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Effect of film forming solution pH on antibacterial, antioxidant and structural characteristics of edible films from modified quinoa protein

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ABSTRACT

The active packaging films were developed from the ultrasound or heat modified quinoa protein (QP) infused with lysozyme, by varying the pH of film forming solution (FFS). It was observed that, due to the increase in the solubility of ultrasonicated or heat-treated QP at higher pH, there was a decrease in the moisture content, light transmittance, solubility, and water vapor permeability of the prepared films. On the other hand, increasing the pH of FFS, an increase in the thickness, tensile strength, elongation at break, color, total phenolic content (TPC), and antioxidant activity (AA) was observed. Morphological analysis revealed that there developed the rough and irregular surfaces in the films when the pH of FFS was lowered. In the antibacterial activity, the film prepared at pH 7.5 had shown the highest inhibitory zones of 27.70 mm, 25.48 mm, and 24.90 mm for *Staphylococcus* spp, *Streptococcus agalactiae* and *Enterococcus faecalis*, respectively, It was noteworthy that the pH of FFS was detrimental in TPC and hence the AA. The FTIR analysis indicated that the higher pH of FFS had induced favorable structural changes, stable intermolecular interactional compatibility, and higher ordered molecular structure in the QP films, The X-ray diffraction analysis showed a decrease in the film intensity and an increase in the crystallinity, whereas the thermal analysis indicated an increase in T_g up to 43.88 °C at higher pH. Hence the films developed at higher pH, while portraying an enhanced physicochemical and structural characteristic had also shown the lowered antibacterial and antioxidant characteristics.

1. Introduction

At present the plastic packaging has become a matter of concern, since it is extremely wasteful, and has a decisive impact on the earth's ecosystem in which we live. Although this human innovation possesses a number of versatile properties like; light-weight, durability, decay resistance, inexpensive and moldability, it also has a negative impacts on the earth's environment because of its non-biodegradable nature (Lebreton & Andrady, 2019). Most of the plastic wastes are either directly sent to the landfills or disposed of into the environment. Every piece of the plastic ever made is still lying on the planet earth (DeMerlis & Schoneker, 2003). Whether the plastic is broken down into microplastics or recycled, it is either dumped on the land or washed away into the oceans. It is either being consumed by the marine animals or it creates havoc on the land. To overcome this problem, the films made from biodegradable underutilized plant proteins can serve as an innovative approach, which in turn can minimize the chances of environmental pollution. Novel antimicrobial edible food packaging for increasing the shelf life of high-quality nutritious foods, is gaining tremendous attention these days. Films made from protein have good aroma, possess good mechanical properties and are the excellent barriers to gases. In addition to this, the films made from protein can also serve as a carrier material for different bioactive compounds like, antimicrobials, antioxidants, colorants, vitamins, and flavoring compounds. They also possess the ability to release the bioactive compounds into their target sites, therefore, can enhance the quality and retention time of various kinds of valuable food supplements (Fabra, Hambleton, Talens, Debeaufort, & Chiralt, 2011).

Quinoa (*Chenopodium quinoa*) is a highly nutritious dicotyledonous *pseudo*-cereal crop. It contains a broad spectrum of essential amino acids and have important nutritional characteristics such as, essential amino acid index, biological value, protein efficiency ratio, amino acid score and nutritional index (Mir, Riar, & Singh, 2018; 2019a). Quinoa protein is characterized by 11S globulins proteins, and its structure is stabilized by the disulfide bridges. Despite of having the structural stability and high nutritional profile of native quinoa proteins, its functional characteristics like solubility, emulsification properties, foaming capacity, foaming stability, water binding capacity, oil binding capacity and

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