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Pentopan mono BG pretreatment of palm kernels modified the aroma of palm kernel oil after kernel roasting

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ABSTRACT

With an interest to enhance the aroma of palm kernel oil (PKO), Pentopan mono BG (xylanase) was applied to alter the carbohydrates in palm kernels (PK) so as to modulate the formation of volatiles during kernel roasting. The result showed that a 1.3-fold increment of total soluble sugars was found in PK after Pentopan treatment, which promoted the generation of *O*-heterocyclic volatile compounds during kernel roasting. Overall, an increment of 1.5-, 1.4- and 1.3-fold of *O*-heterocyclic compounds were found in PKO derived from treated PK after light, medium and dark roasting, of which the elevation in furfural and 2-furanmethanol contents was the most obvious. Principal component analysis (PCA) clearly discriminated treated PKO with various kernel roasting degrees from that of control PKO on the basis of all aroma-active compounds; the aroma in PKO from treated, roasted PK was highly correlated with 2-[(methyldithio)methyl]-furan, 5-methyl-2-furancarboxaldehyde, 2-furanmethanol, 2,5-dimethylpyrazine and ethyl pyrazine. Sensory evaluation showed that PKO derived from medium roasted PK imparted more caramelic, nutty and smoky odor notes relative to the untreated PKO. This study suggests Pentopan pretreatment of PK followed by roasting may be a novel way to modulate PKO aroma and potentially widen its application.

1. Introduction

Palm kernel oil (PKO) is the oil extracted from palm kernels (PK), the seeds of oil palm (*Elaeis guineensis* Jackqu) (Cornelius, 1977). Commercial PKO is generally well refined and deodorized, with a bland flavor. Due to its specific fatty acid composition which can afford it unique melting characteristics, PKO has a wide range of applications in the food industry as non-aroma related specialty fat (Traitler & Dieffenbacher, 1985). Therefore, it would be of interest to enhance the aroma of PKO, which may expand its application beyond being a fat base.

Roasting has been demonstrated to be effective in enhancing the flavor in PKO and other seed oils due to the occurrence of a series of thermal reactions (Jayalekshmy, Narayanan, & Mathew, 1987; Liu et al., 2011; Park et al., 2011; Siegmund & Murkovic, 2004; Zhang, Wang, Yuan, Yang, & Liu, 2016). Previous research indicated that PKO extracted from roasted PK presented a favorable and pleasant odor (Jayalekshmy et al., 1987; Zhang et al., 2016). Gas chromatography-olfactometry (GC-O) identified substituted pyrazines, furan and pyran derivatives are the most aroma-active compounds in roasted PKO, most of which are thought to be originated from thermal reactions during the kernel roasting process (Zhang et al., 2016).

The aforementioned thermal reactions, mainly referred as Maillard reaction and caramelization, contribute to the typical nutty, roasted, burnt or caramelic aroma notes of the thermally processed foods (Parker, Elmore, & Methven, 2014). Therefore, the aroma of PKO is expected to be enhanced if those thermal reactions could be promoted. Simple reducing sugars, being the precursors of both Maillard reaction and caramelization, are a critical factor that can directly affect the thermal reactions and the ultimate aroma profile (Laroque et al., 2008).

However, fresh PK contains low levels of simple sugars but a relatively large amount of cellulose, hemicelluloses and other polysaccharides, with hemicelluloses being the largest portion (Lawal, Iyayi, Adeniyi, & Adaramoye, 2010). Our previous study

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explored the pretreatment of PK with a commercial cellulase (Celluclast 1.5 L) in order to increase the content of simple sugars by hydrolyzing cellulose and we found that the aroma of PK and PKO after kernel roasting was evidently modified positively, owing to more soluble sugars especially glucose being released (Zhang, Zhao, Yang, Zhao, & Liu, 2017).

Pentopan mono BG, a xylanase (endo-1, 4-) produced by *Aspergillus oryzae,* with an activity of 2500 fungal xylanase units (FXU)/g (according to product data sheet), also has the ability to hydrolyze polysaccharides from plant tissues. For instance, the efficiency of bioethanol production from crop residues was found increased due to the degradation of cell wall materials induced by Pentopan (Juodeikiene et al., 2011). Similarly, Pentopan was highly effective in increasing the amount of reducing sugars in rice bran extract by 5-fold (Kim & Lim, 2016). When the substrate is cocoa pod husk, Pentopan was also able to release monosugars when used alone or combined other enzymes such as Viscozyme L and Pectinex 5 XL (Alemawor, Dzogbefia, Oddoye, & Oldham, 2009). Several studies on Pentopan mainly focused on releasing ferulic acid, producing oligosaccharides and modifying the rheological properties of dough (Giet, Roiseux, & Blecker, 2010; Saulnier, Marot, Elgorriaga, Bonnin, & Thibault, 2001; Selinheimo, Kruus, Buchert, Hopia, & Autio, 2006; Vegas, Alonso, Dominguez, & Parajo, 2008). To the best of our knowledge, Pentopan has not been studied to modify PK polysaccharides so as to modulate the flavor of obtained PKO.

In this study, we aimed to examine the possibility of using Pentopan to release simple pentoses from PK pentosans and their subsequent impact on aroma modulation of PK and resultant PKO after different degrees of kernel roasting.

2. Materials and methods

2.1. Materials, chemicals and solvents

Fresh oil palm nuts, which were from a hybrid of Dura and Pisifera variety of *Elaeis guineensis* species cultivated and harvested in North Sumatera Province of Indonesia in 2015, were provided by PT Wilmar Nabati, Indonesia. After manually removing hulls, palm kernels were obtained with a moisture content of 196.7 ± 2.0 mg/g and stored at −20 °C prior to use. Pentopan mono BG, a xylanase (endo-1,4-) with an activity of 2500 FXU/g, was purchased from Novozymes (Bagsvaerd, Denmark). Sugar standards (fructose, glucose, galactose, sucrose and maltose), citrate and trichloroacetic acid were purchased from Sigma Aldrich (St Louis, MO, USA). Amino acid standards were procured from Thermo Scientific (Rockford, IL, USA) while AccQ-Fluor reagent kits and AccQ-Tag eluent A concentrate were procured from Waters (Dublin, Ireland). C7-C40 saturated alkane standards were purchased from Supelco, Sigma Aldrich (Barcelona, Spain). Sodium phosphate dibasic dodecahydrate was purchased from Goodrich chemical Enterprise (Singapore). Acetonitrile acquired from Tedia (Fairfield, OH, USA) was of HPLC grade while petroleum ether (boiling range of 35 °C-60 °C) and ethanol acquired from Merck (Darmstadt, Germany) were of ACS grade.

2.2. Enzymatic treatment of palm kernels

Fresh palm kernels were ground by using a food blender (Panasonic MX-J 210GN, Osaka, Japan) and sifted through a No.12 USA standard testing sieve (Fisher Scientific, Leicestershire, UK) to obtain a fine powder with a uniform particle size.

An aliquot of 120 g of PK powder was transferred into a 500 mL beaker, to which 240 mL of citrate-phosphate buffer (pH 5.0) was added. The mixture was subjected to shearing in a food mixer (Silverson Mixer L4RT, Buckinghamshire, England) for 10 min at 2200 rpm to make it more homogeneous. After shearing, the paste was transferred to a 1 L blue-cap bottle, which was placed in an agitation water bath (Julabo SW22, Seelbach, German) after enzyme was loaded.

Pentopan mono BG was added to the PK paste at a dosage of 0.67 g enzyme/100 g PK powder for the treatment group (16.75 FXU/g PK powder). No enzyme was added to the control group. Enzymatic hydrolysis was carried out in the water bath at 50 °C for 13 h at a constant shaking speed of 180 rpm followed by inactivation at 90 °C for 15 min. Parameters of enzyme treatment were determined by referring to the information provided by the enzyme manufacturer (Novozymes, Bagsvaerd, Denmark) and to peer studies (Escarnot, Aguedo, & Paquot, 2012; Vegas et al., 2008). After that, the PK paste was freeze-dried (Vir-Tis AdVantage, Genevac, SP Scientific, Ipswich, UK) and stored at −20 °C until use.

2.3. Roasting of palm kernel powder

The dried PK powder was equilibrated at 50 °C for 30 min and then distributed on an aluminum tray in a layer of 5–6 mm thickness. The powder was roasted in a baking oven (Euroflours MS01T04-2, Gommegnies, France), preheated to 180 °C, for 8 min, 14 min and 20 min to obtain light, medium and dark roasted PK powders, respectively.

2.4. Determination of moisture and lightness

The moisture content of PK was determined by oven-drying (Memmert UM200, Apeldoorn, Nederland) at 104 °C to a constant weight. The lightness (L^* value) of PK was determined by using a spectrophotometer (Konica Minolta CM-3500d, Osaka, Japan).

2.5. Soluble sugar extraction and analysis

The PK powder was defatted with petroleum ether using an auto fat extraction system (FOSS Soxtec™ 2050, Hillerød, Denmark). The defatted PK powder (2 g) was sonicated with 800 mL/L ethanol for 30 min (2 × 30 mL). Following extraction, the extracts were combined and evaporated using a rotary evaporator (EYELA N-1200, Tokyo, Japan) and concentrated to 2 mL and stored at −20 °C prior to analysis.

The concentration of sugars was determined using Shimadzu ultrafast liquid chromatography system (UFLC, Kyoto, Japan) coupled to a low temperature evaporative light scattering detector (ELSD) (Shimadzu, Kyoto, Japan). The column used was a Zorbax carbohydrate column (150 × 4.6 mm; Agilent, Santa Clara, CA, USA). The column was eluted at 40 °C with a mixture of acetonitrile and water (80:20) at a constant flow rate of 1 mL/min. Identification and quantification were carried out by using retention times and calibration curves of sugar standards with R^2-values ≥ 0.99.

2.6. Free amino acid extraction and analysis

Free amino acids in the defatted PK powder (1.5 g) were extracted with 10 g/L trichloroacetic acid for 30 min using a vortex shaker (Heidolph Rotamax 120, Schwabach, Germany). After extraction, the mixture was made up to 25 mL in a volumetric flask and then centrifuged (Sigma 3–18 K centrifuge, Osterodeam Harz, Germany) at 12,927×*g* for 10 min. The extract was stored at −20 °C before analysis.

Waters AccQ-Tag system (Waters Corp., Waltham, MA, USA) was used to perform the analysis of free amino acids. Chromatographic separation was carried out by using Shimadzu UFLC (Kyoto, Japan) on a Waters AccQ-Tag Nova- Pak C18 column (150 × 3.9 mm,