不同 3D 支架應用於培養魚肉之特性、生物相容性、質地與風味探討

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一、前言

二、不同 3D 支架材料之特性

三、探討不同 3D 支架之生物相容性

四、探討不同細胞培養魚肉之質地與風味

五、結論

摘要

魚類含特殊風味與營養價值在全球廣受喜愛，但過度捕撈與高密度養殖造成生態環境問題，且食魚伴隨重金屬與過敏風險。細胞培養肉(Cultured fish meat)概念最早於 1930 年提出，於 2013 年製作出人造漢堡排，最終在 2020 年於新加坡餐廳推出細胞培養雞肉，並成為全球首個批准培養肉的國家。細胞培養魚肉被視為永續替代方案，透過魚類幹細胞接種在支架上進行培養，形成魚肉類似組織。其中支架材料對細胞增殖、分化及最終質地有關鍵影響。本研究比較不同 3D 支架材料之特性、生物相容性與不同支架製作出的細胞培養魚肉之質地與風味。結果顯示，七帶石斑魚肌肉衛星細胞於 3D 多孔明膠微載體中可增殖 7 倍且具良好存活率，形成之細胞培養魚肉彈性與黏聚性與天然魚肉接近。將大黃魚肌肉幹細胞於豌豆蛋白支架中生長，7SF、11SF、PPIF 三種支架均能支持細胞增殖，其中以 11SF 支架孔隙率超過 80%、孔徑 41.38±1.37 μm，最利於細胞附著與分化。虹鱒肌肉衛星細胞於不同比例 FG/CFG 水凝膠中培養，結果發現 4FG6CFG 水凝膠具高穩定性與可列印性，培養 7 天後仍保持結構且細胞存活率超過 75%，且質地分析顯示其硬度與新鮮魚肉無顯著差異。綜上所述，具高孔隙率、適當孔徑大小與高機械強度之食品級支架，能提供細胞支撐，同時提高營養物質運輸效率，促進魚細胞的增殖分化。

Exploring the Characteristics, Biocompatibility, Texture, and Flavor of Different 3D Scaffolds for Fish Cultured Meat

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Outline

1. Introduction
2. Characteristics of Different 3D Scaffold Materials
3. Investigation of the Biocompatibility of Different 3D Scaffolds
4. Investigation of the Texture and Flavor of Different Cultured Fish Meat
5. Conclusion

Abstract

Fish are widely consumed worldwide for their distinctive flavor and nutritional value; however, overfishing and intensive aquaculture have led to ecological degradation, pollution, and animal welfare concerns. Moreover, fish consumption carries risks of heavy metal accumulation and histamine-related allergies. The concept of cultured meat originated in 1930, with the first *in vitro* meat-based burger produced in 2013, and Singapore becoming the first country to approve cultured chicken in 2020. Cell-based fish meat has emerged as a sustainable alternative, achieved by cultivating fish stem cells on scaffolds to form tissue-like constructs. Scaffold properties play a pivotal role in regulating cell proliferation, differentiation, and final texture. In this study, different 3D scaffold materials were evaluated. Seven-band grouper (*Epinephelus septemfasciatus*) muscle satellite cells proliferated sevenfold on 3D porous gelatin microcarriers, showing high viability and producing constructs with espringness and cohesiveness comparable to native fish meat. Large yellow croaker (*Larimichthys crocea*) muscle stem cells grown on pea protein isolate (PPI) scaffolds demonstrated effective proliferation across 7SF, 11SF, and PPIF scaffolds, with the 11SF scaffold exhibiting >80% porosity and an average pore size of 41.38 ± 1.37 μm, optimizing adhesion and differentiation. Rainbow trout (*Oncorhynchus mykiss*) muscle satellite cells cultured in FG/CFG hydrogels showed that a 4FG6CFG hydrogels provided superior printability, stability, and >75% live cells after 7 days, with no significant difference in hardness compared to fresh fish. Collectively, food-grade scaffolds with high porosity, suitable pore size, and mechanical strength enhance nutrient transport and support fish cell growth and differentiation.

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