International Journal of Biological Macromolecules 91 (2016) 794–803

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

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

Characterization and functional properties of mango peel pectin extracted by ultrasound assisted citric acid

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ARTICLE INFO

Article history:
Received 2 May 2016
Received in revised form 31 May 2016
Accepted 5 June 2016
Available online 6 June 2016

Keyword:
Pectin
Extraction
Ultrasound
Structure
Function

ABSTRACT

Pectin was extracted from '*Tainong No. 1*' mango peels, using a chelating agent-citric acid as extraction medium by ultrasound-assisted extraction (UAE) and conventional extraction (CE) at temperatures of 20 and 80 °C. Chemical structures, rheological and emulsifying properties of mango peel pectins (MPPs) were comparatively studied with laboratory grade citrus pectin (CP). All MPPs exhibited higher protein content (4.74%–5.94%), degree of methoxylation (85.43–88.38%), average molecular weight (M_w, 378.4–2858 kDa) than the CP, but lower galacuronic acid content (GalA, 52.21–53.35%). CE or UAE at 80 °C resulted in significantly higher pectin yield than those at 20 °C, while the extraction time for UAE–80 °C (15 min) was significantly shorter compared to CE–80 °C (2 h) with comparable pectin yield. Moreover, MPPs extracted at 80 °C were observed with higher GalA and protein content, higher M_w, resulting in higher viscosity, better emulsifying capacity and stability, as compared to those extracted at 20 °C and the CP. Therefore, these results suggested that MPPs from '*Tainong No. 1*' may become a highly promising pectin with good thickening and emulsifying properties, using ultrasound-assisted citric acid as an efficient and eco-friendly extraction method.

1. Introduction

Pectins, a family of complex polysaccharides present within the primary cell wall and intercellular regions of dicotyledons, are good food additives in jams, soft drinks, and milk products [1]. Up to the last decade, most pectin applications stemmed from its gel-forming ability, but nowadays, pectin is gradually gaining more acceptance as an effective emulsifier [2]. These functional properties of pectins are highly related to their structure, including the molecular weight (M_w), degree of methylation (DM), and protein content, etc., which depends on the plant source and the extraction method used [3]. Currently, citrus peel and apple pomace are the main sources used for the production of commercial pectins. However, due to their low protein content and number of acetyl groups, citrus and apple pectins are considered less useful for emulsification [4]. The increasing industrial demand for pectins with varying ability to stabilize products increases the need for novel pectins sources, such as sugar beet residues [5], tomato waste [6], papaya peel [7], cacao pod husks [8], etc.

Mango (*Mangifera indica* L.) is an important tropical fruit, and China is the second largest mango producer in the world [9]. Due to high perishability of the fruit, its value added products such as mango pulp [10] and mango nectar [11–13] are of high commercial importance. However, the accruing by-products, mango peel, which represent 10.0–13.7% of the fruit total weight, generate a major disposal problem [3]. They have been reported to be a potential source of pectin [14], and the cultivars used are revealed as a significant effect on pectin qualities [3]. Previous results mainly focused on pectin recovery from several mango cultivars, such as '*Nam Dokmai*' [15], '*Améliorée*' and '*Mango*' [16], '*Kent*' [3,17], and '*Keitt*' mango [18].

Commercially, pectins are extracted with mineral acids, mainly HNO_3, HCl or H_2SO_4, for different time periods around a pH of 1.5–3.0, but generally, this process is time consuming and may lead to pectin degradation. Recently, some organic acids with chelating properties, are reported as effective in pectin extraction in terms of yield and physicochemical properties [8,16,19]. For example, in previous literature, mango peel pectins extracted with ammonium oxalate were observed with high M_w, intrinsic viscosity and a high

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http://dx.doi.org/10.1016/j.ijbiomac.2016.06.011
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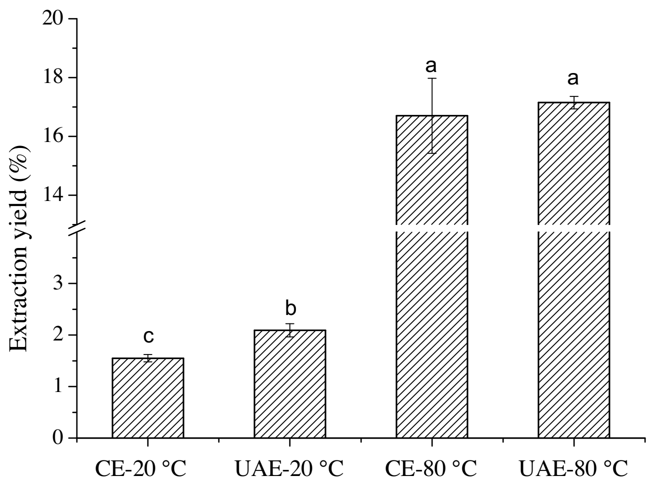

Fig. 1. Comparison of pectin yields of conventional citric acid extraction (CE) and ultrasound assisted extraction (UAE) methods.

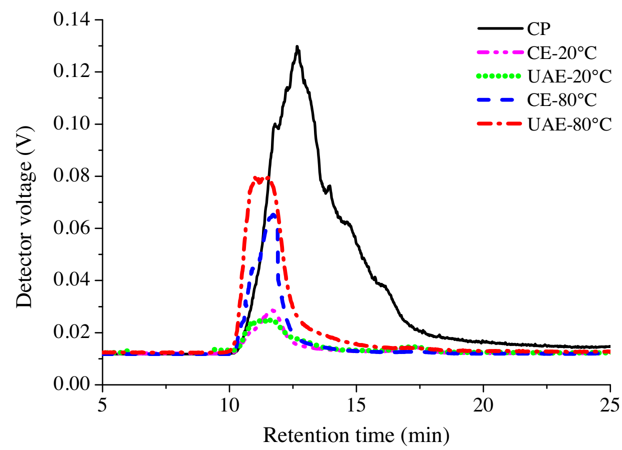

Fig. 2. Chromatograms of citrus pectin (CP) and mango peel pectins obtained by conventional extraction (CE) and ultrasound assisted extraction (UAE) by HPSEC-MALLS.

DM, compared to those extracted with HCl, or deionised water [16]. Besides, new technologies have also explored in pectin extraction, either sequentially or independently, such as microwave extraction [20], ultra-high pressure extraction [21], and enzymatic extraction [22]. Ultrasound (16–100 kHz, power in the range 10–1000 W/cm^2) is another method which has been used extensively in food industry. It uses acoustic energy and solvents to enhance the release and diffusion of cell material for assisting extraction [23]. Ultrasound-assisted extraction (UAE) of pectins from different sources has been studied, with different extraction solvents including HCl [24], ammonium oxalate/oxalic acid [6], and subcritical water [5]. Most of the published studies indicated that UAE results in increased pectin yield as well as important reduction in extraction time. However, limited studies have been performed on the effect of ultrasound-assisted citric acid on pectin extraction, regardless of heating.

In summary, although mango peels have been reported to be a potential source of pectin, the pectin qualities are quite cultivar dependent. To the best of our knowledge, no information about pectin structure and functional properties from mango peels harvested in China is available. On the other hand, limited studies have been documented on the effects of ultrasound-assisted chelating agents on the rheological and emulsifying properties of pectin as related to its chemical structure. Thus, the objective of this study was to study the effects of ultrasound-assisted citric acid extraction (UAE) at different temperatures (20 and 80 °C) to conventional citric acid extraction (CE) on mango peel pectins (MPPs) from '*Tainong No. 1*' cultivated in China, in terms of some valuable functional (rheological and emulsifying) properties and its chemical structure. The quality of MPPs was also compared with laboratory grade citrus pectin (CP). This study could offer a promising pectin source with good thickening and emulsifying properties, and upgrade by-products arising from the processing of mango and other tropical fruits in an efficient and eco-friendly way.

2. Material and methods

2.1. Chemicals

Laboratory grade citrus pectin (CP, P9135), 3-phenylphenol, and D-galacturonic acid were purchased from Sigma-Aldrich (St. Louis, USA). All other chemicals were of analytical grade, purchased from Sinopharm Chemical Reagent Co., Ltd. (Shanghai, China).

2.2. Sample preparation

Fresh mango peels of one of the most productive cultivars ('*Tainong No. 1*') in China were collected from Hainan FangYe Agro-Products Processing Co., Ltd. (Hainan, China), as by-product of mango pulp processing. The collected mango peels were immediately steam blanched for 5 min to inactivate the endogenous enzymes (including polygalacturonase and pectin methyl esterase), and then dried by a vacuum freeze dryer (LGJ-18S, Beijing Songyuan Huaxing Technology Develop Co., Ltd., Beijing, China) for 48 h. The dried sample was then milled with an electric grinder (Zhejiang Industry and Trade Co., Ltd., Zhejiang, China) and filtrated using a filter sieve (ca. 40 meshes). Finally, the mango peel powder was vacuum-packed and stored in a drier for subsequent extraction.

2.3. Pectin extraction and purification

2.3.1. Conventional citric acid extraction (CE)

Pectin extraction of CE was based on the method of Jamsazzadeh Kermani et al. [17], with some modifications. A ratio of 1:40 mango peel powder to citric acid solution was selected. Four hundred milliliters of distilled water was adjusted to pH 2.5 with 1 M citric acid at 20 and 80 °C, respectively. Thereafter, 10 g of mango peel powder was added to the citric acid solution under constant stirring, and the pH was re-adjusted to 2.5. After incubated at 20 and 80 °C respectively for 2 h, the extraction solution was immediately cooled in an ice-water bath and centrifuged at 10,000*g* for 15 min at 4 °C. The supernatant was dialyzed exhaustively against distilled water for 48 h, and the dialyzed extract was then freeze-dried. To obtain pectin with minimal concentrations of pigments, soluble sugars and lipids, the extract was washed three times using ethanol and acetone for 5 min and was referred as CE-mango peel pectin (CE-MPP).

2.3.2. Ultrasound-assisted citric acid extraction (UAE)

Pectin extraction of UAE was carried out using an ultrasound processor model JY92-2D (NingBo Scientz Biotechnology Co. Ltd, Ningbo, Zhejiang, China) with a 0.636 cm diameter titanium probe. A ratio of 1:40 mango peel powder to citric acid solution (pH 2.5) was selected, and the extraction was also performed at 20 and 80 °C, respectively. Prepared samples were treated at 20 kHz at 500 W, with pulse duration of on-time 5 s and off-time 5 s to keep the mixture temperature even and the material getting equal irradiation. According to Grassino et al. [6] and our previous study, the extraction time of 15 min was chosen, since it was observed as suf-