ABSTRACT

Coconut fruit endo- and mesocarp are the by-products of coconut industry and needs to be reduced to ensure food industry sustainability in food waste and loss aspect. This study was aimed to investigate the antioxidant potential of coconut by-products from 6 months old (YE/young endocarp, YM/young mesocarp) and mature stages (ME/mature endocarp, MM/mature mesocarp) using ultrasound-assisted extraction (UAE) by evaluating their extraction yield, antioxidant activity (AA) by DPPH and *β*-carotene bleaching assay and total phenolic content (TPC). The by-product providing highest AA was then optimized its ultrasound-assisted extraction (UAE) factors. At the last step of the study, the investigation of the effect of powder incorporation of the highest AA into the cookies on chemical composition, antioxidant properties, phenolic compounds, and oxidative stability were investigated. Coconut meso- and endocarp at two maturation stages extracted in ethanol:water composition (100:0, 50:50, 0:100). The ethanolic extract of YM resulted in the highest AA with a lowest value IC_{50} value among the coconut by-products (117 µg mL^{-1}) and significantly lower than BHT (170 µg mL^{-1}). In the β-carotene bleaching assay, the slope value of YM was lower compared to the mature samples (MM and ME) YE/young endocarp, YM/young mesocarp. Compared to the synthetic antioxidants, the slope of the extract from YM (0.0156) and MM (0.0212) exhibited lower value compared to TBHQ (0.0243). The low slope value indicated the high inhibition of β-carotene bleaching of the antioxidant compounds in the sample. In TPC measurement, solvent composed by ethanol:water (50:50) was found suitable to extract phenolics from YM (395.97 mg GAE 100 g^{-1}). A chromatographic analysis using HPLC-DAD was found catechin, chlorogenic acid, vanillin, and trans-cinnamic acid in the YM extract. Due to the highest AA and TPC, YM then optimized its ultrasound-assisted extraction by evaluating three factors, *i.e.* temperature (10–70 °C), solvent-to-sample ratio (20:1–10:1 mLg^{-1}), and pulse duty cycle (0.4–1.0 s^{-1}) on TPC and AA as the responses. The developed model produced: high coefficient of determination (R^2): 0.9474 and 0.9701 for antioxidant activity and TPC respectively. Furthermore, the low prediction errors (less than 2.34), and non-significant lack of fit values (p<0.05) for the two responses also produced. The optimum condition of UAE was: 70 °C of temperature, solvent-to-sample ratio (20:1 mLg^{-1}), and pulse duty-cycle (0.55 s^{-1}) for 5 min. Optimized factors that result an extract with 47.78±1.24 mg GAE 100 g^{-1} DW for TPC and 87.28±1.01% of radical scavenging activity. The phenolic compounds were identified by UPLC-PDA and resulted catechin, protocatechuic, chlorogenic, and three derivatives of caffeic acids. As the optimum value of AA and TPC were obtained and the major phenolic compounds in the YM were mostly belong to thermostable compounds (chlorogenic and caffeic acid derivatives), the incorporation was conducted by substituting wheat flour with YM powder at 8% (C8) and 16% (C16). YM incorporation increased antioxidant activity up to 60% which was contributed by catechin and three caffeic acid derivatives which were retained after baking. Also, YM darkened the color, lowered the hardness, and reduced the peroxide value of the incorporated cookies. Chemically, YM increased the fiber and moisture; but reduced the lipid and carbohydrate level of cookies. Therefore, YM tend to be an alternative as a source of natural antioxidant its application could delay oxidation of cookies compared to the regular cookies.

Keywords: coconut mesocarp, coconut endocarp, ultrasound-assisted extraction, antioxidant, phenolic compounds, oxidation, cookies

INTISARI

Pada industri kelapa dihasilkan hasil samping kelapa seperti mesokarp dan endocarp, yang perlu dikurangi sebagai usaha dalam keberlanjutan industri pangan. Penelitian ini bertujuan untuk menginvestigasi potensi antioksidan dari hasil samping kelapa yang dihasilkan pada dua umur ketuaan kelapa: 6 bulan (YE/*young endocarp*, YM/*young mesocarp*) dan 12 bulan (ME/*mature endocarp*, MM/*mature mesocarp*) menggunakan ekstraksi berbantu ultrasonik (EBU) dengan mengevaluasi rendemen ekstraksi, aktivititas antioksidan (AA) menggunakan metode DPPH and *β-carotene bleaching* assay, dan kandungan total fenolik (*total phenolic content*/TPC). Hasil samping dengan AA dan TPC tertinggi kemudian dioptimasi kondisi ekstraksinya untuk menetukan nilai AA, TPC, dan senyawa fenolik yang optimum. Pada tahap akhir penelitian, dilakukan inkorporasi hasil samping kelapa dengan AA tertinggi dan dievaluasi perannya dalam pencegahan oksidasi pada kue kering. Evaluasi AA dari ekstrak air dan etanol pada YE, YM, ME dan MM dengan pengujian DPPH dan system asam linoleat-β-karoten dibandingkan dengan antioksidan sintetik (butilhidroksianisol/BHA, butilhidroksitoluena/BHT, tersier butilhidrokuinon/TBHQ). Di antara limbah kelapa, ekstrak etanol YM menghasilkan AA yang ditandai dengan IC_{50} lebih rendah (117 µg mL^{-1}) dibandingkan (BHT, 170 µg mL^{-1}). Selanjutnya, ketika dibandingkan dengan antioksidan sintetik, slope dari ekstrak YM (0,0156) menunjukkan nilai lebih rendah dibandingkan TBHQ (0,0243). Semakin rendah nilai slope, semakin tinggi penghambatan degradasi β-karoten pada sistem oleh senyawa antioksidan. YM kemudian dioptimasi dengan mengevaluasi tiga faktor ekstraksi, yaitu suhu (10–70 °C), rasio pelarut terhadap sampel (20:1–10:1 mLg^{-1}), dan *pulse duty cycle* (0,4–1,0 $detik^{-1}$), serta AA dan TPC sebagai respon optimasi. Model yang dikembangkan menghasilkan koefisien determinasi (R^2): 0,9474 and 0,9701 untuk aktivitas antioksidan dan TPC. Selanjutnya, dihasilkan pula prediksi eror yang rendah (kurang dari 2,34), dan *lack of fit* yang tidak signifikan ($p<0,05$) untuk kedua respon. Kondisi optimum EBU: suhu 70 °C, rasio pelarut terhadap sampel (20:1 mLg^{-1}), *pulse duty cycle* (0,55 $detik^{-1}$), dan waktu ekstraksi selama 5 menit. Faktor optimum tersebut menghasilkan ekstrak dengan TPC 47,78±1,24 mg GAE 100 g^{-1} DW dan AA sebesar 87,28±1,01%. Pada tahap akhir studi, bubuk YM diinkorporasi ke dalam kue kering dan dievaluasi perubahan komposisi kimia (karbohidrat, protein kasar, lemak kasar, dan abu), aktivitas antioksidan, senyawa fenolik, dan stabilitas oksidatif. Inkorporasi dilakukan dengan mengganti terigu dengan bubuk YM sebesar 8% (C8) dan 16% (C16). Penambahan YM meningkatkan aktivitas antioksidan hingga 60% yang disumbang oleh senyawa fenolik seperti katekin, asam klorogenat dan tiga turunan asam kafeat serta mampu mencegah oksidasi yang ditandai dengan nilai angka peroksida yang lebih rendah setelah 4 bulan penyimpanan dibandingkan dengan kontrol. Penambahan YM juga menurunkan intensitas warna dan menurunkan tingkat kekerasan dari kue kering. Inkorporasi YM menaikkan kandungan serat dan kadar air; tetapi menurunkan kandungan lemak dan protein dalam kue kering. Secara keseluruhan, YM dapat menjadi alternatif sumber antioksidan alami yang memiliki aktivitas antioksidan tinggi sehingga dapat menunda oksidasi dalam sistem pangan.

Kata kunci: mesokarp, endokarp, antioksidan, ekstraksi berbantu ultrasonic, senyawa fenolik, oksidasi, kue kering