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Modification of potato starch by using superheated steam

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ABSTRACT

Conventional hydrothermal modification of starches is a time- and energy-consuming process. In this study, superheated steam (SS) at different temperatures (100–160 °C) was used to modify the structural and physicochemical properties of potato starch (PS). The long- and short-range molecular structures were disrupted without affecting the granular structure of PS and the degree of disruption could be regulated by simply changing the treatment temperature. The swelling power, solubility, transparency, peak viscosity and breakdown of PS were positively correlated with each other and were significantly decreased by SS treatment, while the pasting temperature, final viscosity and setback were significantly increased. Considerable amount (> 9%) of slowly digestible starch was converted to resistant starch by SS treatment at 100 and 120 °C. Considering the high thermal efficiency of SS and the short treatment time (1 h) used in this study, SS treatment could be a superior alternative to conventional hydrothermal modification.

1. Introduction

Heat-moisture treatment (HMT) is a typical physical modification method that involves heating starch granules at a restricted moisture content (below 35%, w/w), and at a temperature (84–140 °C) above the glass transition temperature but below the gelatinization temperatures for a period of time (usually 16 h) (Hoover, 2010; Zavareze & Guerra Dias, 2011). When the semi-crystalline biopolymer undergoes a glassy-rubbery transition, the molecular mobility is enhanced, which facilitates the rearrangement and interaction of starch chains, thereby changing the structural and physicochemical properties. These changes broaden the applications of starches in a “clean-label” way since HMT only uses heat and moisture in the process. In general, HMT leads to a decrease in swelling power, solubility, peak viscosity and breakdown, and an increase in pasting temperature regardless of the botanical sources of starches (Gong et al., 2017; Jiranuntakul, Puttanlek, Rungsardthong, Puncha-arnon, & Uttapap, 2011; Pham Van, Nguyen Thi Mai, Nguyen Thi Lan, & Nguyen Ngoc Thanh, 2017; Phan Thanh Bao, Luu Bui Bao, Phan Ngoc, Nguyen Ngoc Thanh, & Pham Van, 2017; Sun, Han, Wang, & Xiong, 2014). In contrast, the effects of HMT on the molecular structures (long- and short-range crystalline structure, crystalline pattern, ordered helical structure *etc.*) are varied depending on the starch sources and treatment conditions (Ambigaipalan, Hoover, Donner, & Liu, 2014; Huang, Zhou, Jin, Xu, & Chen, 2016; Phan Thanh Bao et al., 2017; Varatharajan, Hoover, Liu, & Seetharaman, 2010, 2011; Wang, Zhang, Chen, & Li, 2016). The differential influences of HMT on the molecular structures and physicochemical properties of starches make the correlations among them worthy of in-depth study. However, few study has been conducted to investigate their correlations. In addition, many studies to date have focused on the role of starch sources and treatment conditions (*e.g.* temperature, moisture and time) in the HMT of starches (Hoover, 2010; Zavareze & Guerra Dias, 2011). The heating method of HMT has received limited attention.

Superheated steam (SS) is obtained by supplying sensible heat to steam to raise its temperature above the corresponding saturation point at a given pressure (Alfy, Kiran, Jeevitha, & Hebbar, 2016). As a new type of heating method, many studies on the application of SS for various food processing operations have been reported in recent years, such as drying, blanching, parboiling, roasting, frying, sterilization and enzyme inactivation (Alfy et al., 2016; Hu, Nie, Hu, & Li, 2016; Pronyk, Cenkowski, & Muir, 2004; Van Deventer & Heijmans, 2001). However, to the best of our knowledge, SS has never been used as a modification

Abbreviations: HMT, heat-moisture treatment; PS (control), native potato starch; SS, superheated steam; PS-100PS-120, PS-140, and PS-160, represent the PS treated by 100, 120, 140 and 160 °C of SS for 1 h respectively; SEM, scanning electron microscopy; PLM, polarized light microscopy; WXRD, wide angle X-ray diffraction; ATR-FTIR, attenuated total reflectance-Fourier transform infrared spectroscopy; RVA, Rapid Visco Analyzer

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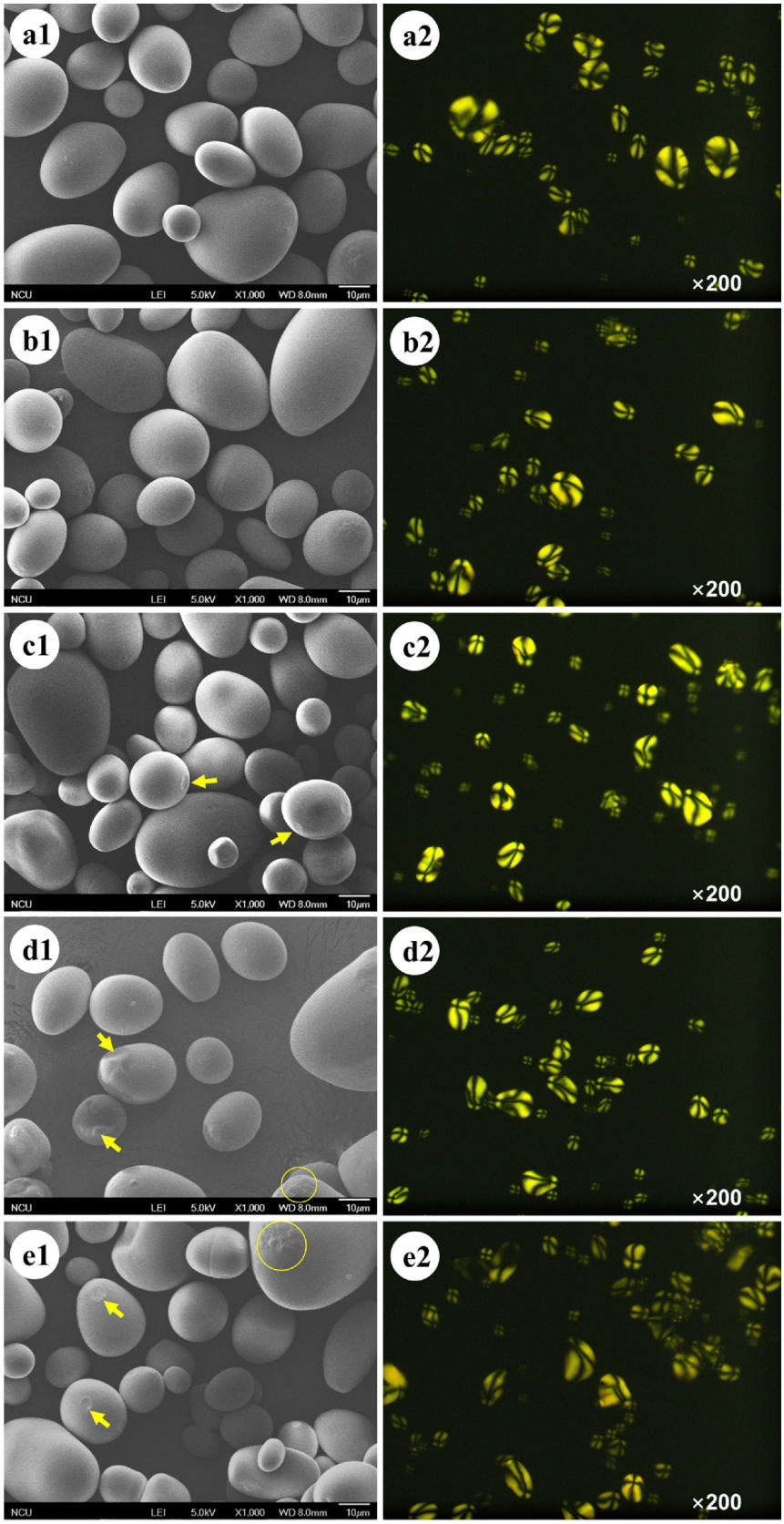

Fig. 1. SEM (a1-e1) and PLM micrographs (a2–e2) of PS (control) (a1, a2), PS-100 (b1, b2), PS-120 (c1, c2), PS-140 (d1, d2) and PS-160 (e1, e2). (For interpretation of the references to colour in the text, the reader is referred to the web version of this article.)