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Effectiveness of Sodium Dodecyl Sulphate (SDS) and Hydrogen Peroxide (H2O2) in The Decellularization Process of Biological Tissues

Daud Yudhistira Sukanto[1], Heroe Soebroto2*

[1]Department of Thoracic, Cardiac, and Vascular Surgery, Dr Soetomo General Academic Hospital, Surabaya, East Java-Indonesia

[2]Department of Thoracic, Cardiac, and Vascular Surgery, Faculty of Medicine, Universitas Airlangga, Surabaya, East Java-Indonesia

***Corresponding author:**

Heroe Soebroto

Department of Thoracic, Cardiac, and Vascular Surgery, Faculty of Medicine, Universitas Airlangga, Surabaya, East Java-Indonesia

Email ID : heroesurgeon@yahoo.com

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ABSTRACT

Background: Tissue engineering requires an effective decellularization process that eliminates cellular components while preserving the extracellular matrix (ECM). Sodium Dodecyl Sulphate (SDS) and Hydrogen Peroxide (H_2O_2) are two common agents used in this process.

Objective: To analyze the effectiveness of SDS and H_2O_2, both individually and in combination, in the decellularization of biological tissues.

Methods: A narrative literature review was conducted using electronic databases (PubMed, ScienceDirect, Google Scholar) with keywords including "decellularization," "SDS," "hydrogen peroxide," "biological scaffold," and "tissue engineering." Eighteen articles published between 2010 and 2025 were selected based on inclusion and exclusion criteria.

Results: SDS showed high efficacy in cellular removal but posed risks of ECM degradation, particularly at high concentrations or prolonged exposure. H_2O_2 was less effective in removing cells but preserved ECM structure better. The combination of SDS 0.5% and H_2O_2 3% offered the most optimal results, yielding acellular scaffolds with well-preserved ECM and low residual toxicity.

Conclusion: Combining SDS and H_2O_2 offers synergistic advantages in decellularization, achieving effective cell removal while maintaining ECM integrity. This approach is promising for future tissue engineering applications.

Keywords: *decellularization, SDS, hydrogen peroxide, extracellular matrix, scaffold, tissue engineering*

1. INTRODUCTION

Tissue engineering has emerged as a crucial area in regenerative medicine aimed at developing biological substitutes to restore, maintain, or improve tissue function. A foundational step in tissue engineering is the preparation of acellular scaffolds derived from natural tissues through the decellularization process. This process eliminates all cellular materials from donor tissues while retaining the architecture and biological cues of the extracellular matrix (ECM). The ECM plays a vital role in supporting cell adhesion, migration, and differentiation.

Among the various agents employed for decellularization, Sodium Dodecyl Sulphate (SDS) and Hydrogen Peroxide (H_2O_2) are commonly utilized. SDS, an anionic detergent, is known for its ability to solubilize cellular membranes and remove intracellular contents. However, its aggressive nature may disrupt ECM components, particularly at high concentrations. H_2O_2, a reactive oxygen species, exhibits antimicrobial and oxidizing properties that aid in the breakdown of residual DNA while preserving ECM proteins more effectively than SDS.

Despite their widespread use, there is limited consensus regarding the optimal use of these agents, especially in combination. This review aims to synthesize current findings and compare the efficacy of SDS and H_2O_2 in decellularization protocols, either alone or combined, in various biological tissues.

METHODS

This study employed a narrative literature review approach. Articles were sourced from electronic databases including PubMed, ScienceDirect, and Google Scholar. Keywords used in the search included "decellularization," "SDS," "hydrogen peroxide," "biological scaffold," and "tissue engineering."

Inclusion Criteria:

Experimental in vitro or ex vivo studies on biological tissues.

Use of SDS and/or H_2O_2 as decellularizing agents.

Assessment of decellularization efficacy (e.g., residual DNA, ECM structure, histology).

Articles published in English or Indonesian between 2010 and 2025.

Exclusion Criteria:

Review articles, editorials, or non-original research.

Articles not employing SDS or H_2O_2.

Non-accessible full texts.

From the initial 135 records, 5 articles met the inclusion criteria and were analyzed descriptively.

2. RESULTS

EFFECTIVENESS OF SDS

SDS concentrations ranging from 0.1% to 1% were frequently used in tissue decellularization. Khosropanah et al. (2024) demonstrated that 0.1% SDS for 24 hours effectively removed cellular components from fetal kidney tissues while preserving ECM elements such as collagen, fibronectin, and laminin. Conversely, Sembiring et al. (2022) found that SDS 1% applied for two weeks yielded optimal decellularization in bovine vascular tissue. However, prolonged exposure beyond two weeks caused ECM degradation.

Effectiveness of H_2O_2

H_2O_2, typically at 3%, was shown to maintain ECM integrity while removing a moderate amount of cellular material. Pawanis et al. (2025) reported that H_2O_2 preserved collagen I and III in bovine pericardium better than SDS. Qing et al. (2019) found that 3% H_2O_2 applied for 12 hours did not compromise biomechanical strength in bone matrix but did reduce BMP-2 expression, suggesting lower osteoinductivity.

Effectiveness of SDS and H_2O_2 Combination

The combined use of SDS 0.5% and H_2O_2 3% resulted in synergistic benefits. Jiwangga et al. (2024) applied this combination to goat tracheal tissue, achieving high decellularization efficacy, ECM preservation, and low residual immunogenicity. Histological analysis revealed minimal nuclear remnants and intact ECM architecture.

3. DISCUSSION

The findings suggest that SDS is highly effective in lysing cells and clearing nucleic material but may damage structural ECM proteins if overused. H_2O_2, while gentler, is insufficient alone for complete decellularization but excels in preserving ECM structure and minimizing toxicity.

Combining SDS and H_2O_2 appears to harness their complementary strengths—effective cell removal by SDS and ECM preservation by H_2O_2. The synergy enables the production of scaffolds that are structurally and biochemically viable for tissue engineering applications.

However, this review also highlights limitations such as heterogeneous methodologies across studies and the lack of standard evaluation criteria for scaffold quality. Further investigations are warranted to standardize protocols and validate findings through in vivo models.

4. CONCLUSION

SDS and H_2O_2 are both effective decellularizing agents, each with distinct advantages. SDS is potent in removing cellular material, whereas H_2O_2 better preserves ECM components. Their combination, particularly SDS 0.5% with H_2O_2 3%, achieves superior outcomes by balancing efficacy and safety.

This review supports the adoption of SDS-H_2O_2 combinations in scaffold preparation for regenerative medicine. Future studies should focus on protocol optimization, standardization, and clinical validation.

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