CHAPTER 7

SUSTAINABLE BIOMATERIALS FOR TISSUE ENGINEERING APPLICATIONS

Nur Ilyana Sahira Murizan, Nor Hasrul Akhmal Ngadiman, Noordin Mohd Yusof, and Ani Idris

7.1 INTRODUCTION

An engineered tissue can be a massive aid in expediting the recovery process of a damaged tissue. The mixture of cells, engineering, material, methods, and appropriate biochemical and physiochemical factors can lead to a successful restoration, improvement, replacement and maintenance of damaged tissue with the aid of the scaffold (Lanza et al., 2020). Scaffold is a crucial part of tissue engineering as it is essential to tissue regeneration. A scaffold can be defined as a device that provides a framework for cell attachment and proliferation during the healing process. A scaffold also acts as a medium that forms a suitable extracellular matrix (ECM) that helps promote the recovery process. However, many things need to be considered when producing a scaffold since it has to be able to imitate the native tissues' properties. An excellent scaffold must be developed using specific materials that can control the biological and physical properties of the scaffold (Manoukian et al., 2019).

The researchers have widely studied sustainability in the past few decades. Sustainability can be defined as the process by which we develop certain things that can cater to the present world's demands without compromising future generations' needs (Bartlett, 2012). Sustainability and biomaterials are two terms that balance each other and support the development of sustainable tissue engineering processes. Researchers have discovered many approaches to developing new, novel, sustainable biomaterials for scaffolds by implementing biomass waste valorisation with the proper usage of green technologies (Kumar Gupta et al., 2015). By implementing a sustainable tissue engineering technique, we can overcome many future challenges mainly related to energy conservation, decreasing fossil resources and other environmental issues.

This chapter provides an overview of the sustainability efforts in tissue engineering. Many sustainability biomaterials are polymeric and can be derived from renewable natural resources (plants, lignocellulosic biomass, animal kingdoms). This chapter briefly reviews two categories of sustainable biomaterials for tissue engineering applications: Polysaccharides (cellulose, chitosan, alginate) and protein-based biomaterials (silk, collagen, gelatine).

7.2 SUSTAINABLE BIOMATERIALS

The relationship between biomaterials and renewable resources has produced sustainable biomaterials, opening the opportunity gap in developing sustainable processes and products. With the progression of green technologies, significant steps and attention in the tissue engineering field have been focused on designing sustainable biomaterials from renewable and abundant resources to substitute conventional materials. The sustainability of the materials can be achieved when the derivation and designing process is conducted in such a way that it is required to be reused, recycled and composted in nature and always prioritises renewable resources in designing the biomaterials and avoid fossil-fuel-based products in order to maintain the lifecycle of the manufactured products (Malik et al., 2020). In tissue engineering applications, sustainable biomaterials can be categorised into polysaccharides-based and protein-based biomaterials.

7.2.1 Polysaccharides-based Biomaterials

Polysaccharides, naturally occurring biopolymers, are widely used in biomaterial applications due to their biocompatibility, biodegradability, and renewable nature. Derived from sources like cellulose, chitosan, and alginate, they offer diverse functionalities in fields such as tissue engineering, drug delivery, and wound healing.

7.2.1.1 Cellulose

The discovery of cellulose as biomaterials for tissue engineering applications is because of its reputable performance. Cellulose is known as the most abundant material on Earth and is almost inexhaustible. Chemically, cellulose is an organic compound that consists of a linear chain of repetitive D-glucose units that are linked by β-(1-4) of glycosidic bonds (Domingues et al., 2014; Kargarzadeh et al., 2017; Murizan et al., 2020). Cellulose has become the main sustainable biomaterial for tissue engineering because it can be derived from renewable resources and lignocellulosic agricultural wastes. The agricultural wastes include rice straw, empty fruit brunch, sugarcane bagasse, wood pulp, soy hulls and cassava peels (Xu et al., 2018). Different kinds of resources offer different physical properties of cellulose — further chemical processes like acid hydrolysis produce nanocellulose (Phanthong et al., 2018).

The customisable mechanical qualities, excellent biocompatibility and hydrophilicity properties of cellulose biomaterials have sparked much interest in employing them for artificial skin and wound dressing applications. The scaffold or artificial skin adheres to the damaged skin site during application to support the healing process. After fully healing skin damage, the scaffold is expected to be removed without disrupting the newly formed tissue (Gonzalez et al., 2014; Hickey & Pelling, 2019).