International Journal of Biological Macromolecules 247 (2023) 125795

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

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

Chachafruto starch: Physicochemical characterization, film-forming properties, and 3D printability

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ARTICLE INFO

Keywords:
Erythrina edulis Triana
Food packaging
Edible inks

ABSTRACT

This work aimed to characterize the physicochemical, film-forming properties, and 3D printability of a nonconventional starch from chachafruto. The chachafruto native starch (CHS) presented an excellent extraction yield (10 % db) and purity (99 % db), along with an oval and round morphology, a smooth surface with few defects, and a mean diameter of 15.4 μm. The typical B-type diffraction pattern was observed in the CHS with a crystallinity of 17.4 %. The starch presented a paste temperature of 66.1 °C, an enthalpy of 11.5 J g^{-1}, and a final viscosity of 596 Brabender Units. The thermal analysis demonstrated good thermal stability. The evaluated film presented a reduction in crystallinity (8.18 %) to the CHS, which generated a good elasticity in the material. Likewise, it presented a continuous structure without cracks, providing good barrier properties (2.3 × 10^{-9} g•m^{-1}•s^{-1}•Pa^{-1}) and high transparency. Meanwhile, 3D prints prepared with CHS showed good textural properties and high consistency. The morphological analysis showed that the prints generated organized cell structures. However, high concentrations of CHS were not efficient in obtaining 3D prints. The results of this work demonstrate the tremendous industrial potential of chachafruto as an unconventional source of starch and some alternative uses for adding value to the crop.

1. Introduction

Starch is a natural polysaccharide in cereal grains, legumes, tuber, and root crops. This macromolecule is consumed worldwide and is used as a raw material in different industries such as pharmaceuticals, food, biomedical, and plastics [1]. By 2026, the production of this material is expected to reach 120 million tons, with corn, wheat, cassava, and potatoes being its primary sources [2]. This situation has generated concern worldwide about the possible impact on food security, which has led to the search for alternative sources of starch in its native form [3–5]. However, the chemical composition of the starches obtained from these alternative sources, as well as their industrial potential, may vary according to the crop's botanical source and agro-ecological conditions. Consequently, it is necessary to characterize the physicochemical properties and evaluate their industrial potential.

The chachafruto (*Erythrina edulis* Triana) is a legume plant native to South America, cultivated mainly at altitudes between 1600 and 2000 m above sea level. The plant has a broad spectrum of uses ranging from animal feed (as fodder) to soil recovery due to its nitrogen fixation capacity in soils [6]. The seeds have a high protein content with values ranging from 18 % to 24 %, as well as a high content of carbohydrates (70 %), mainly starch (28.6 % db) [7–9]. Despite its nutritional potential, its use in the human diet is limited and is restricted to consumption by local populations. The lack of a chachafruto industry represents an opportunity for exploitation and adding value to this crop. Recent studies have focused on obtaining chachafruto protein fractions with different biological potentials [7,10]. However, the studies focused on revaluing the starch obtained from its seeds, and its use is limited. In order to promote the integral use and exploitation of the chachafruto, as well as generating a circular economy around this crop, it is necessary to carry out studies focused on the complete characterization of the macromolecules obtained from the starch and its potential use at industrial level.

Among the alternative uses of starch in the food industry, the production of biodegradable films that can partially replace petroleum-derived plastics, has been a topic of interest and development in

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https://doi.org/10.1016/j.ijbiomac.2023.125795
Received 17 April 2023; Received in revised form 26 June 2023; Accepted 10 July 2023
Available online 11 July 2023