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Reducing retrogradation and lipid oxidation of normal and glutinous rice flours by adding mango peel powder

Sirithon Siriamornpun [a,*], Ekkarat Tangkhawanit [a], Niwat Kaewseejan [b]

[a] Research Unit of Process and Product Development of Functional Foods, Department of Food Technology and Nutrition, Faculty of Technology, Mahasarakham University, Kantarawichai, Maha Sarakham 44150, Thailand
[b] Department of Chemistry, Faculty of Science, Mahasarakham University, Kantarawichai, Maha Sarakham 44150, Thailand

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ABSTRACT

Green and ripe mango peel powders (MPP) were added to normal rice flour (NRF) and glutinous rice flour (GRF) at three levels (400, 800 and 1200 ppm) and their effects on physicochemical properties and lipid oxidation inhibition were investigated. Overall, MPP increased the breakdown viscosity and reduced the final viscosity in rice flours when compared to the control. Decreasing in retrogradation was observed in both NRF and GRF with MPP added of all levels. MPP addition also significantly inhibited the lipid oxidation of all flours during storage (30 days). Retrogradation values were strongly negatively correlated with total phenolic and flavonoid contents, but not with fiber content. The hydrogen bonds and hydrophilic interactions between phenolic compounds with amylopectin molecule may be involved the decrease of starch retrogradation, especially GRF. We suggest that the addition of MPP not only reduced the retrogradation but also inhibited the lipid oxidation of rice flour.

1. Introduction

Currently, the utilization of synthetic antioxidants in food has been limited as a result of their potential carcinogenicity and other toxic properties (Hocman, 1998); hence, the development and application of natural antioxidants to substitute synthetic ones is required. Natural antioxidants, including phenolics, flavonoids and carotenoids can be used at higher concentrations to give greater health benefits as well being non-toxic for consumers (Kaisoon, Konczak, & Siriamornpun, 2012; Kubola & Siriamornpun, 2011). Recently, there has been growing interest in the use of natural antioxidants as additives in food or pharmaceutical products, not only in terms of health benefits but also the quality improvement or preservation of food (Li et al., 2012; Wu, Chen, Li, & Li, 2009; Zhu, Cai, Sun, & Corke, 2009). Phenolic antioxidant-rich plants play an important role in food products by affecting the nutritional, textural and sensory properties during processing and storage such as fruits, vegetables and tea (Li et al., 2012; Zhu et al., 2009).

Mango is an important tropical fruit in many regions and it is widely consumed as fresh food or processed as commercial products, such as juice or dried, pickled and canned slices, which are popular worldwide. In Thailand, mango can also be consumed in many ways. The fresh flesh of green fruit is commonly consumed with chili paste or used as an ingredient in salads, whereas the flesh of ripe fruit is eaten as fresh food or as an ingredient in deserts. As a result, a large number of by-products or waste, especially mango peel, are generated that cause environmental pollution. However, they are in turn known as sources of bioactive compounds. A recent study showed that mango peel from India varieties contains high levels of polyphenols, carotenoids and fibers (Ajila, Aalami, Leelavathi, & Prasada Rao, 2010; Ajila, Jaganmohan Rao, & Prasada Rao, 2010).

Rice is a primary source of carbohydrates and calories in the human diet, especially in oriental countries that consume rice as a staple food (OAE, 2003). In Thailand, rice is the major agricultural product produced and there are many derived products from rice grain, rice flour or rice by-products, such as rice bran and germ. Of those, rice flour is widely used for making many rice flour based-products including main meals, snacks, deserts and others. However, because of its low nutritional values, including protein, vitamin and other nutrients, so the nutritional quality of rice flour as well as physicochemical properties needs to be improved. Many studies have demonstrated that the addition of natural antioxidants, such as polyphenols, catechin, tannic acid and other compounds, in the native starch can increase the nutritional value and health benefits along with strongly improving the retrogradation and starch qualities (Beta & Corke, 2004; Wu et al., 2009; Zhu et al., 2009). As mentioned, although rice flour is one of major flours produced in Thailand, there are not many products derived

* Corresponding author.
E-mail address: sirithons@hotmail.com (S. Siriamornpun).

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from this kind of flour because it has limitations especially high retrogradation and low nutritional value. Up to date, there has been no information available in the literature on use of phenolic compounds from mango peel, which is a by-product from mango processing, to reduce the retrogradation and to increase the nutritional and functional properties of rice flours. Thus, it was of our interests to investigate the effects of mango peel use as additive on the physicochemical properties, particularly retrogradation, and lipid oxidation inhibition of normal rice and glutinous rice flours. We expected to provide practical information about the use of mango peel power as a natural food additive in rice flour products to improve its quality and increase its nutritional values before cooking.

2. Materials and methods

2.1. Chemicals and reagents

The 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,4,6-tripiridyl-s-triazine (TPTZ), Folin–Ciocalteu's reagent, phenolic acid standards (gallic, ferulic, vanillic, *p*-hydroxybenzoic, protocatechuic, *p*-coumaric, caffeic, syringic, sinapic and chlorogenic acids) and flavonoid standards, namely rutin, myricetin, quercetin, apigenin and kaempferol, were purchased from Sigma–Aldrich Co. (St. Louis, MO, USA). The ethanol, methanol and acetonitrile used in the HPLC analysis were purchased from Merck (Darmstadt, Germany), and other chemicals used in the study were of analytical grade.

2.2. Materials and sample preparations

Commercial rice flours, including normal rice flour (NRF) and glutinous rice flour (GRF) were purchased from local markets in Maha Sarakham Province, Thailand. The green and ripe peels of mango (*Mangifera indica*, Kaew variety) were collected from freshly processed mango products in Khamriang campus canteen, Mahasarakham University. The mango peels were cleaned twice with tap water followed by washing with distilled water and then dried using a hot-air oven at 60 °C for 6–8 h to provide a moisture content of around 7% according to previously publication of Siriamornpun, Ratseewo, Kaewseejan, and Meeso (2015), Siriamornpun, Weerapreeyakul, and Barusrux (2015). The dried peel was ground into a fine powder using a blender (MX-AC 400, Panasonic, Thailand) and then sieved through an 80 mesh sieve to obtain a mango peel powder (MPP) with particle size of approximately 178 μm. To prepare rice flours containing MPP, both the NRF and GRF were evenly mixed with MPP at three different levels (400, 800 and 1200 ppm). The prepared flour was then stored in a plastic bag at −18 °C until analysis.

2.3. Determination of crude fiber content

The crude fiber contents of all tested samples were determined by the standard method of AOAC (1990). A sample (1 g) was boiled in 50 ml of 1.25% H_2SO_4 solution for 30 min and the insoluble residue was then filtered and washed with distilled water. The obtained soluble substance was subsequently boiled in 50 ml of 1.25% KOH solution for 30 min, filtered and washed with distilled water. A sample thus prepared was dried in the oven at 105 °C for 1 h. Finally, mass loss was determined after ashing at 500 °C for 3 h. The crude fiber content in the sample was calculated in mass percent relative to the content of dry mass in the product.

2.4. Determination of physicochemical properties of rice flours

The physicochemical properties of rice flours with or without MPP were determined using a Rapid Visco-Analyzer (RVA) (RVA-4, Newport Scientific, Australia). The flour samples (3 g) were mixed with 25 ml of distilled water in the RVA canisters and then stirred for 1 min to allow thorough dispersion. The heating and cooling cycles were performed as follows: the test temperature was first held at 50 °C for 1 min; heated to 95 °C at a rate of 12 °C/min and held at 95 °C for 3 min; and cooled to 50 °C at a rate of 12 °C/min and held at 50 °C for 3 min. The RVA parameters were measured from RVA curves, including peak viscosity, trough viscosity, break viscosity, final viscosity, setback viscosity and pasting temperature. All measurements were done in triplicate and the results are expressed as means ± SD.

2.5. Extraction of phenolic-antioxidant compounds

The MPP and flour with or without MPP samples were extracted using the method described previously by Bakar, Mohamed, Rahmat, and Fry (2009), with some modifications. Each sample (2 g) was extracted three times with 20 ml of 80% ethanol on a shaker set at 180 rpm for 3 h at room temperature. The mixture was filtered through Whatman filter paper No. 1, and then the filtrate was used to determine the total phenolics, total flavonoids and antioxidant activity.

2.6. Determination of total phenolic content

Total phenolic content (TPC) was estimated using the Folin–Ciocalteu method (Bakar et al., 2009). Briefly, 0.3 ml of each extract was mixed with 2.25 ml of 10% Folin–Ciocalteu reagent dissolved in distilled water. After 5 min incubation, 2.25 ml of 6% sodium carbonate solution was added and the mixture was left to stand for 90 min at room temperature. The absorbance of the solution was measured at 725 nm using a spectrophotometer. The TPC was expressed as mg gallic acid equivalents (GAE) per g dry weight (mg GAE/g DW).

2.7. Determination of total flavonoid content

The total flavonoid content (TFC) was determined using a modified method, as described previously by Bakar et al. (2009). Briefly, 0.5 ml of sample solution was mixed with 2.25 ml of distilled water and 0.15 ml of 5% $NaNO_2$ solution. The solution was allowed to stand for 6 min and then 0.3 ml of 10% $AlCl_3$ was added to the solution. After 5 min, 0.1 ml of 1 M NaOH solution was added and then the absorbance was measured at 510 nm using a spectrophotometer. Results were expressed as mg rutin equivalents (RE) per g dry weight (mg RE/g DW).

2.8. Analysis of phenolic compounds using HPLC

HPLC analysis of phenolic compounds was performed using Shimadzu LC-20AC pumps, SPD-M20A diode array detection and chromatographic separations on a column Inetsil ODS-3, C18 (4.6 mm × 250 mm, 5 μm) (Hichrom Limited, Berks, UK). The mobile phase consisted of acetic acid pH 2.74 (solvent A) and acetonitrile (solvent B) at a flow rate of 0.8 ml/min. The gradient elution conditions were described previously by Kubola and Siriamornpun (2011). The operating conditions were as follows: column temperature 38 °C, injection volume 20 μl and UV-diode array detection at 280 nm for phenolic acids and 370 nm for flavonoids. Phenolic compounds in the samples were identified by comparing their relative retention times and UV spectrum with those of authentic compounds and the contents were detected using external standard methods.