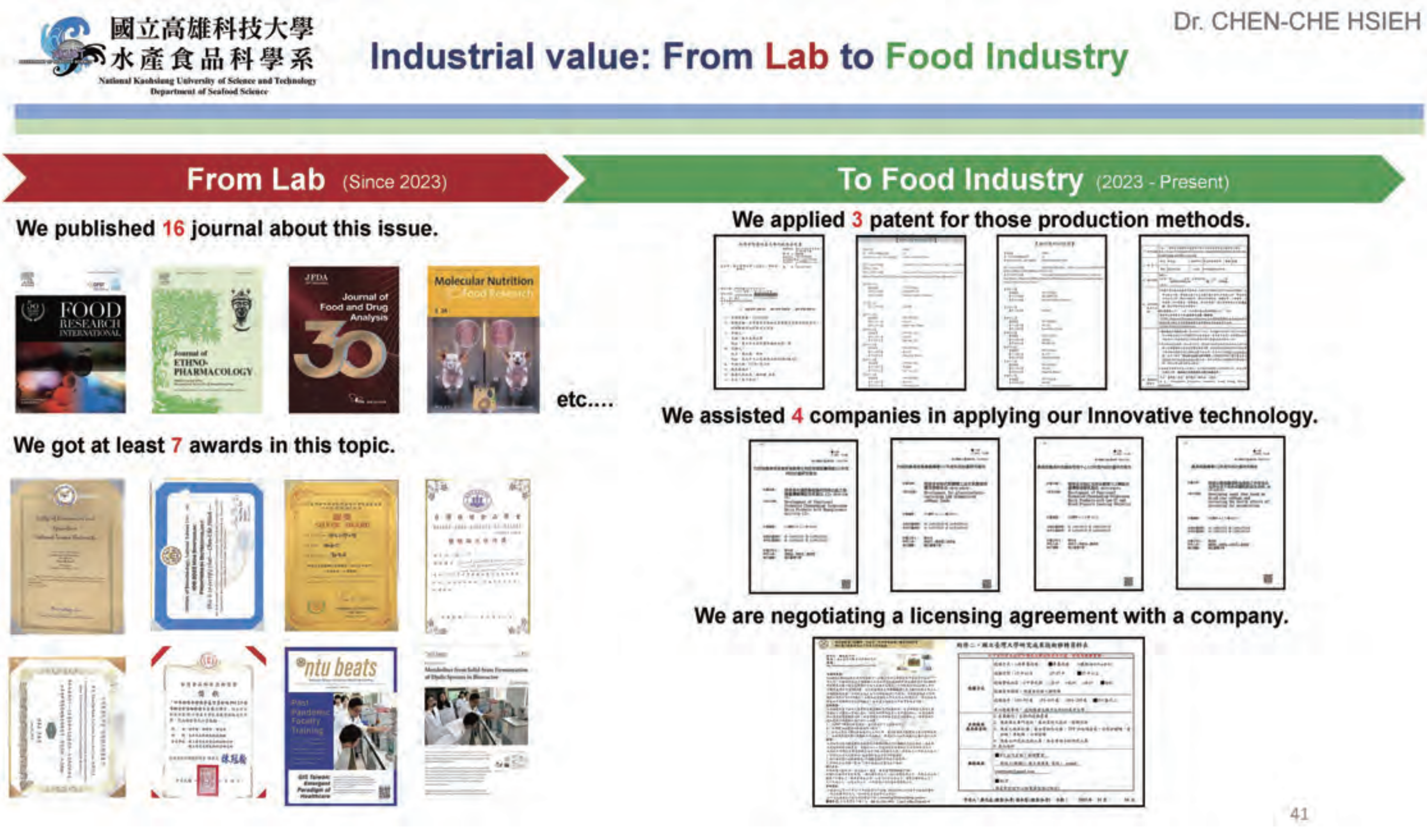
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National Kaohsiung University of Science and Technology
Department of Seafood Science
Dr. CHEN-CHE HSIEH
Industrial value: From Lab to Food Industry
From Lab (Since 2023)
To Food Industry (2023 - Present)
We published 16 journal about this issue.
etc....
We got at least 7 awards in this topic.
We applied 3 patent for those production methods.
We assisted 4 companies in applying our Innovative technology.
We are negotiating a licensing agreement with a company.
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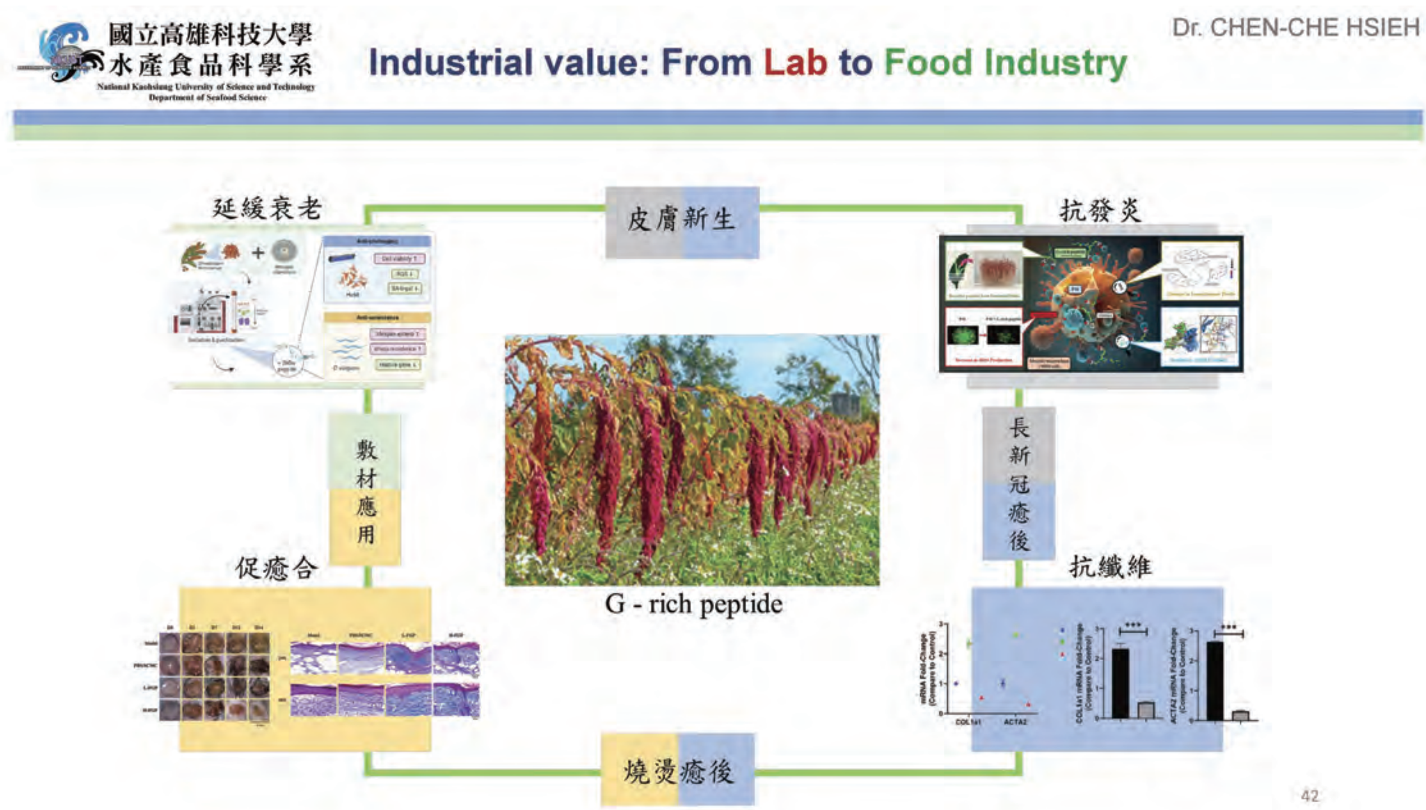
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Industrial value: From Lab to Food Industry
延緩衰老
皮膚新生
抗發炎
敷材應用
長新冠癒後
促癒合
G - rich peptide
抗纖維
燒燙癒後
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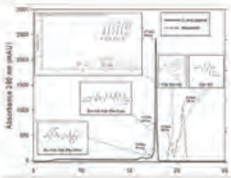
Industrial value: From Lab to Food Industry

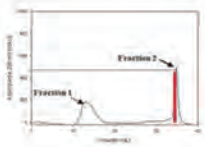
自臺灣紅藜低分子量蛋白中找到獨特寡肽



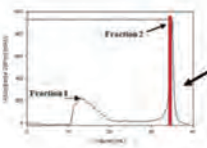
FCS protein	ABTS (mM Trolox)
Above 10kDa FCS fraction	0.11 ± 0.03^{e}
2-10kDa FCS fraction	0.19 ± 0.03^{d}
Below 2kDa FCS fraction	0.23 ± 0.01^{c}
Below 2kDa FCS fraction (fraction1)	0.32 ± 0.04^{b}
G-rich peptide (fraction2)	1.01 ± 0.05^{a}

關鍵胜肽化合物:

自臺灣藜中低分子量蛋白中，經質譜儀鑑定發現臺灣藜胜肽結構，具有優秀抗氧化力。



發酵後提升兩倍產量



獨特催芽與固態發酵製程可顯著提升臺灣藜低分子量胜肽所占比例(見 Fraction 2)。

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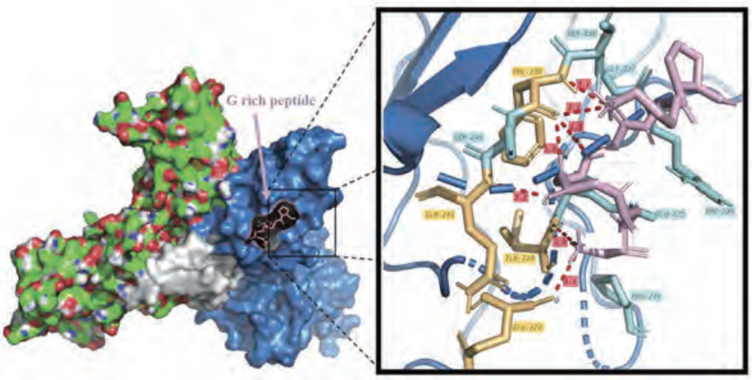
Industrial value: From Lab to Food Industry

功效介紹：延緩 PM2.5 所致肺細胞發炎現象

細胞-抗炎

特點：透過分析找到胜肽獨特抗發炎藥物關鍵靶點可供後續臨床評估

Hsieh, C. C., Yu, S. H., Kuo, H. C., Khumsupan, D., Huang, H. C., Liou, Y. W., Kao, C. Y., Shen, S. C., ... & Cheng, K. C. (2023). Glycine-rich peptides from fermented *Chenopodium formosanum* sprout as an antioxidant to modulate the oxidative stress. **Journal of Food and Drug Analysis**, 31(4).



臺灣藜胜肽可結合到發炎關鍵蛋白，並抑制其轉錄到細胞核中，降低發炎現象。

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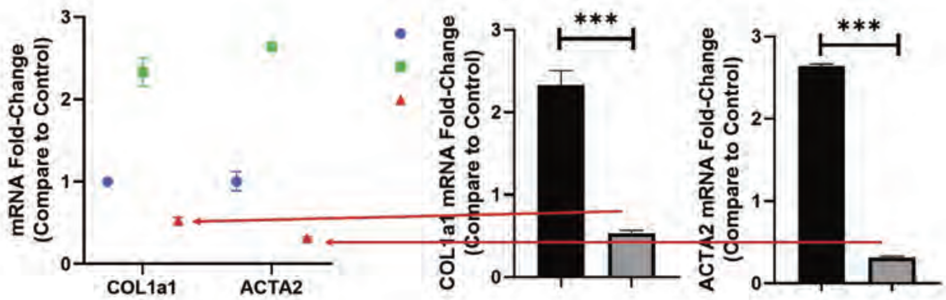
Industrial value: From Lab to Food Industry

細胞-抗纖維化

功效介紹：抑制細胞不正常纖維化之能力
特點：模擬長新冠後遺症減少肺不正常纖維化



臺灣藜胜肽減少 TGF beta 誘導下，減少肺細胞纖維化基因表現(長新冠後遺症減輕)。

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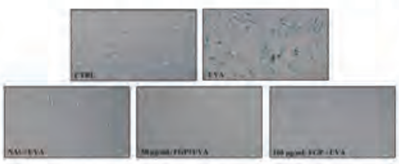
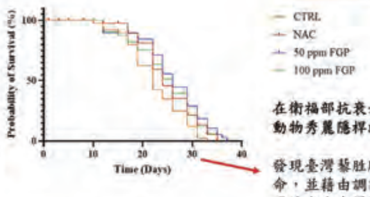
Industrial value: From Lab to Food Industry

細胞 + 動物
(延緩衰老)

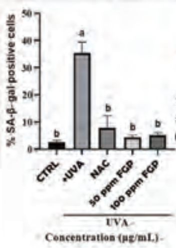
功效介紹：降低長波紫外線誘導皮膚衰老
特點：具有抗衰老與抗皮膚老化能力



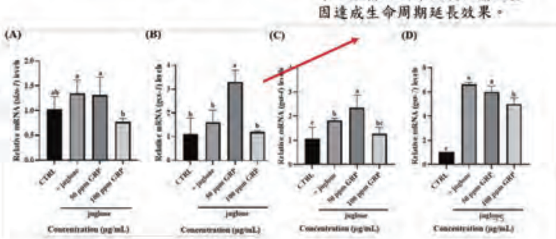


在衛福部抗衰老準則中以模式動物秀麗隱桿線蟲實驗

發現臺灣藜胜肽可增加健康餘命，並藉由調節抗氧化關鍵基因達成生命周期延長效果。



臺灣藜胜肽可大幅減少細胞衰老指標性物質(藍綠色 SA beta Gal)。



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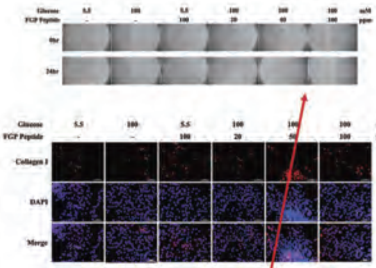
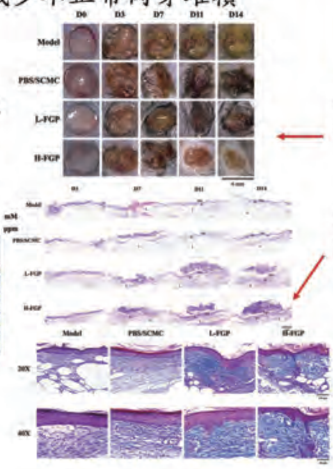
Industrial value: From Lab to Food Industry

功效介紹:促進糖尿病傷口癒合
特點: 增進傷口癒合速度,減少不正常肉芽堆積,
使傷口復原更漂亮。

細胞 + 動物
(助皮膚傷口癒合)
台大、台科大、師大三校研究成果





在糖尿病小鼠實驗中,
臺灣藜胜肽有效促進傷口癒合速度。

在糖尿病小鼠實驗中,
臺灣藜胜肽有效減少傷口出血區域,
並促進血管新生與表現表皮層較厚
而平整且肉芽組織排列整齊緻密。

在糖尿病小鼠實驗中,
臺灣藜胜肽有效促進
傷口膠原蛋白生成。

在模擬糖尿病高糖環境下,
臺灣藜胜肽有效促進成纖維細胞遷移
並增加細胞膠原蛋白I生成能力。

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Industrial value: From Lab to Food Industry

進行臨床前評估: 藥代動力學、藥理相似度、吸收性及安全性

Properties	Items	Parameters
Physicochemical	Sequence	
	Formula	
	Structure	
	Bioavailability Radar	
	Mol. wt.	529 (g/mol)
	ROTB	22 (n)
	HBA	9
	HBD	7
	TPSA	234.92Å²
Pharmacokinetics	CYP1A2 inhibitor	NO
	CYP2C19 inhibitor	NO
	CYP2C9 inhibitor	NO
	CYP2D6 inhibitor	NO
	CYP3A4 inhibitor	NO
Drug likeness	Lipinski	MW>500, NorO>10, NHorOH>5
Toxicity	ToxinPred	Non-toxin
Allergenicity	AllerTOP	Non-allergen
Potential bioactive seq.	ACE inhibitor	GG, GK
	Antioxidative	KP
	DPPIV inhibitor	GG, KP

據拓樸表面積、可旋轉鍵結分析顯示,胜肽具有吸收性。

以機器學習法分析藥代動力學,顯示胜肽不具有生物累積性,易於代謝。

與國際多數臨床試驗所使用小分子胜肽藥物相比,具有相似之性質。

以機器學習分析其致敏與毒性,顯示胜肽無毒且無過敏性。

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Industrial value: From Lab to Food Industry

可技術合作授權部分:

一、已通過臺大研發處鑑價，可授權之技術:

1. 有抗發炎、抗纖維、抗衰老、促進糖尿病傷口癒合功效之臺灣紅藜七胜肽與低分子量蛋白質純化物。

二、已發表 (審查中) 之國際期刊:

1. 臺灣紅藜保健原料生產:
Production and Analysis of Metabolites From Solid-state Fermentation of *C. formosanum* (Djulis) Sprouts in a bioreactor (Food Research International, Rank: Q1 (5%), Category Food Science & Technology: 10/144, 5 year IF: 8.2)
2. 臺灣紅藜萃取物可對抗PM2.5:
Alleviation of PM2.5-induced alveolar macrophage inflammation using extract of fermented *C. formosanum* Koidz sprouts via regulation of NF-κB pathway (Journal of Ethnopharmacology, Rank: Q1 (12%) Category Integrative & Complementary Medicine: 4/28, 5 year IF: 5.3)
3. 臺灣紅藜七胜肽生產與抗發炎功效:
Glycine-rich peptides from fermented *C. formosanum* sprout as an antioxidant to modulate the oxidative stress (Journal of Food and Drug Analysis, Rank: Q1 (18%), Category Food Science & Technology: 27/144, 5 year IF: 6.4)
4. 臺灣紅藜七胜肽具延緩衰老 (生理與皮膚) 功效:
A glycine-rich peptide from tempeh-like fermented *C. formosanum* senescence while enhancing antioxidant ability in non-replicative aging (*LWT*) Pass !

5.臺灣紫芝美白關鍵物質鑑定與功效:
Aromatic compounds and organic acids identified from *Ganoderma formosanum* exhibit synergistic anti-melanogenic effects (Journal of Food and Drug Analysis, Rank: (18%), Category Food Science & Technology: 27/144, 5 year IF: 6.4)

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Department of Seafood Science

Industrial value: From Lab to Food Industry

可技術合作授權部分:

一、已通過臺大研發處鑑價，可授權之技術:

1. 有抗發炎、抗纖維、抗衰老、促進糖尿病傷口癒合功效之臺灣紅藜七胜肽與低分子量蛋白質純化物。

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Aromatic compounds and organic acids identified from *Ganoderma formosanum* exhibit synergistic anti-melanogenic effects (Journal of Food and Drug Analysis, Rank: (18%), Category Food Science & Technology: 27/144, 5 year IF: 6.4)

三、中華民國專利已准證:

1. 具抗氧化和PM2.5誘發之細胞毒性抑制效果的台灣藜極性劃分物萃取方法 (可授權)
https://mip.ord.ntu.edu.tw/prod1.asp?ser=12422&c1=01&c2=01
2.具美白功效之台灣紫芝菌絲體萃取物及其製備方法 (可讓售)
https://mip.ord.ntu.edu.tw/onsale1.asp?ser=11346&

四、中華民國專利申請中:

1.一種具有促進糖尿病皮膚傷口癒合及延緩皮膚衰老之臺灣藜七胜肽 (專利局一審)
2.台灣藜芽多肽及其製備方法與用於抗氧化、抗細胞毒性或抗發炎之用途 (Pass !審)
3.臺灣藜麥發酵乳製品，其製作方法以及包含臺灣藜麥發酵乳製品有機層萃取物的醫藥組合物與其用途(專利局一審)
4.臺灣紫芝美白化合物之組合物及其用途 (專利局補件 Pass!)
5.用於製備薏苡仁發酵物的方法，包含薏苡仁發酵物的組成物及其用於抗老化及抗氧化的用途 Pass !審)

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Publication (2023-2025)

1. **Chen-Che Hsieh**, Hui-Wen Lin, Hsiao-Chu Huang, Darin Khumsupan, Szu Chuan Shen, Shin-Ping Lin, Chang-Wei Hsieh, Tsung-Yu Tsai, Sirima Suvarnakuta Jantama, Hsing-Chun Kuo, Kuan-Chen Cheng (2025, Mar). Peptide from tempeh-like fermented Chenopodium formosanum counters senescence while enhancing antioxidant ability in non-replicative aging. LWT – Food Science and Technology, 29(23), 5688. (**SCI, Q1:20/173** in Food Science & Technology).

2. Ting-Yu Hsu, Chien-Hao Chen, Yen-Tso Lai, **Chen-Che Hsieh**, Chang-Wei Hsieh, Kuan-Chen Cheng (2025, Feb). Influence of sequential inoculation on physicochemical properties, microbial community, and flavor metabolites of pineapple wine by non Saccharomyces yeast and lactic acid bacteria. *Journal of the Science of Food and Agriculture*, DOI: 10.1002/jsfa.14207. (**SCI, Q1:20/89** in Agriculture, Multidisciplinary). DOI: 10.1002/jsfa.14207.

3. **Hsieh, C. C**., Liu, Y. H., Lin, S. P., Santoso, S. P., Jantama, K., Tsai, T. Y., ... & Cheng, K. C. (2024). Development of High - Glucosinolate-Retaining Lactic-Acid-Bacteria-Co-Fermented Cabbage Products. *Fermentation*, 10(12), 635. (**SCI, Q2:72/174** in Biotechnology & Applied Microbiology)

4. **Hsieh, C. C**., Yi, T. K., Kao, Y. F., Lin, S. P., Tu, M. C., Chou, Y. C., ... & Cheng, K. C. (2024). Comparative Efficacy of *Botryocladia leptopoda* Extracts in Scar Inhibition and Skin Regeneration: A Study on UV Protection, Collagen Synthesis, and Fibroblast Proliferation. *Molecules*, 29(23), 5688. (**SCI, Q2:88/313** in Biochemistry & Molecular Biology).

5. Y. C. Chou; H.W. Lin; C.Y. Wang; **C.C. Hsieh**; S. P. Santoso; S. P. Lin, K.C. Cheng. (2024). Enhancing Antioxidant Benefits of Kombucha Through Optimized Glucuronic Acid Production with SCOBY Strain Combination. *Antioxidants*. 10.3390/antiox13111323. (**SCI, Q1:50/313** in Biochemistry & Molecular Biology).

6.Lin, S. P., Hong, L., **Hsieh, C. C**., Lin, Y. H., Chou, Y. C., Santoso, S. P., Cheng, K. C. (2024, Sep). In situ modification of foaming bacterial cellulose with chitosan and its application to active food packaging. International Journal of Biological Macromolecules, 135114. (**SCI, Q1:34/313** in Biochemistry & Molecular Biology).

7. **C. C. Hsieh**, C. Y. Hou, H. Y. Lei, D. Khumsupan, K. C. Cheng. (2024). Aromatic Compounds and Organic Acids Identified from Ganoderma formosanum Exhibit Synergistic Anti-Melanogenic Effects. *Journal of Food and Drug Analysis*.(**Rank: Q2 (46.2%),** Category Pharmacology & pharmacy-scie: 34/278)

8. Cheng, K. C. Chong, P.C. **Hsieh, C. C.,** Yu, S. H. (2024) Identification of Anti-Fibrotic and Pro-Apoptotic Bioactive Compounds from Ganoderma formosanum and Their Possible Mechanisms in Modulating TGF- 1-Induced Lung Fibrosis. Journal of Ethnopharmacology, 118008.) (**Rank: Q1 (12%),** Category Plant Sciences: 29/238)

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Publication (2023-2025)

9. Kusuma, A. C. Chou, Y.C. **Hsieh, C. C.,** Santoso, S. P., Go, A. W., Lin, H. T.... & Lin, S. P. **(2024).**
Agar-altered foaming bacterial cellulose with carvacrol for active food packaging applications. *Food Packaging and Shelf Life* (Accepted) (**Rank: Q1 (7.7%),** Category Food Science & Technology: 11/142)

10. Cheng, K. C. Chong, P.C. Hsieh, C. C., ... & Yu, S. H. (2024). Identification of anti-fibrotic and pro-apoptotic bioactive compounds from Ganoderma formosanum and their possible mechanisms in modulating TGF-β1-induced lung fibrosis. Journal of) Ethnopharmacology (**Rank: Q1 (12%),** Category Plant Sciences: 29/238)

11. Hou, C. Y., **Hsieh, C. C.*,** Hung, Y. C., Hsu, C. C., Yu, S. H., ... & Cheng, K. C. **(2024).** Evaluation of the amelioration effect of *Ganoderma formosanum* extract on delaying PM2.5 damage to lung macrophages. *Molecular Nutrition & Food Research*. (**Rank: Q1 (23.6%),** Category Food Science & Technology: 34/142) **(co-first author)**

12. **Hsieh, C. C.** et al. **(2024).** Alleviation of PM2.5-induced alveolar macrophage inflammation using extract of fermented *Chenopodium formosanum* Koidz sprouts via regulation of NF-κB pathway. *Journal of Ethnopharmacology*, 116980. (**Rank: Q1 (12%),** Category Plant Sciences: 29/238, 5 year IF: 5.4)

13. Wu, C. N., Wang, T. E., **Hsieh, C. C.,** Cheng K. C., ... &Wu, C. W. **(2023).** Novel biocompatible and antibacterial poly (lactic acid)/cellulose nanofiber-silver nanoparticle biocomposites prepared via Pickering emulsion method. International *Journal of Biological Macromolecules*. (**Rank: Q1 (9%),** Category Chemistry, Applied: 7/72)

14. **Hsieh, C. C.** et al. **(2023).** Glycine-rich peptides from fermented *Chenopodium formosanum* sprout as an antioxidant to modulate the oxidative stress. *Journal of Food and Drug Analysis*. 31(4). (**Rank: Q2 (46.2%),** Category Pharmacology & pharmacy-scie: 34/278)

15. **Hsieh, C. C.** et al. **(2023).** Production and analysis of metabolites from solid-state fermentation of *Chenopodium formosanum* (Djulis) sprouts in a bioreactor. *Food Research International*, 168, 112707. (**Rank: Q1 (6.7%),** Category Food Science & Technology: 10/142)

16. Lu, J. J., Cheng, M. C., Khumsupan, D., **Hsieh, C. C.,** Hsieh, C. W., & Cheng, K. C. **(2023).** Evaluation of Fermented Turmeric Milk by Lactic Acid Bacteria to Prevent UV-Induced Oxidative Stress in Human Fibroblast Cells. *Fermentation*, 9(3), 230. (**Rank: Q2 (41.3%),** Category Biotechnology & Applied Microbiology: 65/156)

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臺北醫學大學
TAIPEI MEDICAL UNIVERSITY

Innovative Production of Foaming Bacterial Cellulose and Its Potential Applications

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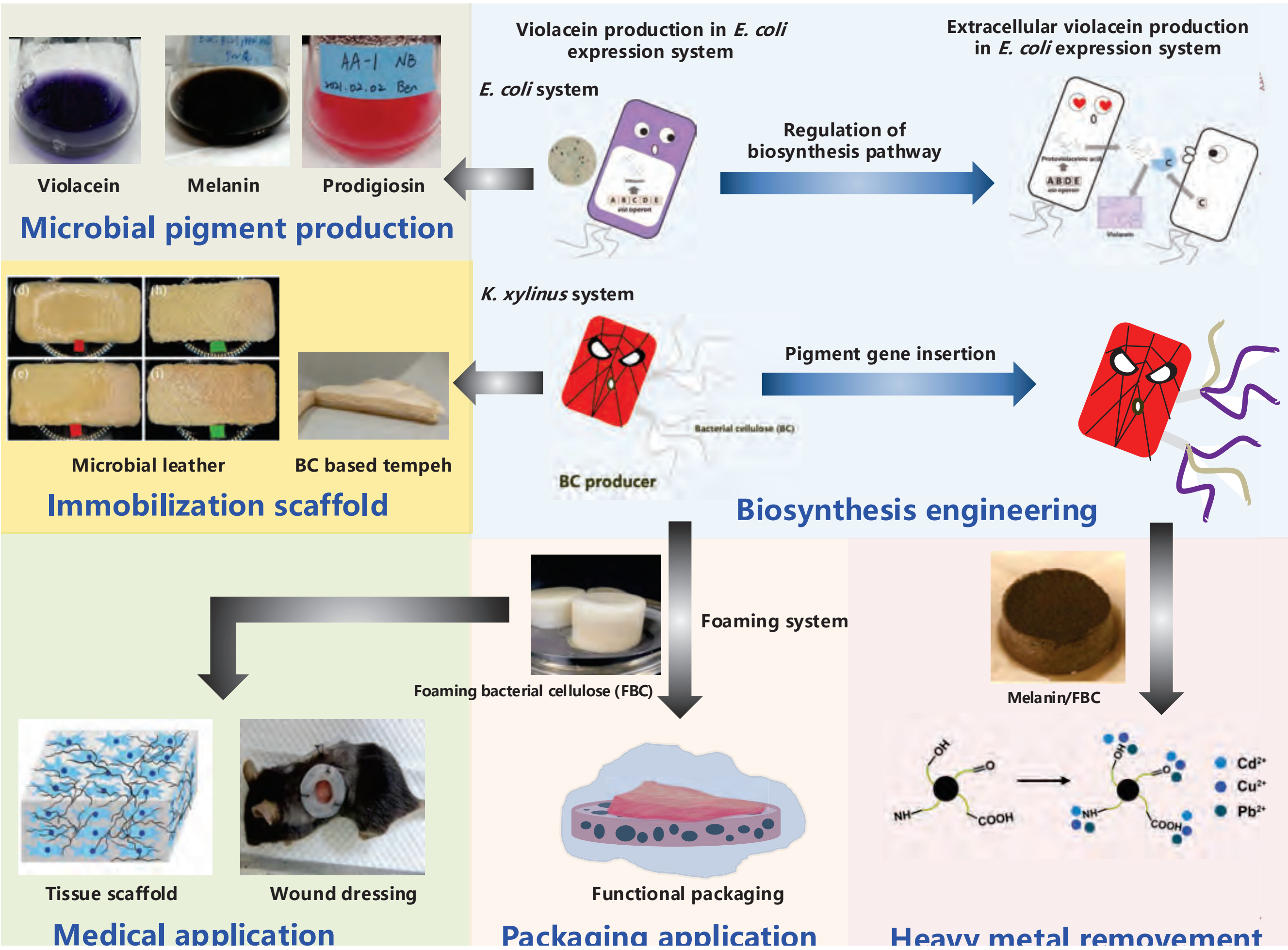
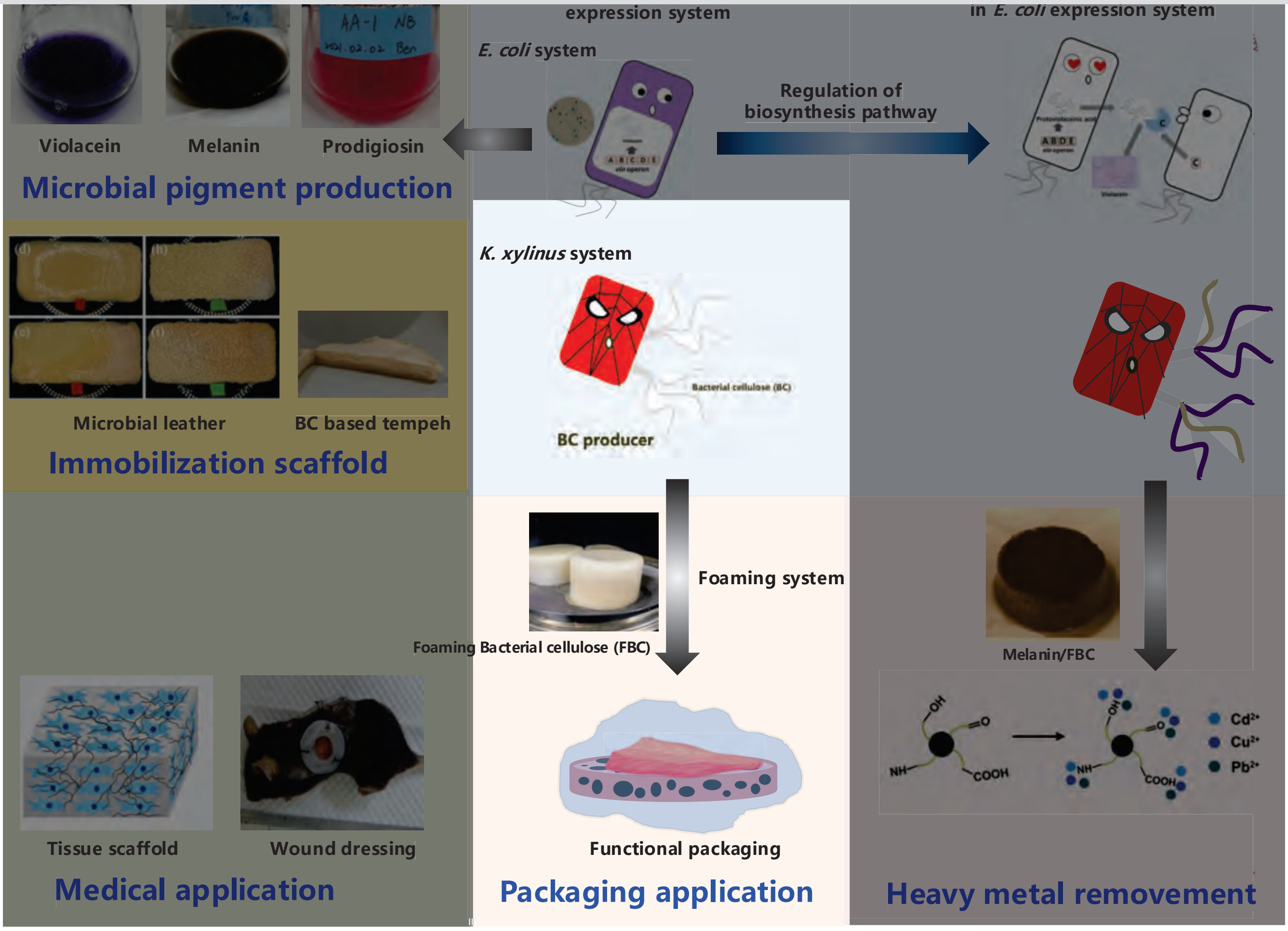
School of Food Safety, College of Nutrition
Taipei Medical University

Winpact

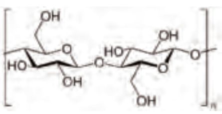
2025年第五屆醱酵技術研討會

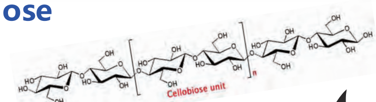




Cellulose

Structure of cellulose



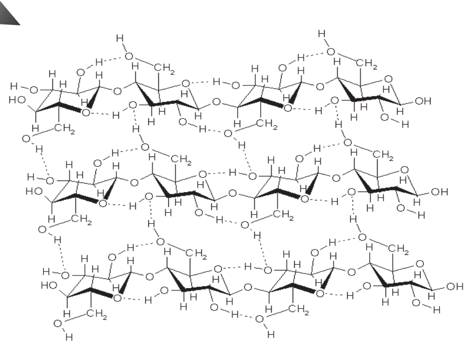


Single chain (1~9 mm in length)

Hydrogen-bind

β-(1,4)-linkage

Formula: $(C_6H_{10}O_5)_n$



Multi-layer

Origin of cellulose

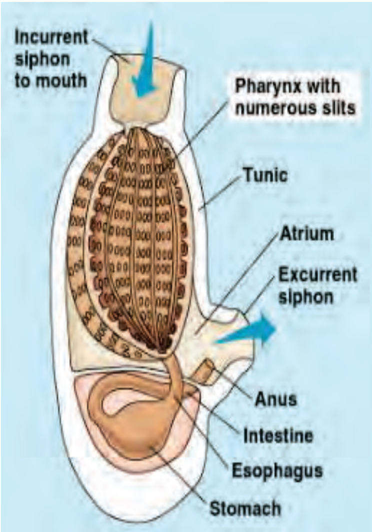
Animal

Plant

Microorganism

Animal cellulose

Tunic, a kind of animal cellulose



Ascidiacea

(Matthysse et al., 2004)

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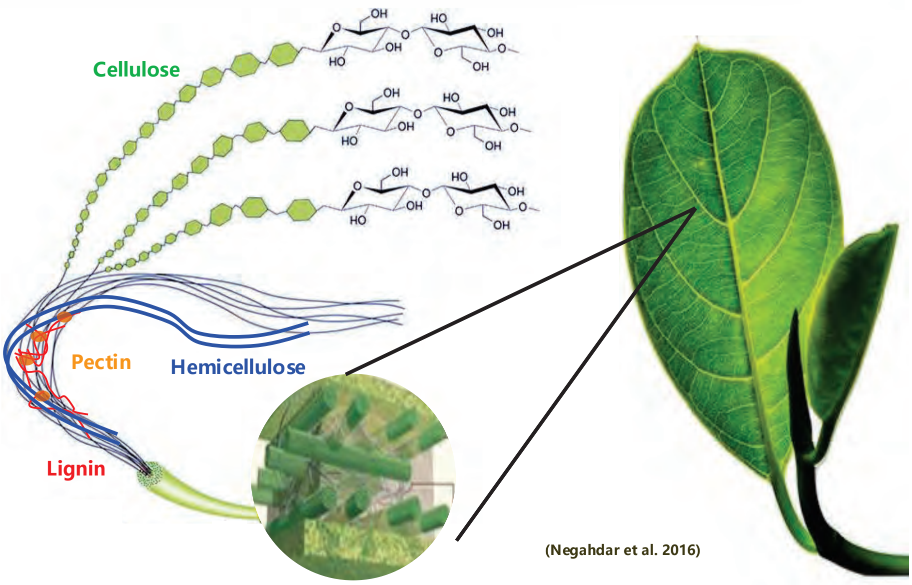
Plant cellulose

Applications

Furniture

Clothes

Paper



(Negahdar et al. 2016)

Plant cellulose (PC)

(Sannigrahi et al,. 2010)

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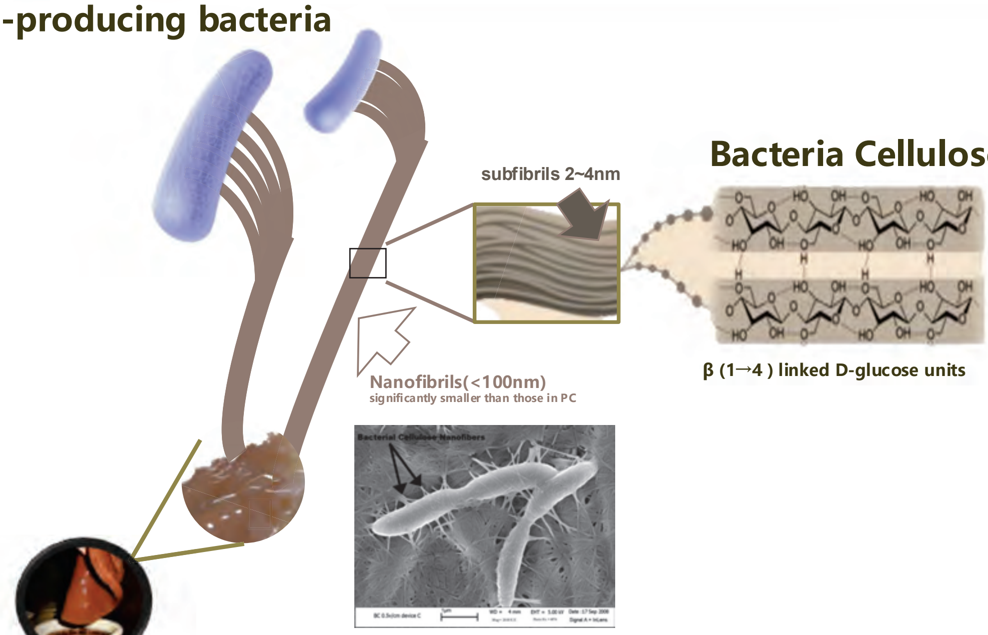
Bacterial cellulose (BC)

BC-producing bacteria



Komagataeibacter xylinus

(Castro et al. 2011; Lin et al. 2016)

(Klemm et al., 2001; Kunahoko et al., 1998)

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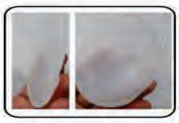
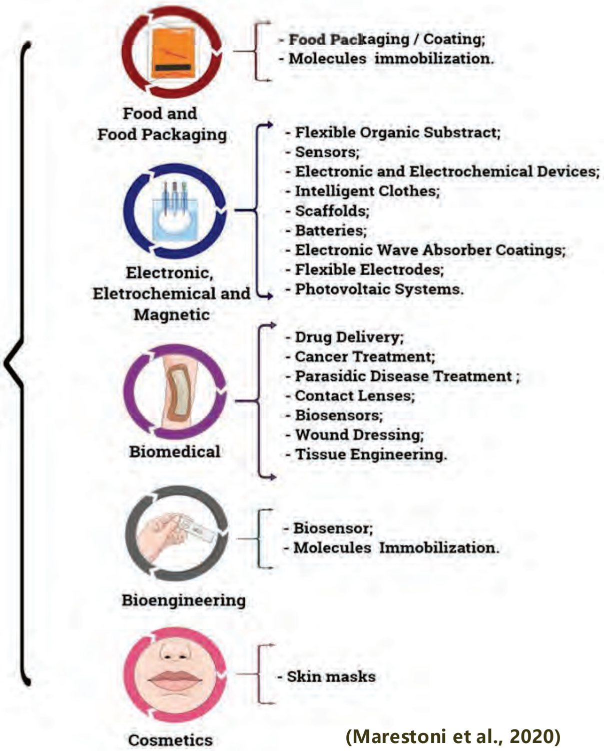
The unique properties of BC

BC possesses unique properties

1) High purity
2) Excellent mechanical strength
3) High water uptake capacity
4) Good permeability for gas and fluid exchange
5) Biocompatible
6) Non-toxic



Applications of Bacterial Cellulose in Brazil



Limitation of BC

1) Additives incorporation is difficult.
2) Lack of biological functions.

(Marestoni et al., 2020)

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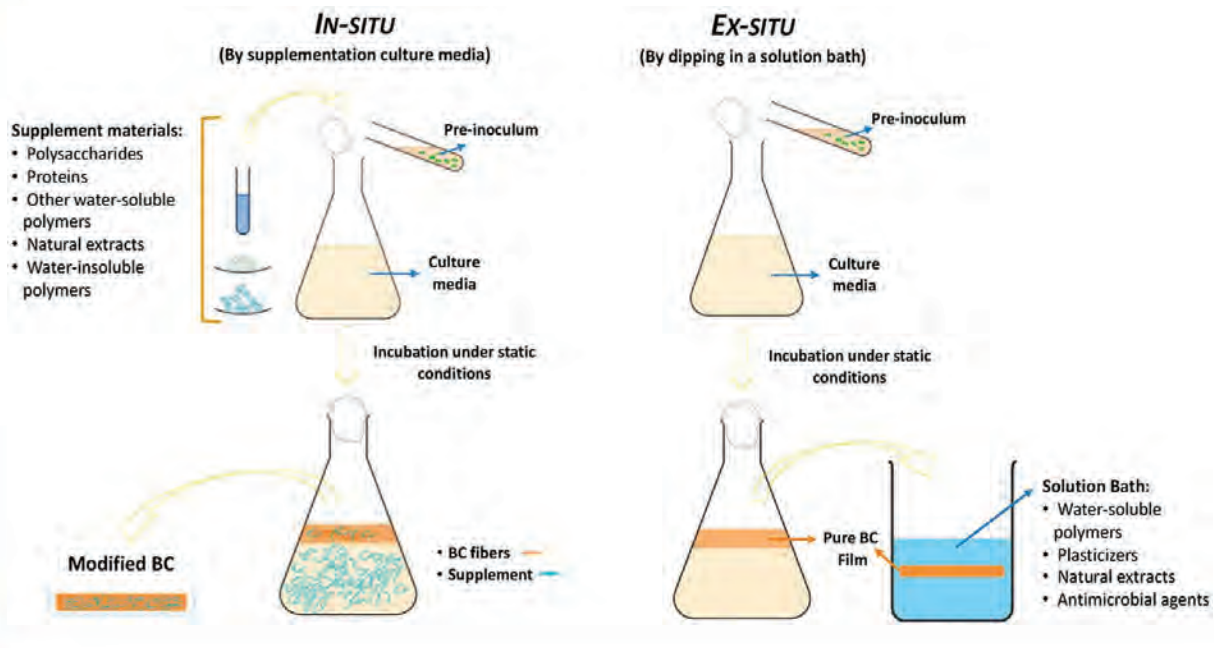
Modification of BC



(Cazón and Vázquez, 2021)

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Foaming BC (FBC) system

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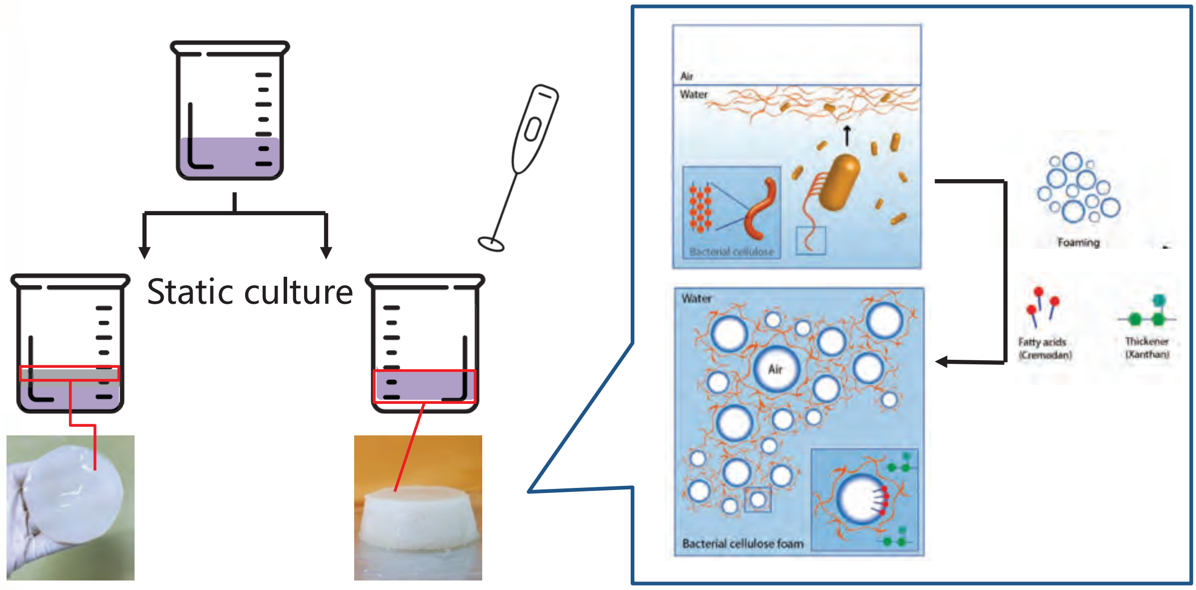
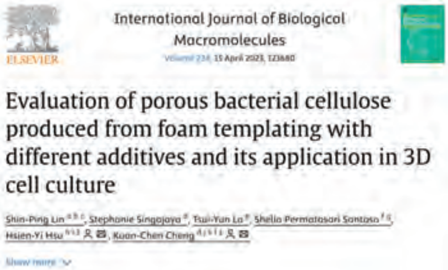


(Rühs *et al.*, 2018)

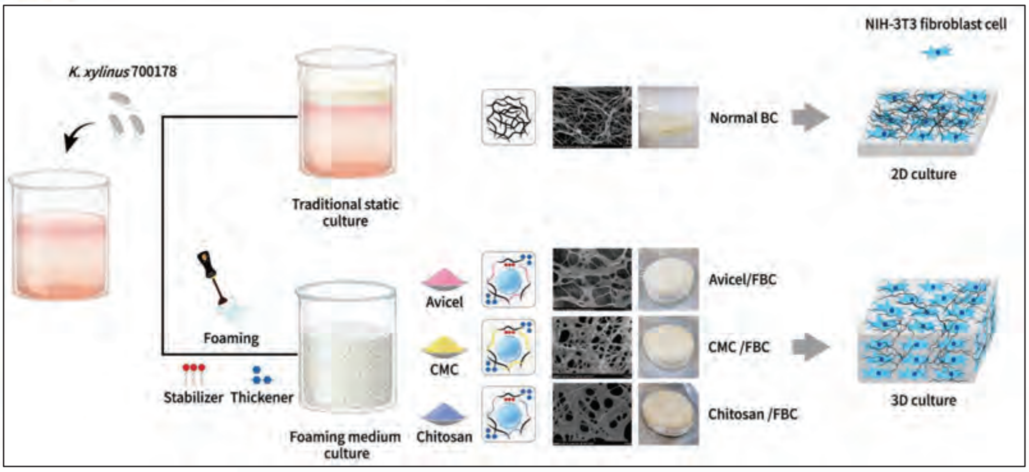
FBC modified with different additive


International Journal of Biological Macromolecules

Evaluation of porous bacterial cellulose produced from foam templating with different additives and its application in 3D cell culture

Shin-Ping Lin, Stephanie Singajaya, Tsui-Yun Lo, Shella Permatasari Santoso, Hsien-Yi Hsu, Kuan-Chen Cheng


Stephanie Singajaya



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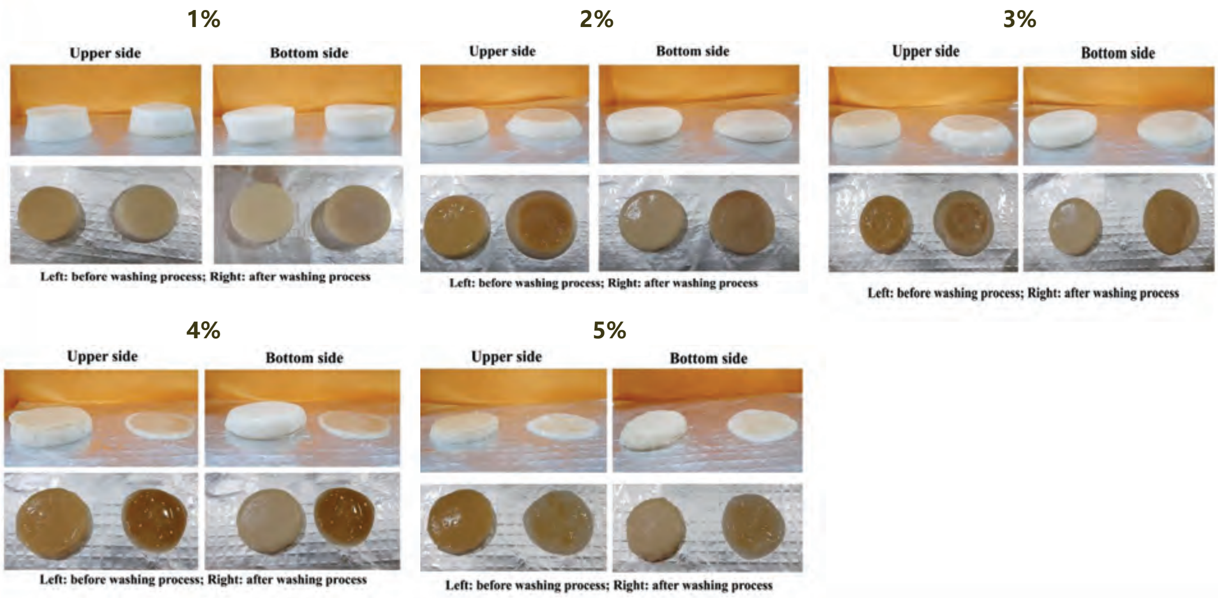
Optimization of xanthan and cremodan

Modified CSL-Fructose with xanthan 0.2% and cremodan 1% ~5%



Choose modified CSL-Fructose with **0.2%** xanthan and **1%** cremodan

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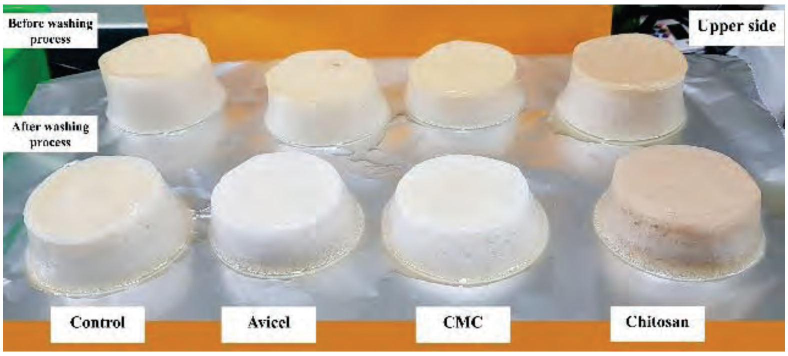
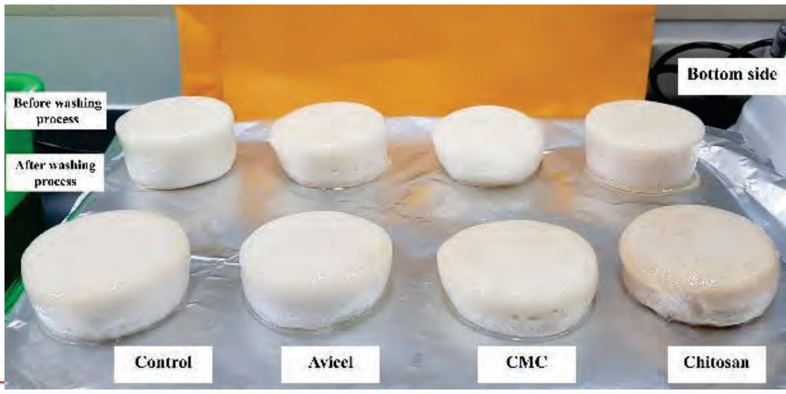
Foaming BC with additives (avicel/CMC/chitosan)





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Water content analysis

Treatment	Water content (%)	Treatment	Water content (%)
Normal control	98.85[b] ± 0.09	Foaming control	98.09[c] ± 0.19
Normal avicel	98.66[b] ± 0.21	Foaming avicel	97.37[b] ± 0.28
Normal CMC	98.79[b] ± 0.02	Foaming CMC	97.51[b] ± 0.45
Normal chitosan	97.67[a] ± 0.13	Foaming chitosan	96.64[a] ± 0.38

- Only **normal BC with chitosan addition** showed lowest water content **97.67%** which is significantly differences compared to normal BC control, with avicel addition and with CMC addition.
- Foaming BCs with additives had significantly lower water content compared to the control.
- There were significantly decreased of water content by adding the additives for normal BC and foaming BC.
- Lower holding capacity obtained from foaming BCs **but still considered as high water content**.

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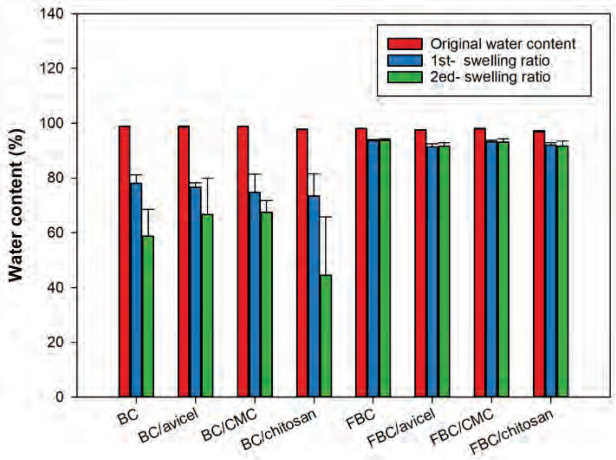
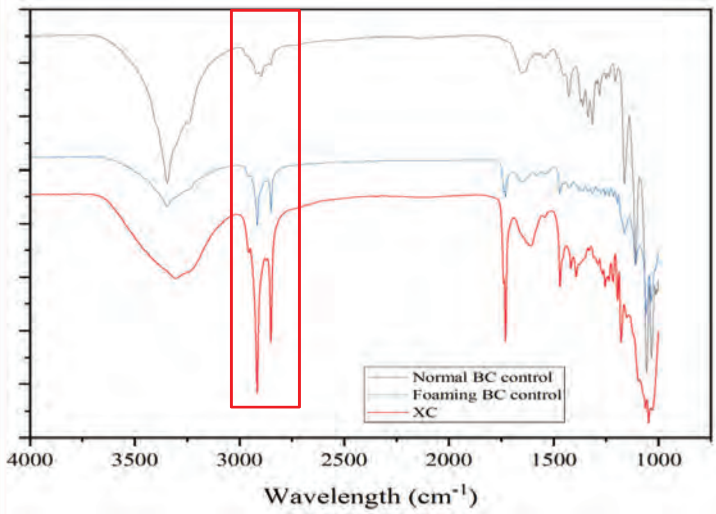
Swelling ratio of additive/ FBCs



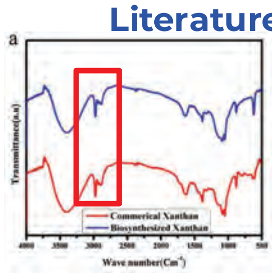
	Swelling ratio (%)	Reswelling ratio (%)
BC	77.96±3.2[a]	58.73±9.79[bd]
BC/avicel	76.61±1.61[b]	66.72±13.19[be]
BC/CMC	74.70±6.7[acd]	67.50±4.3[be]
BC/chitosan	73.41±8.15[bde]	44.52±21.23[cde]
FBC	93.55±0.53[a]	93.67±0.57[a]
FBC/avicel	91.36±1.1[b]	91.57±1.29[a]
FBC/CMC	93.22±0.54[bd]	93.05±1.19[a]
FBC/chitosan	91.973±0.9[ae]	91.57±1.94[a]

Foaming BC showed **superior swelling ratio** while the swelling ration of normal BC decreased.

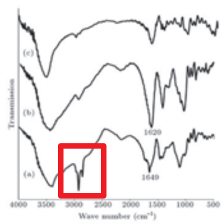
FTIR result of FBC



Literature review:



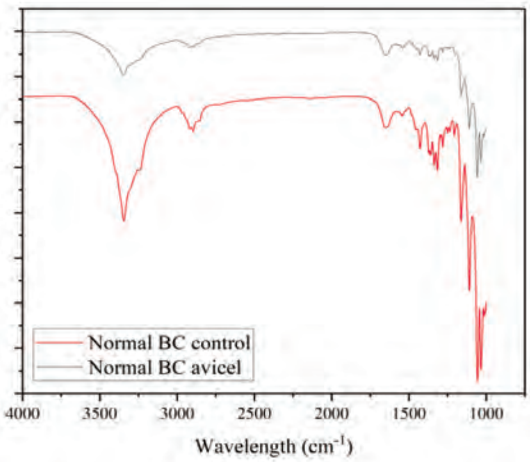
FTIR of Xanthan samples
The characteristic peak located at 2800–2950 cm^{-1} showed the axial deformation of C-H (Mohsin *et al.*, 2017)

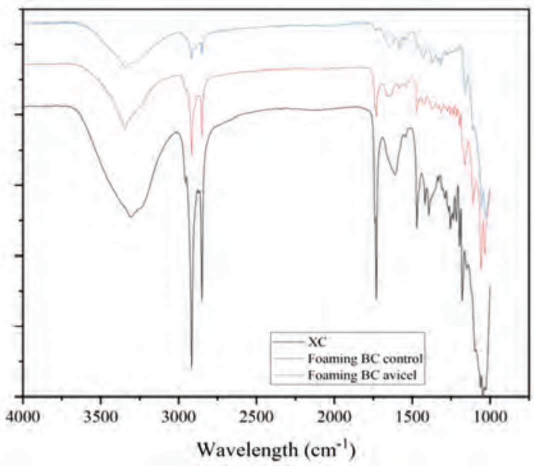


FTIR of sodium alginate
Stretching vibrations of aliphatic C–H were observed at 2920–2850 cm^{-1} (Daemi *et al.*, 2012)

All of foaming BC showed two strong peaks at 2916 cm^{-1} and 2850 cm^{-1}, these peaks probably come from: **xanthan** and **sodium alginate** from cremodan.

FTIR result of avicel/ FBC





There is **no peak different** between normal BC and foaming BC control with avicel addition

Literature review for avicel FTIR:

Lin et al., (2016): the absorption intensity of 3348 cm^{-1} (stretching of O–H) increased with the ratio of avicel to BC concentration.

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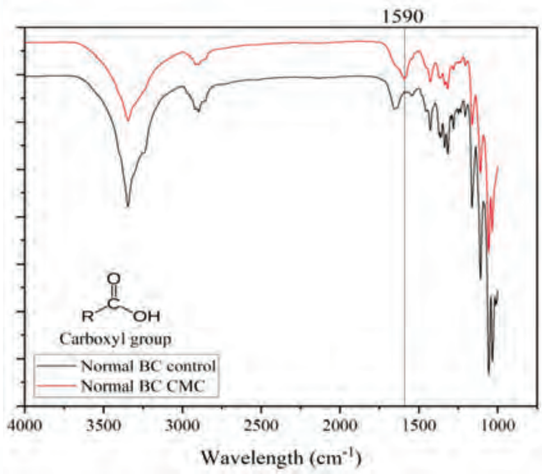
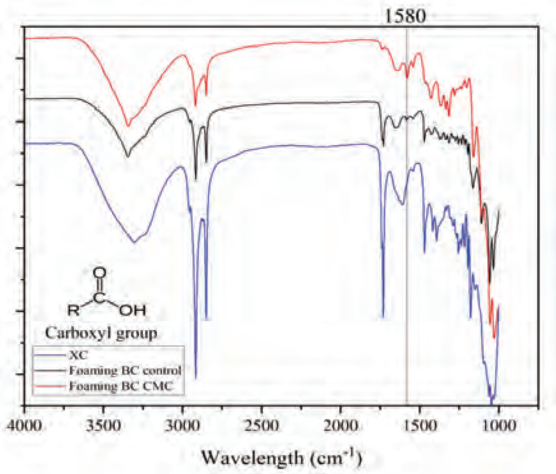
FTIR result of CMC/ FBC





There is a peak at **1590 cm^{-1}** for CMC/BC and **1580 cm^{-1}** for CMC/FBC.

Literature review for CMC FTIR:

- Zhou et al., (2019): modified BC with CMC showed a new peak at around **1590 cm^{-1}**, which corresponds to the **carboxyl group**.
- Chai et al., (2013): The band at **1590 cm^{-1}** confirmed the presence of COO− and assigned to stretching of the **carboxyl group**.

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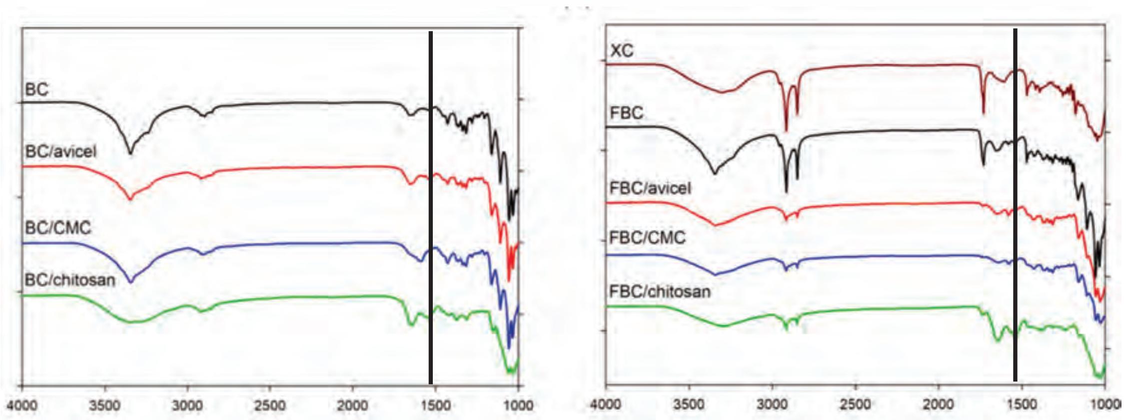
FTIR result of chitosan/ FBC

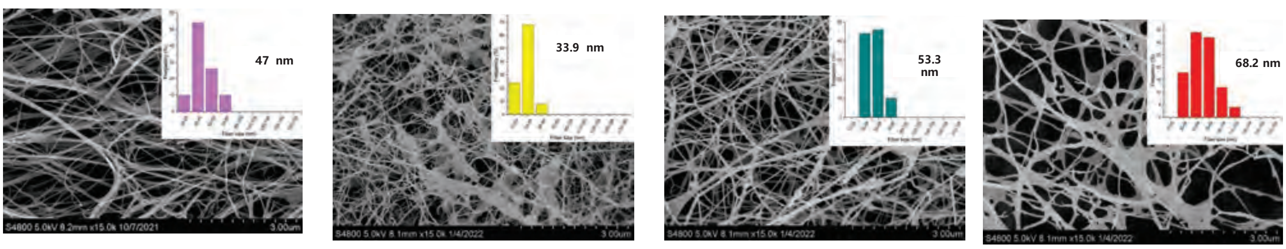


- There is a peak at **1560 cm⁻¹** for both normal and foaming BC with chitosan addition.

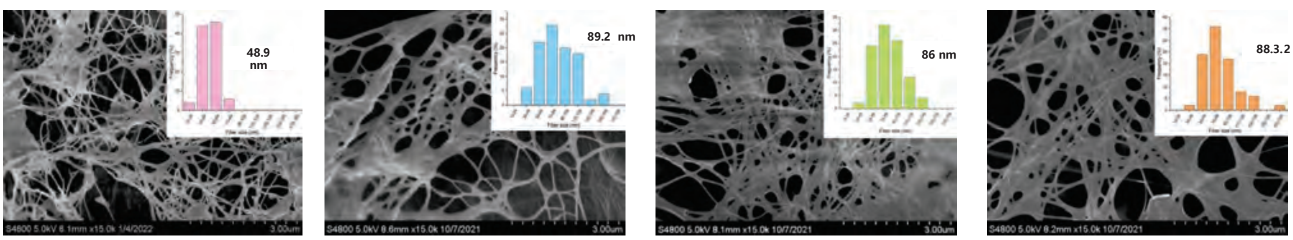
Literature review for chitosan FTIR:

- Ciechańska (2004): The peaks for modified BC were found at **1650 cm^{-1} (amide I)** and **1560 cm^{-1} (amide II)**, attributed to the amide groups characteristic for chitosan.

SEM images of additive/ FBCs

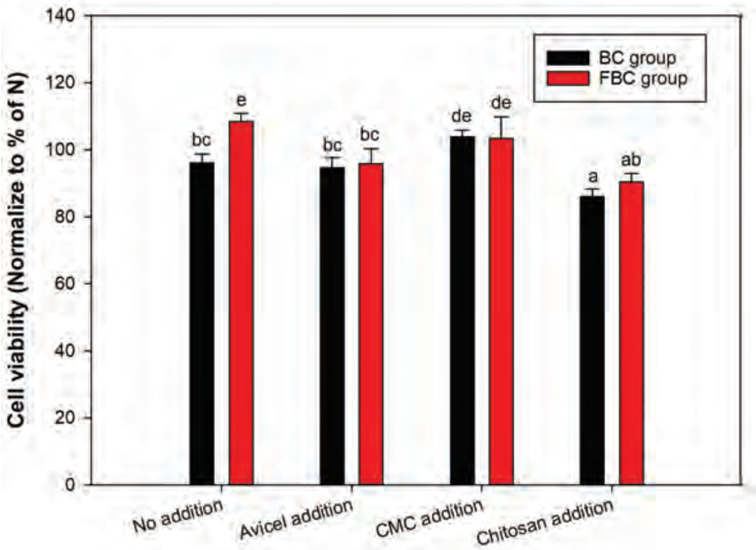


BC | BC/avicel | BC/CMC | BC/chitosan



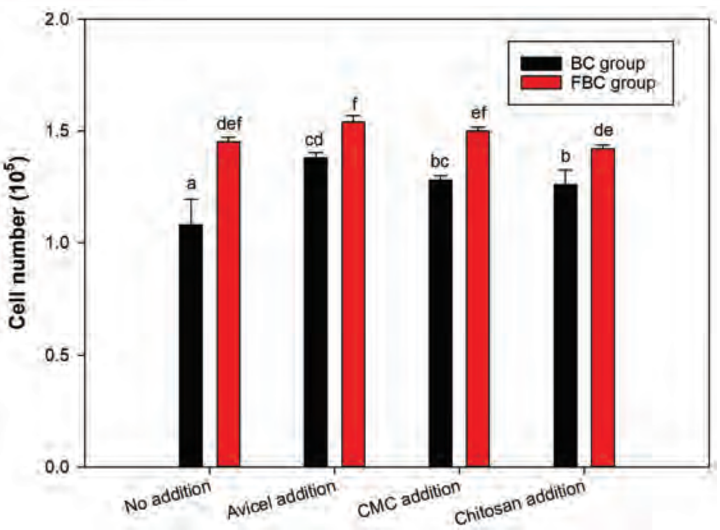
FBC | FBC/avicel | FBC/CMC | FBC/chitosan

Cell cytotoxicity



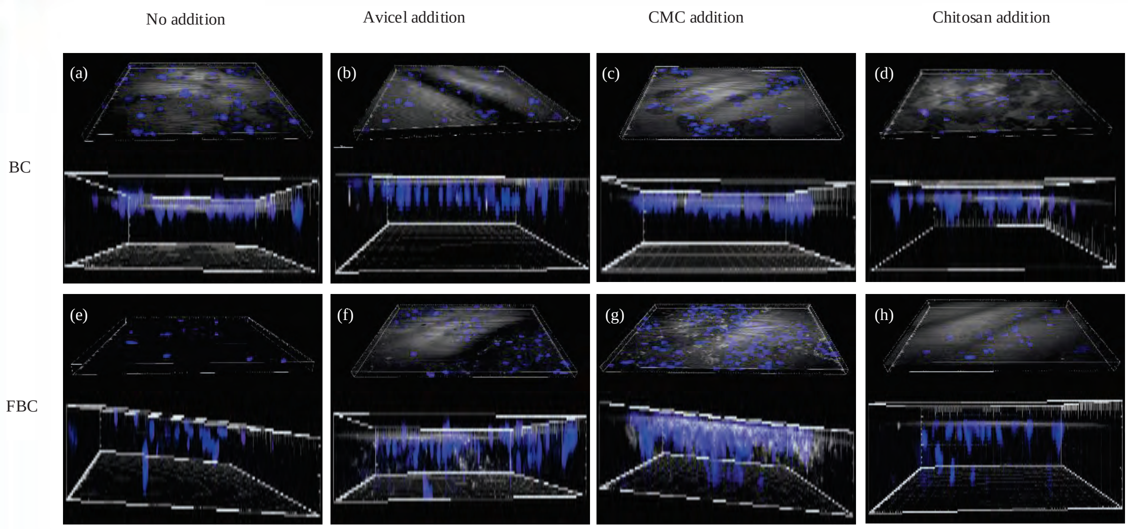
- All of BCs have cell viability percentage above 80% → **non-cytotoxic.**
- Highest survivability showed by foaming BC control, followed by normal BC and foaming BC with CMC addition.

Cell adhesion



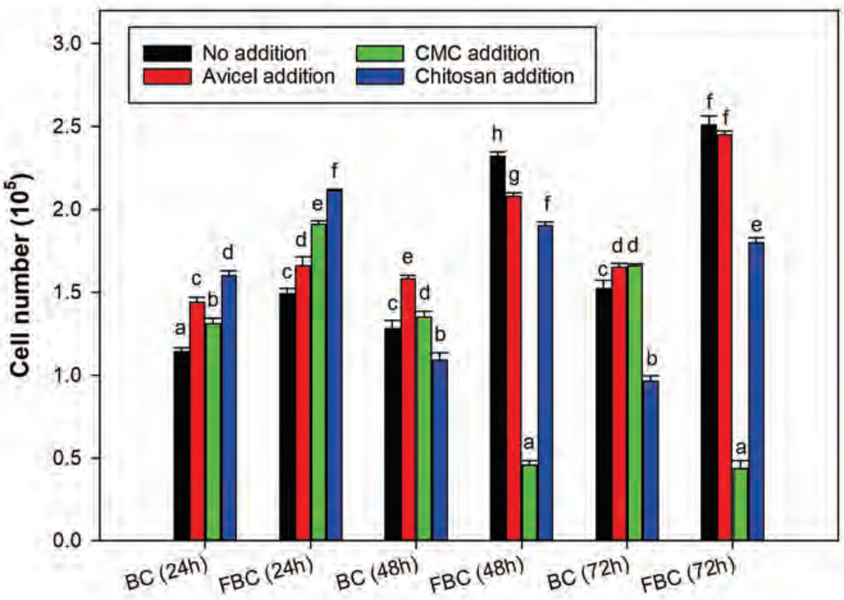
- Cell adhesion in foaming BC has **significantly higher** compared to normal BC
- The highest cell number was achieved from foaming BC without additives and with avicel and CMC addition, followed by foaming BC with chitosan addition and normal BC with avicel addition.

3D Cell culture



- In the BC groups, the cells only on the surface of BC.
- The cells can penetrate into deeper layer in each FBC groups.

Cell proliferation

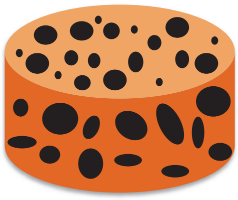


- Cell proliferation in foaming BC has **significantly higher** compared to normal BC
- The highest cell number was achieved from foaming BC without additives and with avicel addition while the lowest cell number was obtained from foaming BC with CMC addition.

Conclusion 1

Avicel, CMC and chitosan

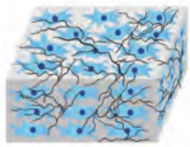
FBC production with different additive



- High water content (96%~98%)
- Great swelling ability (91%~93%)
- No cytotoxicity
- Well cell adhesion and proliferation

Additive/FBC

Evaluation of additive/FBC in biomedical application



Tissue scaffold or wound dressing

Pore size control of FBC using agar addition

Food Packaging and Shelf Life
Volume 47, March 2024, 101269

Agar-altered foaming bacterial cellulose with carvacrol for active food packaging applications

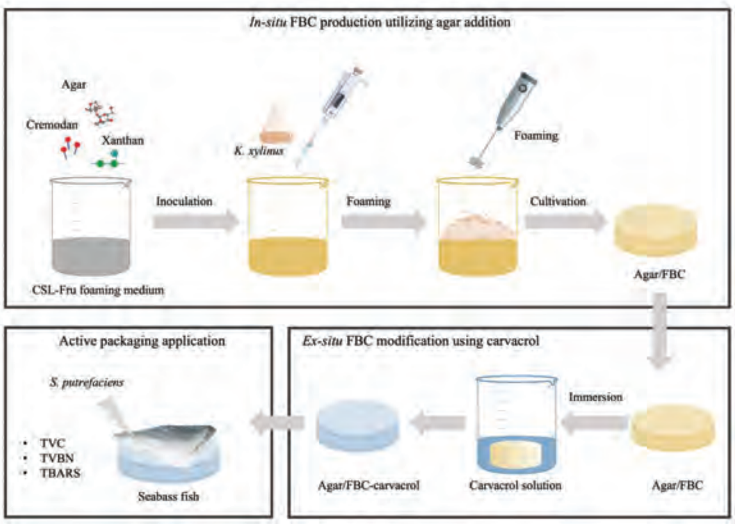
Anita Chandra Kusuma [a], Yu-Chieh Chou [b], Chen-Che Hsieh [c], Shella Permatasari Santoso [d], Alchris Woo Go [e], Hong-Ting Victor Lin [f], I.-Lun Hsiao [g], Shin-Ping Lin [b g h i]

Anita Chandra Kusuma

Yu-Chieh Chou

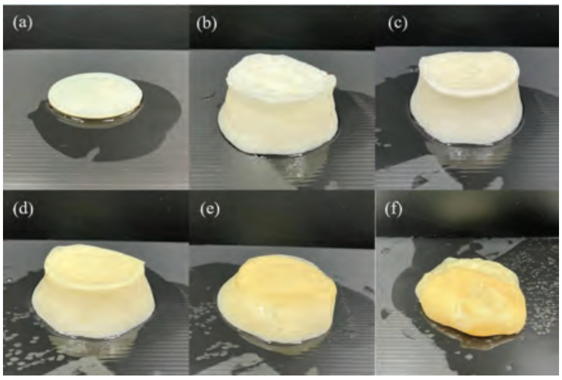
Pei-Ching Chan

Yi-Chi Yu



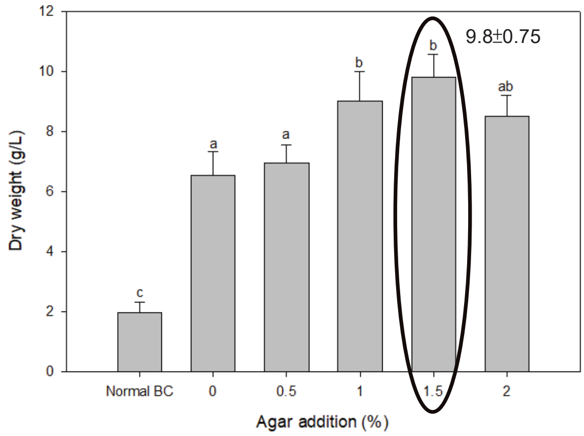
Foaming BC with agar addition

Normal BC　0% agar/FBC　0.5% agar/FBC



1% agar/FBC　1.5% agar/FBC　2% agar/FBC

Dry weight of Foaming BC with Agar Addition



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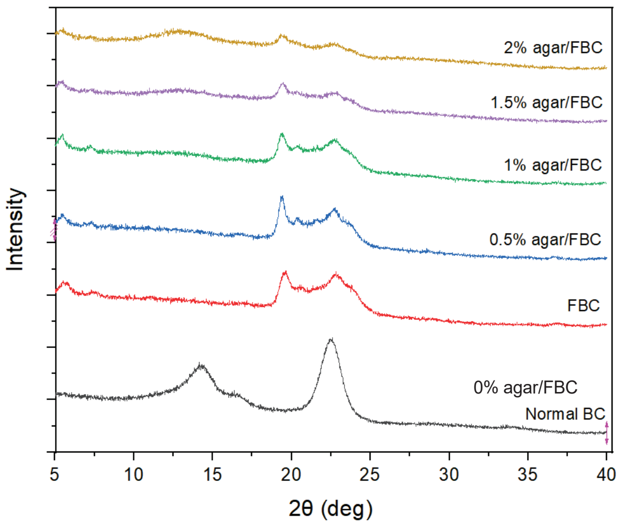
XRD result



Samples	Crystallinity index in %
Normal BC	87.24
0% agar/FBC	75.85
0.5% agar/FBC	71.43
1% agar/FBC	69.42
1.5% agar/FBC	67.96
2% agar/FBC	59.89

- All BC samples exhibited four distinct peaks appearing at diffraction angles of 14°, 16°, 22°, and 34°. Another peak at 21.5°, was identified as representing the amorphous portion of the sample.
- As agar is added to BC, **the crystallinity of the material decreases**. Agar molecules can disrupt the regular arrangement of cellulose microfibrils.

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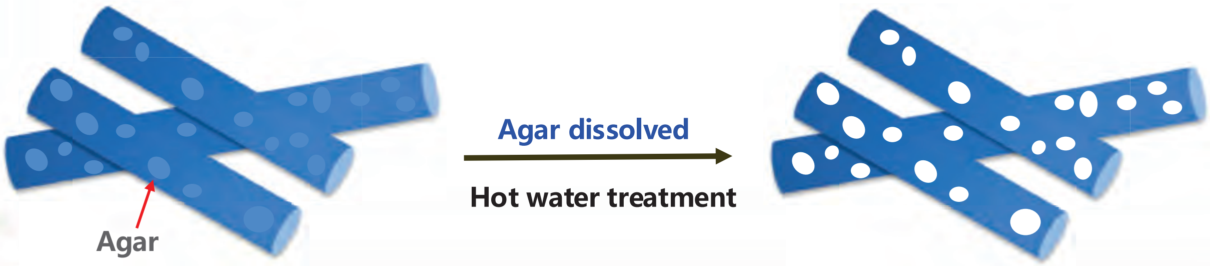
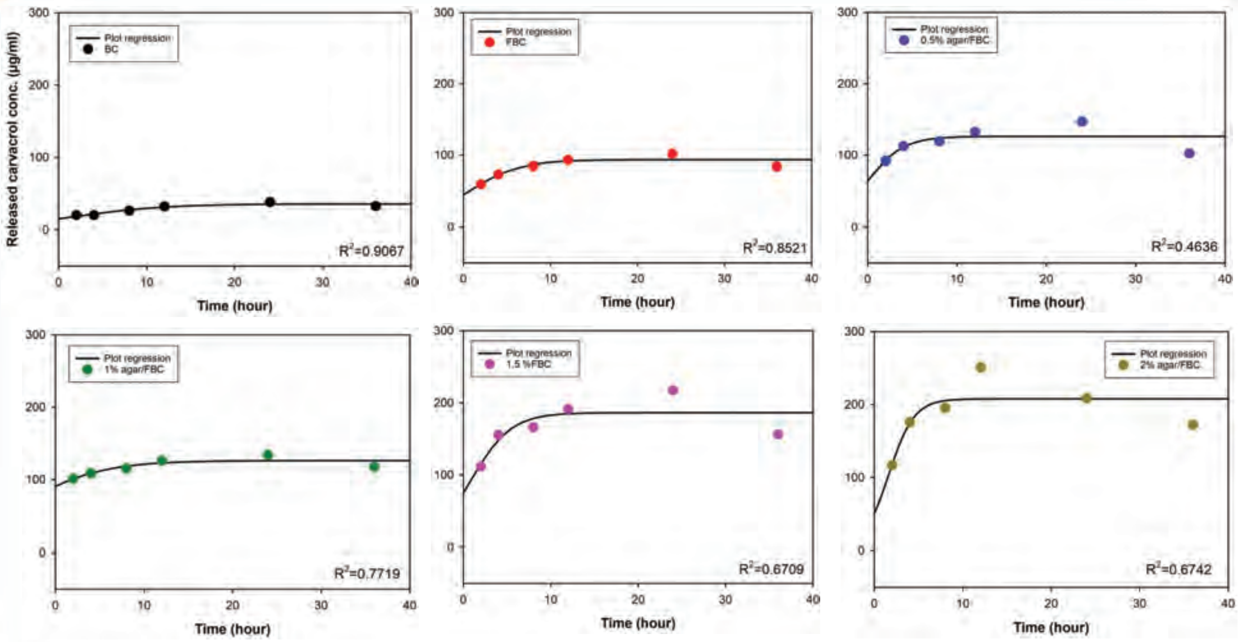
The BET result of agar/FBCs

Groups	BET surface area (m^2 g^{-1})	Pore volume (cm^3 g^{-1})	Pore size (Å)
	Cold water washing		
FBC	2.1878 ± 0.0671	0.007108	129.9533
0.5% agar/FBC	0.6865 ± 0.0253	0.001483	86.4118
1.5% agar/FBC	0.3598 ± 0.0330	0.000843	93.6560
2% agar/FBC	0.3599 ± 0.0457	0.000594	65.9689
	Hot water washing		
FBC	0.5445 ± 0.0627	0.005010	368.0539
0.5% agar/FBC	0.9337 ± 0.0427	0.002775	118.8770
1.5% agar/FBC	1.3997 ± 0.0852	0.002279	65.1203
2% agar/FBC	4.4179 ± 11.9561	0.001218	11.0305



Brunauer-Emmett-Teller (BET)

Measurement of carvacrol release



- The high agar addition group provided **high carvacrol release** and **longer release time**.

Active food packaging application

- Control (no addition)
- *S. putrefaciens*
- *S. putrefaciens* + agar/FBC
- *S. putrefaciens* + agar/FBC + carvacrol

TVC analysis from different groups

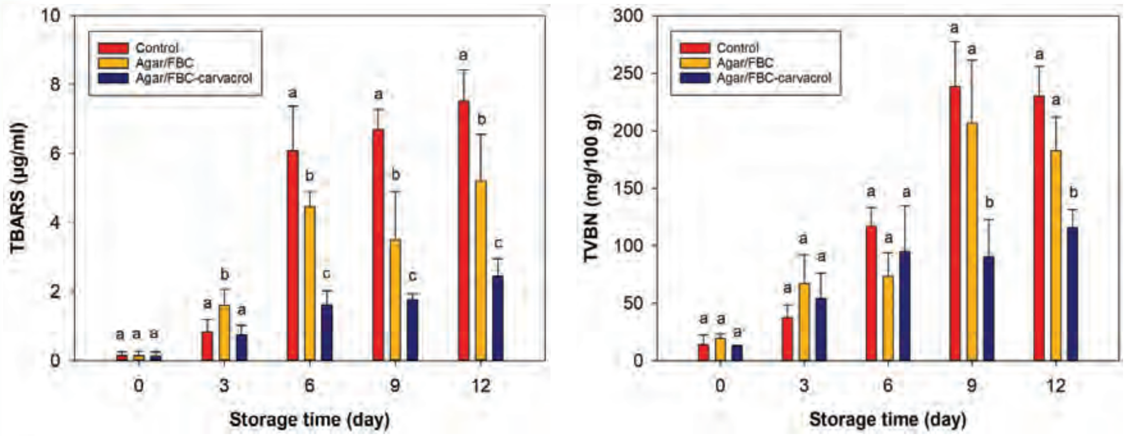
TVC analysis from different groups in sea bass fish filet for 12 days of storage. Distinct letters ($p < 0.05$) indicate the presence of significantly different values.

Group	Total viable count (log_{10} CFU/mL)				
	day 0	day 3	day 6	day 9	day 12
Control	5.97 $\pm$ 0.06^b	8.98 $\pm$ 0.08^b	11.495 $\pm$ 0.28^a	15.25 $\pm$ 0.04^b	TNTC
Agar/FBC	5.86 $\pm$ 0.12^b	7.82 $\pm$ 0.03^c	11.128 $\pm$ 0.3^a	15.04 $\pm$ 0.05^a	TNTC
Agar/FBC-Carvacrol	4.99 $\pm$ 0.59^c	6.70 $\pm$ 0.2^d	10.08 $\pm$ 0.36^b	14.96 $\pm$ 0.03^a	TNTC

CFU, colony-forming units; the conc. of Agar/FBC is 1.5%; TNTC, too numerous to count. Data are expressed as the mean$\pm$standard deviation (n = 3).

- The growth of *S. putrefaciens* in Carv. Agar/FBC is **the lowest** compared to other groups.

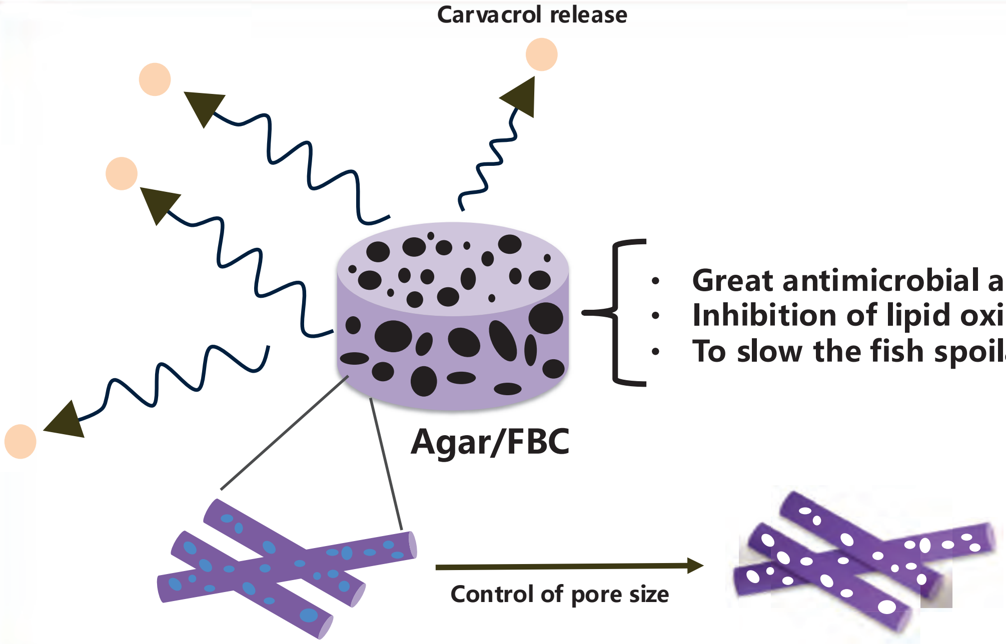
Result of TVB-N and TBARS



- Carvacrol addition to the 1.5% agar/FBC film showed a significant difference in TBARS results that **lower to the control and 1.5% agar/FBC**.
- In the TVBN result, the 1.5% agar/FBC can still **maintain lower TVBN amounts** which were around 95.07 and 90.59 TVBN mg/100 g.

Total volatile basic nitrogen (total volatile basic nitrogen); thiobarbituric Acid Reactive Substances (TBARS)

Conclusion 2



- Great antimicrobial ability
- Inhibition of lipid oxidation
- To slow the fish spoilage

Development of antimicrobial FBC for active packaging application


International Journal of Biological Macromolecules
Volume 279, Part 2, November 2024, 135114

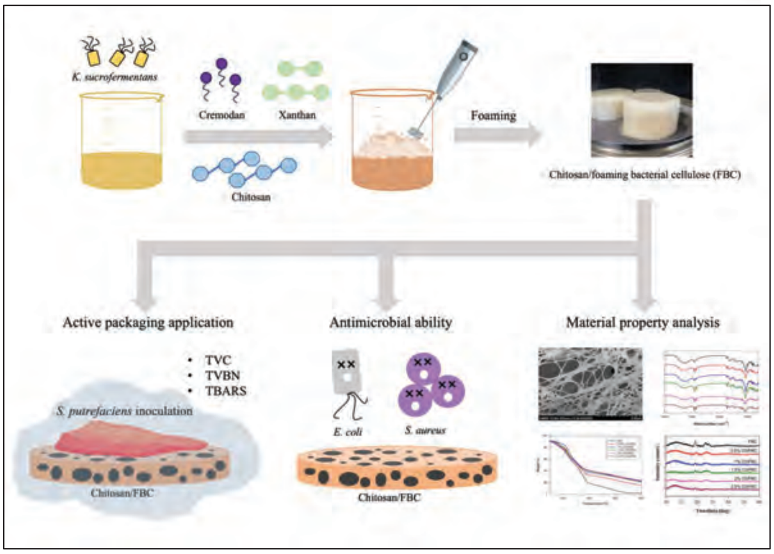
In situ modification of foaming bacterial cellulose with chitosan and its application to active food packaging

Shin-Ping Lin, Ling Hong, Chen-Che Hsieh, Yun-Hsin Lin, Yu-Chieh Chou, Shella Permatasari Santoso, Chang-Wei Hsieh, Tsung-Yu Tsai, Kuan-Chen Cheng

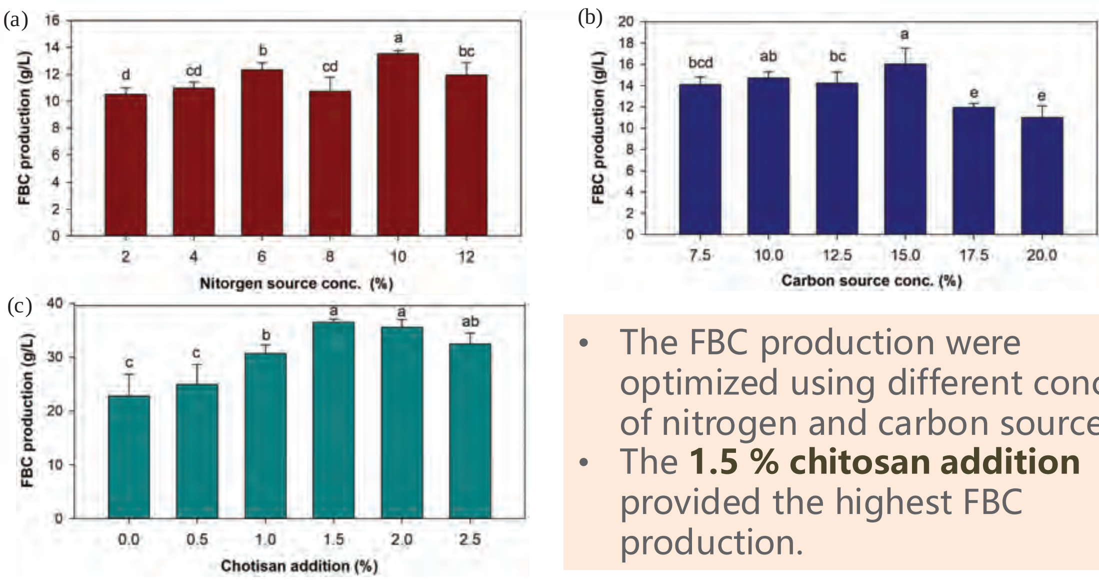
Ling Hong

Yu-Chieh Chou

Yu-Chen Huang



Production of CS/FBC



- The FBC production were optimized using different conc. of nitrogen and carbon source.
- The **1.5 % chitosan addition** provided the highest FBC production.

Figure 1. Production of foaming bacterial cellulose (FBC) with different concentrations of a nitrogen source (A), carbon source (B), and chitosan (CS) addition (C). Different letters on the error bars indicate a significant difference ($p < 0.05$).

Result of SEM

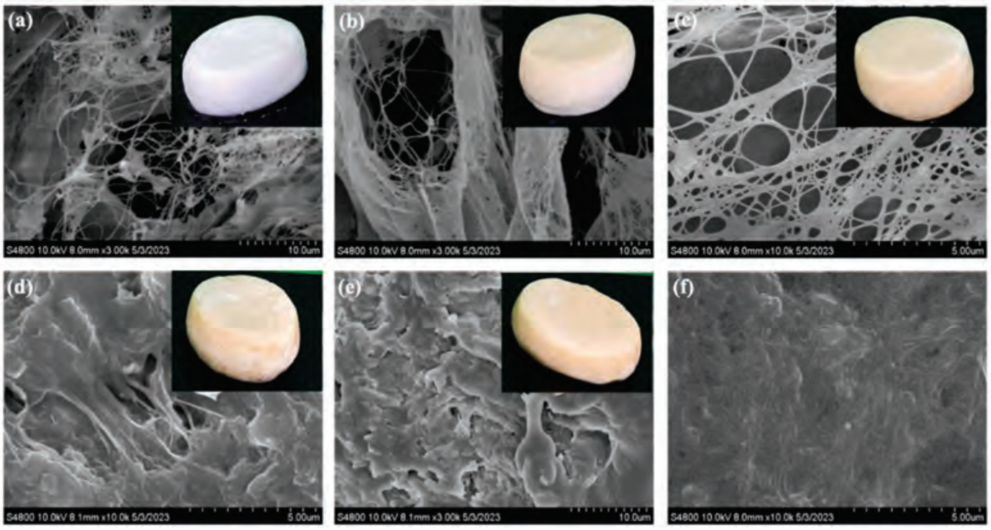


Figure 2. Visualization of chitosan (CS)/foaming bacterial cellulose (FBC) samples. (A) FBC, (B) 0.5% CS/FBC (C) 1% CS/FBC, (D) 1.5% CS/FBC, (E) 2% CS/FBC and (F)2.5% CS/FBC.

- In SEM image data suggested that chitosan may incorporate with the microfibrils of BC membranes, forming a denser network structure, and decreasing the pore size.

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Characterization of CS/FBC

Table 2

Characterization of chitosan (CS)/foaming bacterial cellulose (FBC) samples.

Group	Crystallinity (%)	Tensile strength (MPa)	Elongation at break (%)
FBC	73.39	1.52 ± 0.80^{a}	4.15 ± 0.99^{a}
0.5 % CS/FBC	70.64	1.17 ± 0.26^{a}	2.13 ± 0.60^{c}
1 % CS/FBC	70.81	1.44 ± 0.43^{a}	3.11 ± 1.19^{b}
1.5 % CS/FBC	69.3	1.61 ± 0.59^{a}	1.87 ± 0.69^{c}
2 % CS/FBC	68.54	0.34 ± 0.09^{b}	1.82 ± 0.26^{c}
2.5 % CS/FBC	67.44	n.d.*	n.d.

* Not determined. Values in a row with different superscript letters significantly differ ($p < 0.05$).

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Antimicrobial property of CS/FBC

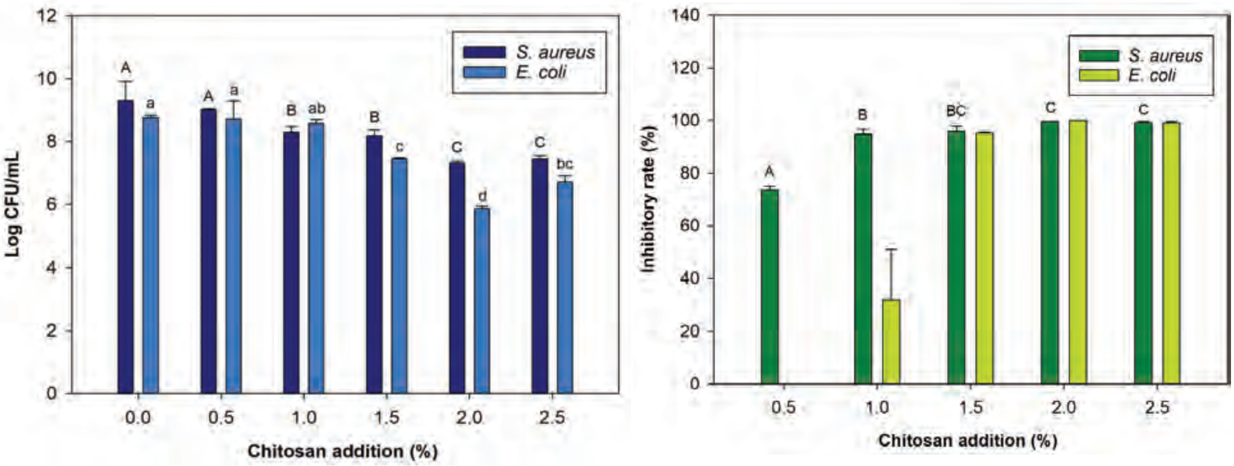
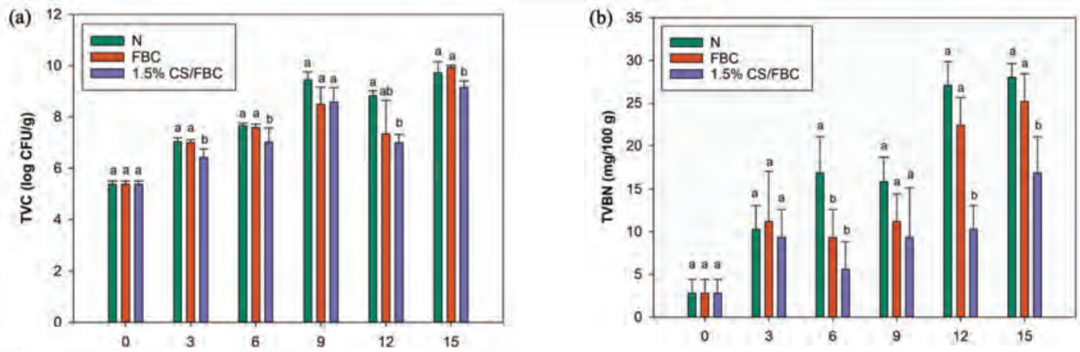
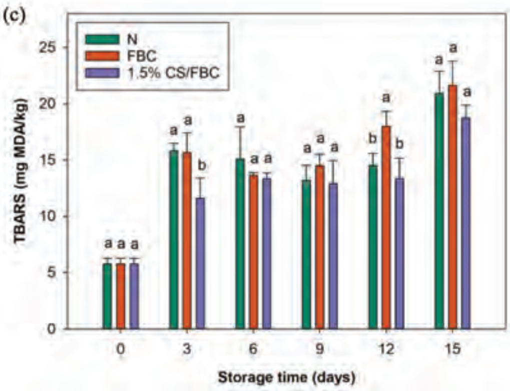


Figure 4. Antimicrobial property evaluation of chitosan (CS)/foaming bacterial cellulose (FBC) samples against Staphylococcus aureus and Escherichia coli utilizing viable cell counts (A) and viability reduction (B). Different letters on the error bars indicate a significant difference ($p < 0.05$).

The antibacterial experiment showed that the foaming BC (FBC) with chitosan added **significantly reduced *Staphylococcus aureus* and *Escherichia coli*** by approximately 2 logCFU/mL.

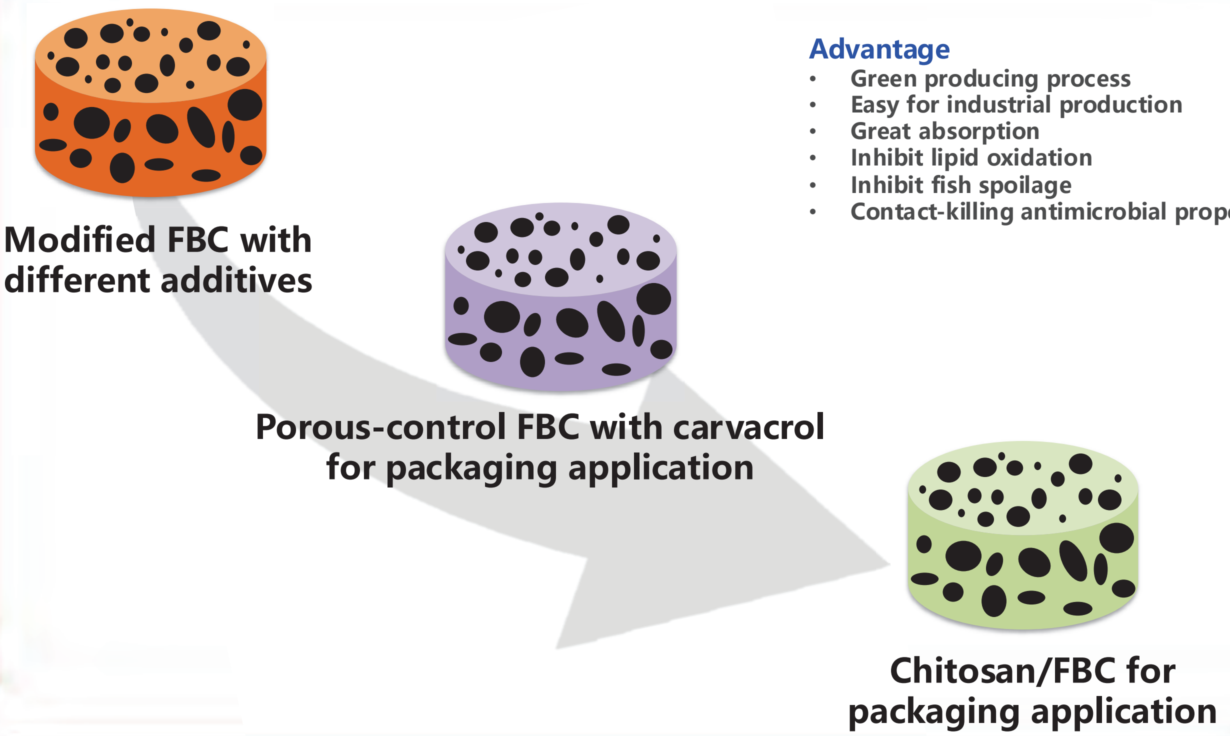
Application of CS/FBC in food packaging





- 1.5 % CS/FBC group presented the **highest growth inhibition of *S. Putrefaciens*** compared to the control and FBC groups.
- The TVBN value presents the condition of volatile alkaline nitrogen- containing substances released out of fresh fish, and should be limited to a value of **20–35 mg/100 g**.
- 1.5 % CS/FBC group was still **lower than 20 mg/100 g after 15 days of storage.**
- The TBRAS result also showed that 1.5 % CS/FBC group presents **the lowest MDA content** compared to the other groups.

Conclusion 3



Advantage

- Green producing process
- Easy for industrial production
- Great absorption
- Inhibit lipid oxidation
- Inhibit fish spoilage
- Contact-killing antimicrobial property

Acknowledgment

TOHOKU UNIVERSITY

RIKEN

教育部教學實踐研究計畫 MOE Teaching Practice Research Program

新藥研發產業博士學位學程

UNIVERSITAS KATOLIK WIDYA MANDALA SURABAYA

NSTC 國家科學及技術委員會 National Science and Technology Council

MOS RCFS NH NM

白燿嘉
Hamilton 台灣區產品經理
生技產業產品經理資歷 25 年
中興大學 分子生物研究所碩士

Hamilton Company 在過程分析領域提供先進的在線傳感器技術，致力於提升生物製藥生產的效率與品質。其中，溶解二氧化碳（DCO_2）傳感器與細胞密度傳感器是兩款重要產品，分別用於監測生物製程中的關鍵參數，以確保穩定性與最佳化控制。

CO_2NTROL 傳感器

溶解二氧化碳是影響細胞生長、產品形成與品質的重要參數。Hamilton Company 的 CO_2NTROL 傳感器 是一款固態、免維護的在線傳感器，專為生物製造過程設計，能夠提供即時監測與自動化控制。其主要優勢包括：

- 提升產量：優化 DCO_2 水平，有助於細胞代謝，提高生產效率。
- 增強一致性：適用於不同規模的生物反應器，確保從實驗室到大規模生產的穩定控制。

細胞密度傳感器

在生物工藝過程中，實時監測細胞密度對於過程控制與優化至關重要。Hamilton Company 提供兩款先進的細胞密度傳感器，以滿足不同應用需求：

- Incyte Arc 傳感器：用於測量活細胞密度，滿足生物製藥對過程分析技術（PAT）的需求。該傳感器提供即時資訊，確保關鍵變化不會在離線採樣間隔內被忽略。
- Dencytee 傳感器：基於近紅外（NIR）光密度測量技術，用於監測總細胞密度。此傳感器能檢測所有散射 NIR 光的顆粒與分子，並可與不同的離線測量方法相對應。

這些傳感器適用於多種細胞系與微生物菌株，能夠滿足生物製藥產業對於即時、高準確性監測的需求。

透過 Hamilton Company 的 CO_2NTROL 傳感器與細胞密度傳感器，生物製藥企業可實現更高效的過程控制，提升產品品質與生產穩定性，確保每個生產階段的最佳化運行。

HAMILTON

THE MEASURE OF EXCELLENCE

Online digital dCO2 probe and VCD (Viable cell density) / TCD probe

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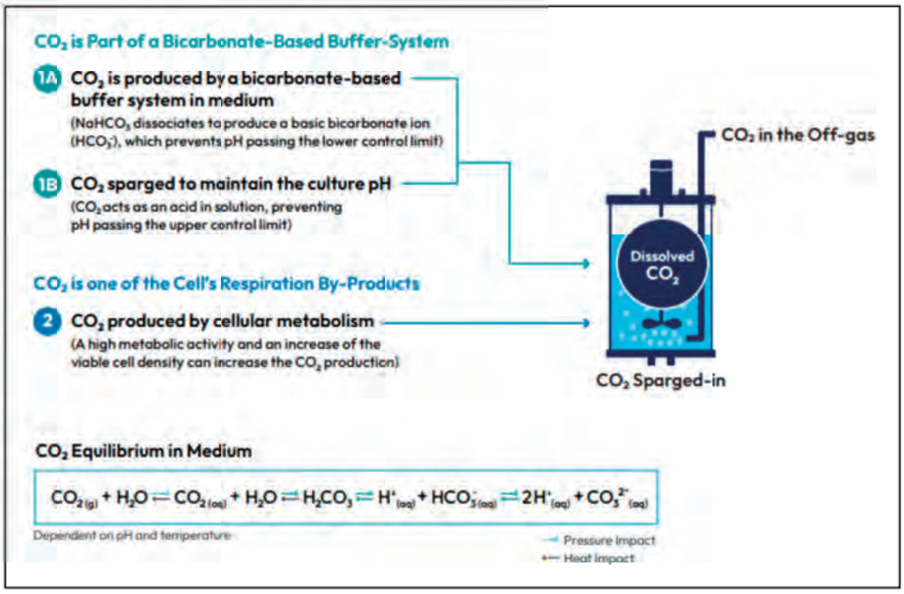
CO_2 Fundamentals: The Cell Culture Example



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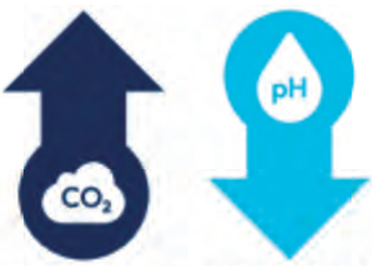
CO2 to Control pH in Buffer Systems



6.8 < Cell Culture Physiological pH < 7.4

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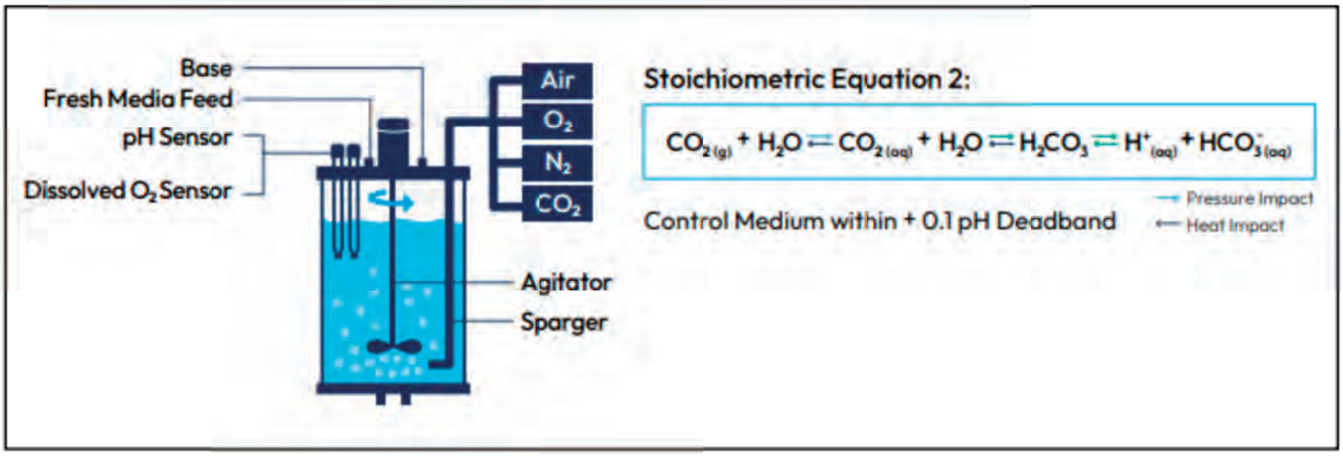

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Culture Type	Too High pCO_2	pCO_2 Average Toxic Levels*
Mammalian	Up to -60% Growth Rate Up to -70% Protein Titer Up to -50% Product Quality (Glycosilation)	>20% (>200 mmHg) (> 30% in Continuous Culture)
Bacteria	Up to -40% Growth Rate	> 30% (150/300 mmHg)
Yeast	Up to -25% Growth Rate	> 50% (500 mmHg) Can Survive and Adapt Even at Higher Dissolved CO_2
Fungi	Up to -36% Antibiotic Content	> 15% (150 mmHg)

*Consolidated from the scientific literature referenced in the text and detailed in the references at the end of the white paper.

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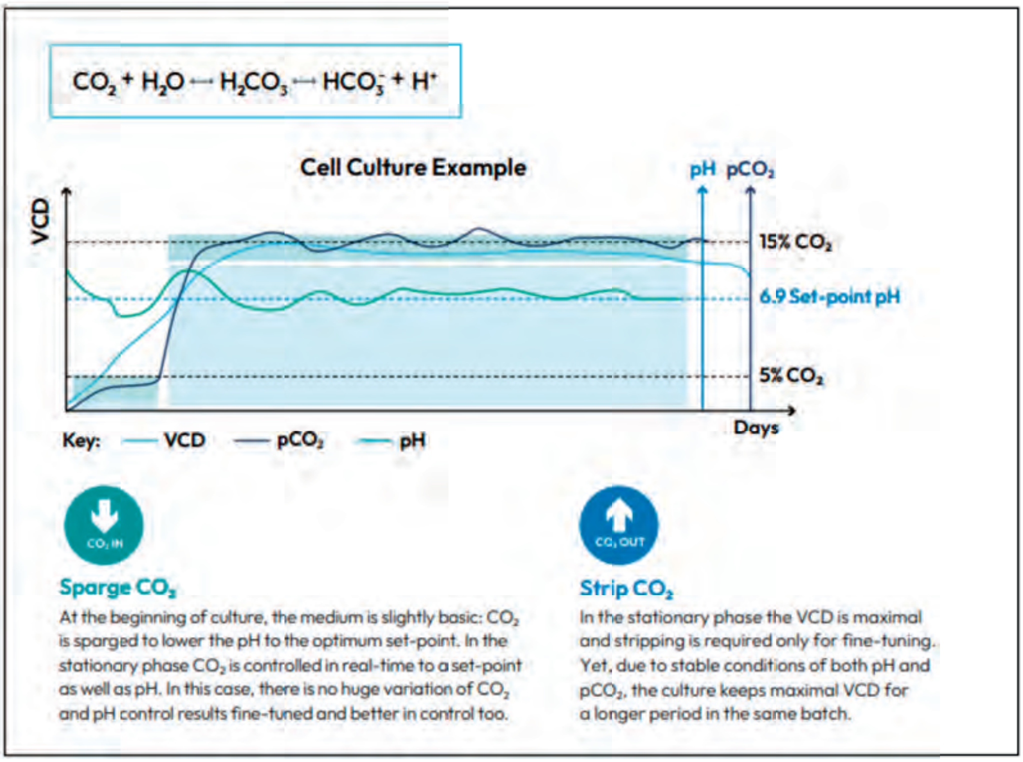

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Learn how Implementing Real-Time Control of Carbon Dioxide can Impact Productivity at R&D and Production Scale Bioreactors

Dissolved CO_2 is a Critical Process Parameter (CPP) in biopharma production processes, as it has a direct impact on product titer and its critical quality attributes. It influences other culture parameters like extracellular and intracellular pH, as well as key performance indicators such as Viable Cell Density. Uncontrolled dissolved carbon dioxide levels in the bioreactor can result in growth inhibition, lower product titer, and decreased product quality.

Download our White Paper to learn about:

- The fundamentals of DCO2 in bioprocesses
- Why DCO2 is a Critical Process Parameter
- Why monitoring and controlling DCO2 in real time is important

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Automated Control of Dissolved CO_2 Enables:

Increased Titer

Increased Product Titer

Reproducibility

Better Batch-to-Batch Reproducibility

Consistency

More Consistency from R&D to Production Scale Reactors

HAMILTON

KEY FEATURES

1. WIRELESS CONNECTIVITY

An optional Bluetooth adapter enables wireless calibration, configuration, and monitoring of all sensor details.

2. INTEGRATED INTELLIGENCE

Arc sensors save space and cost with integrated micro-transmitters that store calibration and sensor quality data.

3. PROCESS DATA

The sensor transmits process data through a hard-wired connection. Communication options include modbus RTU and 4-20 mA.

4. COMPLIANT HYGIENIC DESIGN

The hygienic design makes it compliant with requirements of biopharma applications.

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CO2 基礎知識：

CO2 是生物製程中的重要參數，影響細胞生長和產品質量。
過高的 CO2 濃度會抑制哺乳動物細胞的生長，降低產品產量和質量。

CO2 控制 pH ：

CO2 作為緩衝系統的一部分，用於控制培養基的 pH 值。
pH 值的穩定對於細胞的生長和產品的表達至關重要。

CO2 作為關鍵過程參數 (CPP) ：

CO2 被認為是關鍵過程參數，需在實時中進行監控和控制。
過高或過低的 CO2 濃度都會對生物製程產生負面影響。

不同培養 / 發酵類型的影響：

哺乳動物細胞對高 CO2 濃度較敏感，細菌和酵母菌則相對耐受。
不同細胞株和發酵類型對 CO2 的耐受範圍不同。

實時監控和控制 CO2 的策略：

需要根據具體的生物製程確定最佳的 CO2 設定點和控制策略。
實時監控和控制 CO2 可以提高生產效率，縮短開發和放大過程中的迭代次數。

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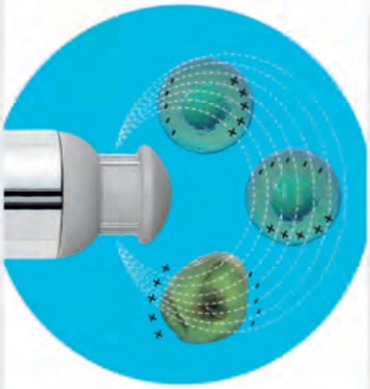
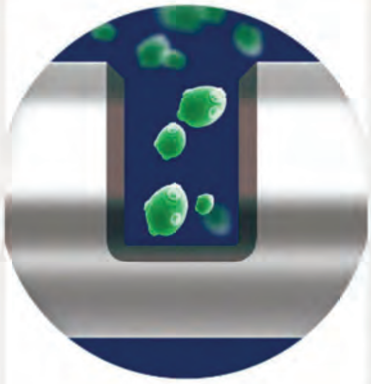


Viable Cell Density Sensors

Incyte Arc sensors provide a means for directly measuring viable cell density in real-time, meeting the increasing need for PAT in the biopharmaceutical industry. Clear, instantly available information ensures critical events that could have been missed between off-line samples are now immediately recognizable.



Total Cell Density Sensors

Total cell density measurement by the Dencytee sensor is based on optical density, commonly known as the turbidity of a suspension at near-infrared (NIR) wavelengths. All particles and molecules that scatter the NIR light will be detected. This optical density signal can be correlated to the total cell density measured by different offline measurement techniques.

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HAMILTON

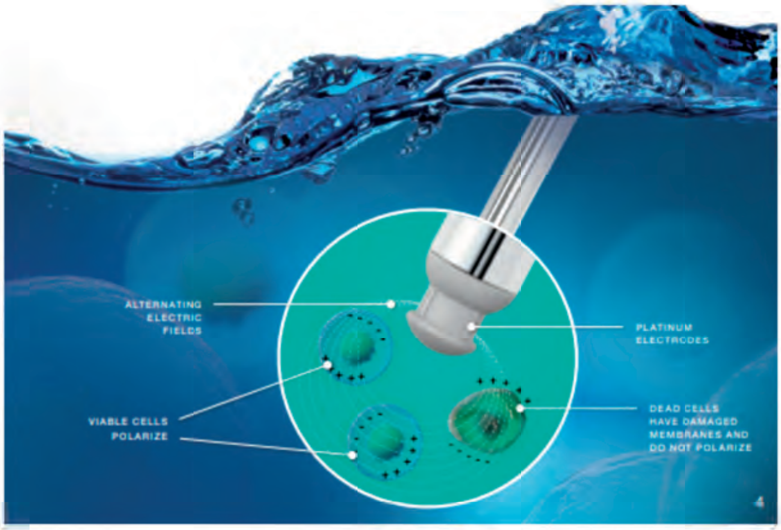
About Incyte

Real-Time, On-Line Viable Cell Density Measurement by Permittivity

Incyte sensors measure permittivity in the on-line process to give a continuous, in-situ reading of viable cells in solution. This eliminates time-intensive manual cell counting.

Incyte Highlights:

- Not influenced by changes in the media, microcarriers, dead cells, or debris
- Can increase yield and lower production costs
- Can detect changes in cell physiology with frequency scanning
- Offers precise data to control harvesting in continuous culture
- Offers early detection of process deviations
- Available in optimized versions for multiple conductivity ranges



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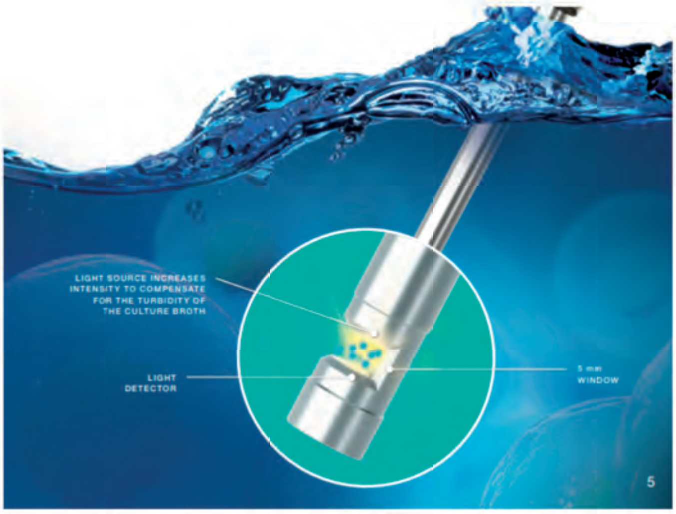
About Dencytee

Real-Time, On-Line Total Cell Density Measurement by Optical Density

Dencytee sensors determine optical density by measuring how cells in solution absorb and scatter light. These on-line, continuous readings eliminate the need for a technician to manually sample and count cells off the production line.

Dencytee Highlights:

- Simple on-line measurement of cell growth
- Reliable values during the growth phase
- Early detection of process deviations



HAMILTON

1.即時在線細胞密度測量：

1. Hamilton 的 Incyte 和 Dencytee 感測器可以即時、連續地測量細胞密度，節省時間並提高過程控制的精確度。

2.Incyte 感測器：

1. 使用電容測量法來提供即時的活細胞密度讀數，不受培養基、微載體、死細胞或碎片的影響。
2. 可提高產量並降低生產成本，並能早期檢測過程偏差。

3.Dencytee 感測器：

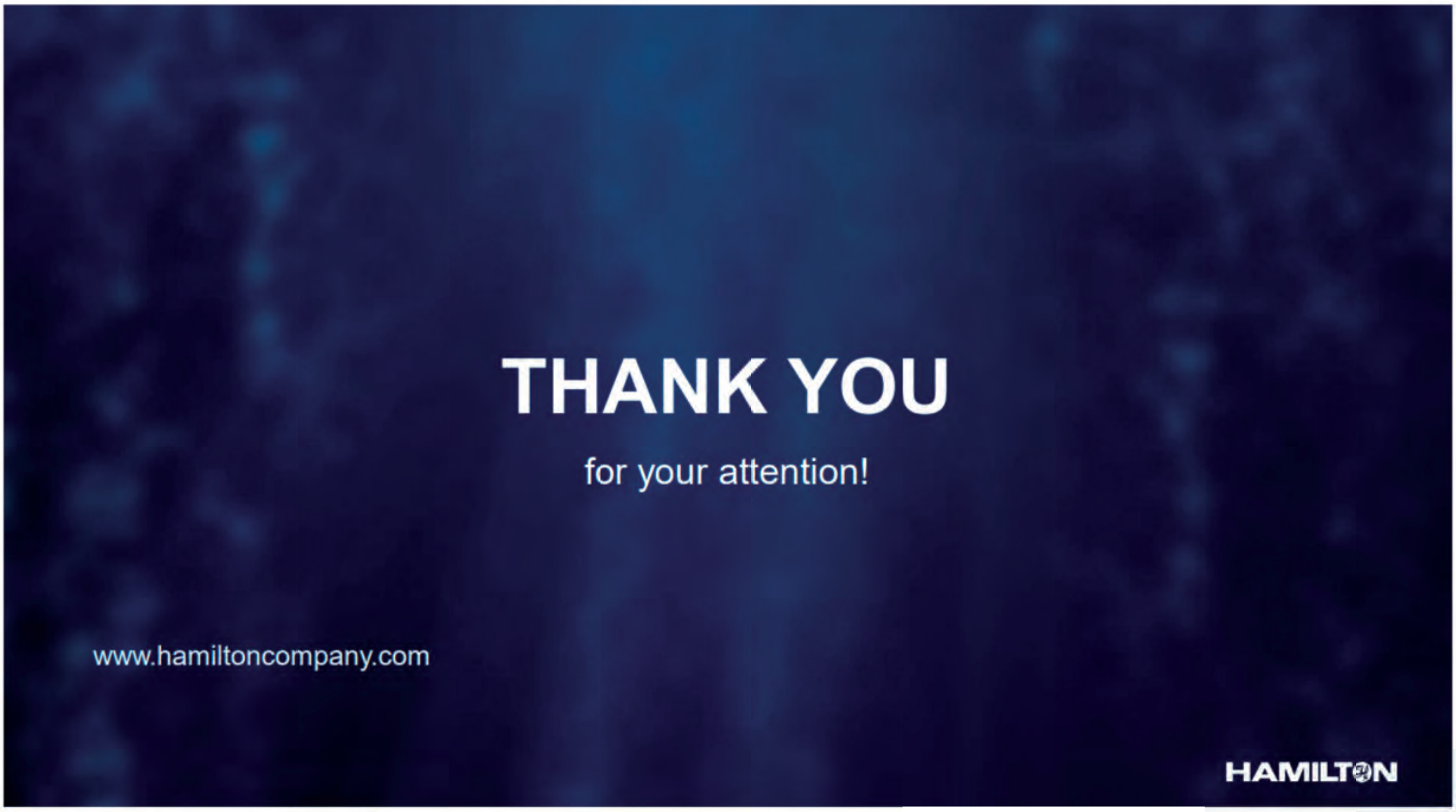
1. 通過測量細胞對光的吸收和散射來確定總細胞密度，提供簡單可靠的在線測量。

4.應用範圍：

1. 適用於哺乳動物細胞（如 CHO 和 BHK 細胞）、昆蟲細胞（如 SF9 細胞）、酵母（如 Orgatae ）和細菌（如 E. coli ）等多種細胞株和發酵類型。

5.實際應用案例：

1. 提供了多個實際應用案例，展示了這些感測器在不同細胞株和發酵過程中的優勢和機會。



Cellometer X2
高倍率自動化計數器
專為酵母菌和細菌設計

Jack Chou | Product Manager

Mar 13, 2025

revvity

level 進階生物科技 Level Biotechnology Inc.

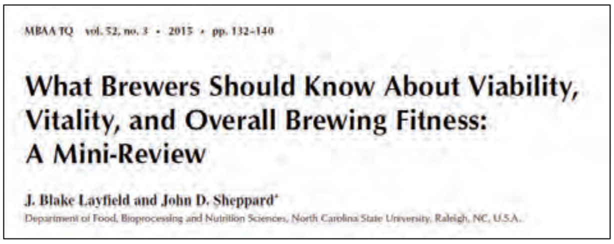
Nexcelom-Revvity致力於細胞定量方法的研究和參與相關標準的建立

- Since 2003
- Nexcelom創始人兼CTO Dr. Jean Qiu是ISO美國技術專家委員會成員
- 和美國計量院 (NIST) 合作開發基於成像原理細胞計數和活率分析的控制策略和標準
- 合作發表了多篇同行評議文章以及組織多場研討會
- Nexcelom獨立發表了約60篇細胞計數相關文獻，是這一研究領域的重要貢獻者之一

進階生物科技 Level Biotechnology Inc.

釀酒工業品管 Brew beer

“ Our new Cellometer X2 has cut the time we spend on cell counts drastically, freeing up time for much more. The transition was very easy, the software is a piece of cake to learn and the support is excellent!” -美國威斯布魯克釀酒公司


MBAA TQ vol. 52, no. 3 • 2015 • pp. 132–140

What Brewers Should Know About Viability, Vitality, and Overall Brewing Fitness: A Mini-Review

J. Blake Layfield and John D. Sheppard

Department of Food, Bioprocessing and Nutrition Sciences, North Carolina State University, Raleigh, NC, U.S.A.


Contents lists available at ScienceDirect

Journal of Microbiological Methods

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

ELSEVIER

A novel image cytometry-based *Lactobacillus* bacterial enumeration method for the production of kettle sour beer

Matthew Hodgkin[a], Suzanne M. Purseglove[d], Leo Li-Ying Chan[d,*], Jennifer Perry[a], Jason Bolton[b,c]

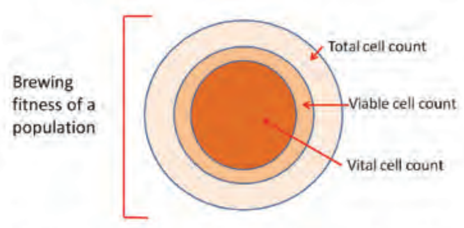
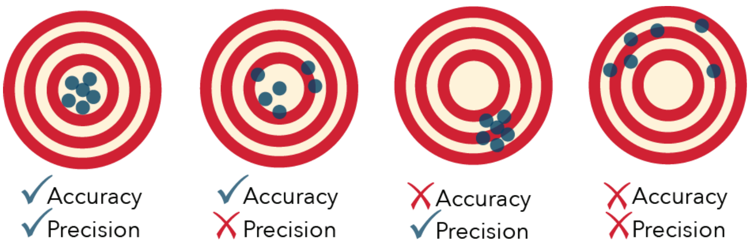


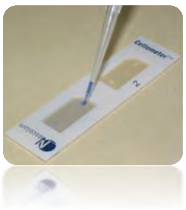
Figure 1. Parameters that contribute to overall brewing fitness (37).



進階生物科技 Level Biotechnology Inc.

Nexcelom – Revvity 的三個世界首創

更方便

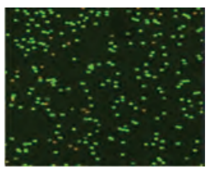


2003：
發明一次性細胞計數板

自動化

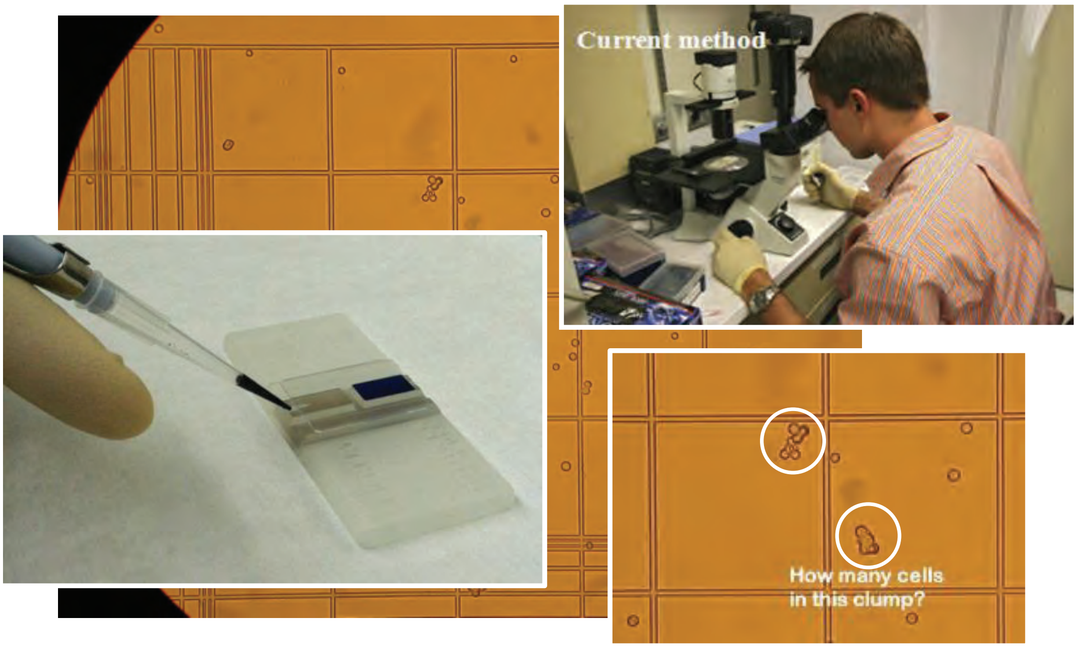
2006：
發佈世界首個基於血球計數板原理的細胞計數儀

更準確

2008：
首次將AO/PI雙螢光細胞染色法商業化

傳統人工細胞計數：費工、費時、人為差異



Cellometer X2細胞分析系統 - 工業酵母監控與研究

Cellometer® X2

專為酵母菌和細菌所設計，快速、準確的自動化計數平台

樣本濃度與存活率：明視野與紅綠螢光雙視野偵測成像

快速偵測：上樣至分析結束僅需60秒

僅需少量樣本：僅20 μl樣本即可偵測

可靠的線性範圍：$2 \times 10^5 - 5 \times 10^7$ cells/mL

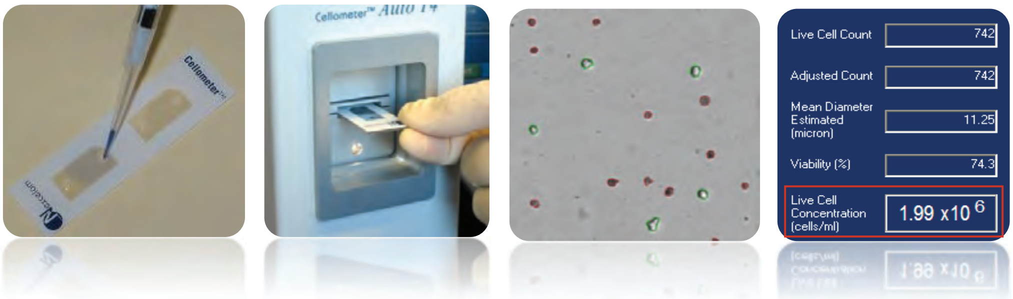
直覺的操作介面：無學習門檻

適配染劑：Trypan blue, AO, PI, EB, 7AAD, AO/PI, AO/EB, Calcein AM, CFDA-AM, Calcein AM/PI, CFDA/PI

Cellometer 細胞計數儀

進階生物科技 Level Biotechnology Inc.

簡單3步完成細胞計數



- 細胞數，濃度
- 細胞活率
- 細胞直徑
- 1分鐘/樣本
- 資料保存和匯出

X2 可辨識不同形態的酵母細胞

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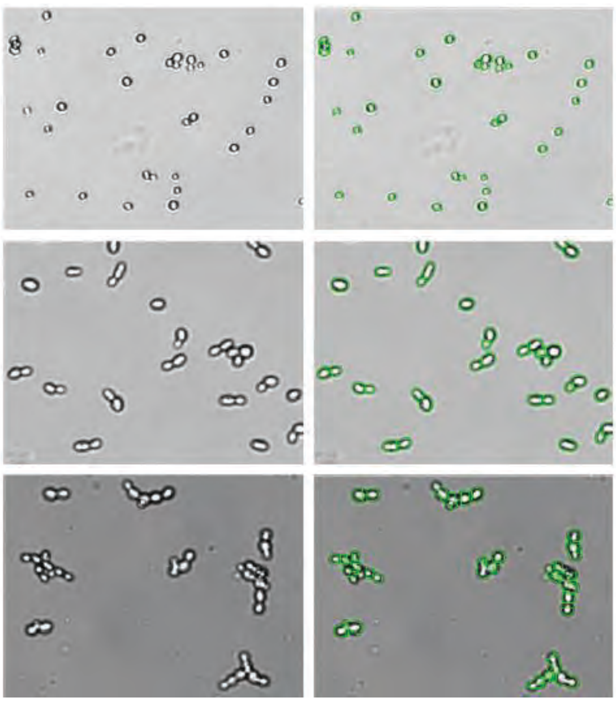


單個游離酵母

- 計數單個細胞粒子
- 通過細胞大小參數排除碎片或細胞團

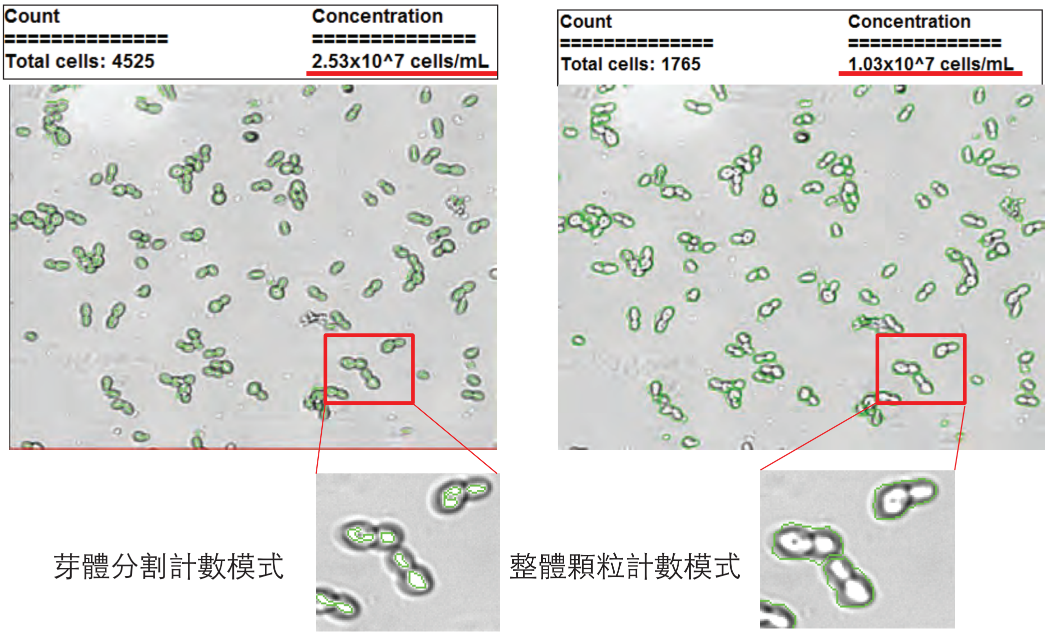
出芽酵母的去聚團 (de-cluster)

- 圖像分析演算法去聚團和計數單個酵母細胞

成鏈酵母的去聚團

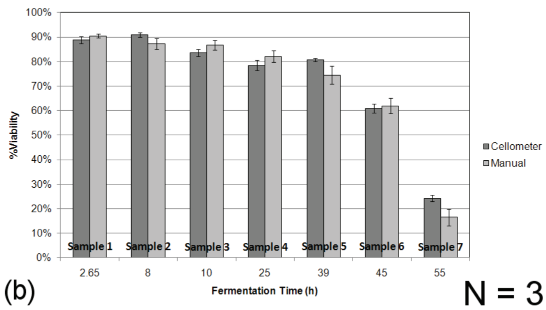
- 計數形成鏈的單個酵母細胞

X2 可辨識不同形態的酵母細胞



使用AO/PI測量酵母存活率

- 乙醇發酵過程中監測酵母樣品
- 發酵早期活率約90%
- 發酵結束時活率低於30%
- 與人工計數方法一致

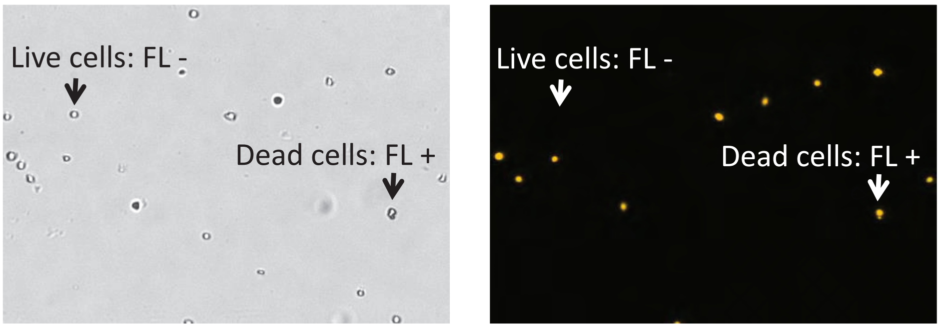


(b)

N = 3

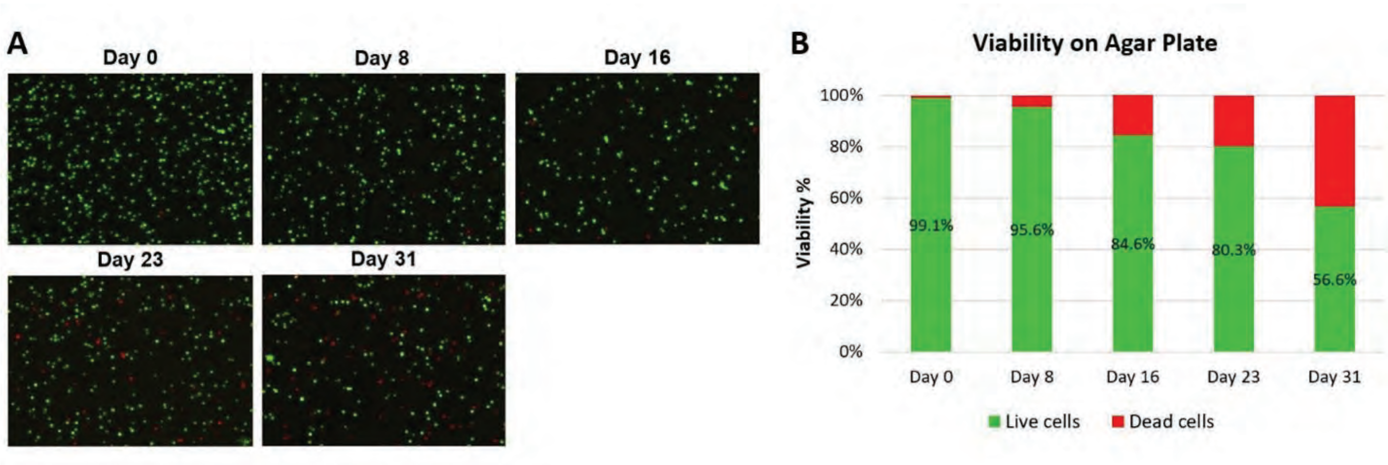
Propidium iodide——膜完整性的存活率檢測

螢光核酸活性染色分子與DNA結合時會發出強烈的螢光
- PI染料分子不可滲透膜完整的活細胞
- PI染料分子容易通過膜受損的死亡細胞



白色念珠菌在培養皿 4°C 長時間培養的存活率變化

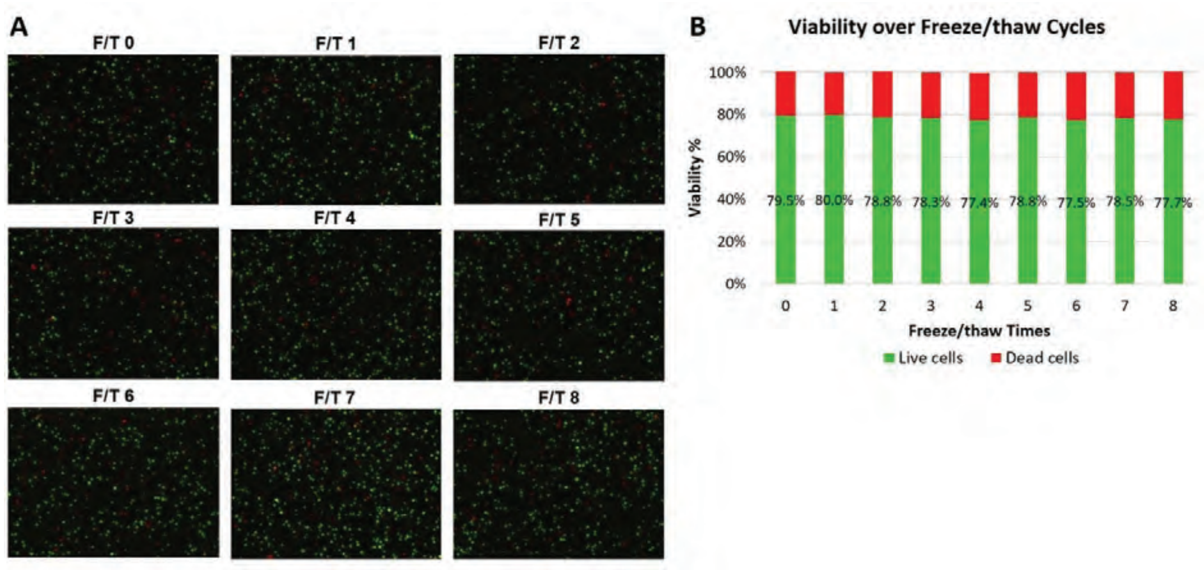
Stability of *C. albicans* culture on agar plate stored at 4°C from Day 0 to Day 31



level 進階生物科技 Level Biotechnology Inc.

白色念珠菌保存在甘油重複冷凍/解凍的存活率檢測

Stability of *C. albicans* frozen culture stock in 10% glycerol over 8 freeze/thaw cycles.



X2 在發酵工業品管帶來的好處

- 絕對計數與存活率計數準確，高線性範圍。
- 操作快速，從取樣到分析完成 < 5min。
- 操作簡單，看過一次就上手。
- 拋棄式耗材，無交叉感染，儀器無須維護。

X2 在發酵工業品管的相關應用

- 快速偵測不同時間製程樣本數與存活率。
- 製程管理、購買菌株確認、品管確效。
- 客製化輸出報告，減少人為操作差異。

高壓滅菌釜
HIGH PRESSURE STEAM STERILIZER

HiPoint

結構穩定 安全可靠：

- ◆ 耐壓平移側開門、雙壓力軸承設計，開關門輕鬆順暢。
- ◆ 密封圈選用高抗撕食品級矽膠材料，正常使用壽命長達5年以上。
- ◆ 304鏡面不銹鋼檯面，美觀、易清潔、耐老化、不開裂。

*有符合國際標準的校驗接口，方便使用者進行檢驗

產品用途：主要用於科研、大學、非醫用目的醫療實驗室、製藥工業、生物科技、食品工業和化學工業實驗室。

安全系統：高壓安全保護裝置、密閉蓋偵測系統、自動故障檢查裝置、腔蓋防燙安全罩、超溫、超壓、乾燒、缺水、安全閥、過電流、短路感漏電等全面安全保護。

控制系統：

- ◆ " HA微電腦控制系統" 滅菌過程全自動壓力控制，蒸氣內循環，自動排氣。
- ◆ 滅菌過程螢幕動態顯示，滅菌溫度、時間過程顯示，故障自動警報並自動停止運轉工作。
- ◆ 滅菌密碼權限管理功能，可實現滅菌過程中自動鎖定。

滅菌腔蓋：壓力容器專用不銹鋼板一體沖壓成型無焊接，安全可靠美觀，表面通過化學拋光處理提高抗腐蝕性能和使用壽命。

防燙設計：滅菌腔蓋防燙保護罩採用抗熱塑膠材料，流線型複合式設計，時尚美觀。

耐壓部件：橫樑經鍛打熱調質工藝處理，強度及韌性大大提高，更安全、可靠。

HA系列

型號	HA60	HA80	HA100
容量	60L	80L	100L
腔體直徑	377mm		
滅菌溫度	105-135℃		
排氣溫度	100-135℃		
數據紀錄	內置滅菌記錄印表機 選配：USB數據儲存		
電力	220V 60Hz 15A		

HiPoint 台灣海博特股份有限公司
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www.majorsci.com
info@majorsci.com

主辦單位：

協辦單位：

贊助單位：

山水科技儀器有限公司、Hamilton、進階生物科技股份有限公司、友和貿易股份有限公司、
台灣寶帝股份有限公司、桂鼎科技股份有限公司、台灣海博特股份有限公司