Available online at www.sciencedirect.com

ScienceDirect

Journal of Food Engineering 84 (2008) 289–296

JOURNAL OF FOOD ENGINEERING

www.elsevier.com/locate/jfoodeng

Selective extraction of palm carotene and vitamin E from fresh palm-pressed mesocarp fiber (*Elaeis guineensis*) using supercritical CO_2

Harrison Lik Nang Lau [a,b,*], Yuen May Choo [a], Ah Ngan Ma [a], Cheng Hock Chuah [b]

[a] Malaysian Palm Oil Board, No. 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia
[b] Department of Chemistry, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia

Received 9 November 2006; received in revised form 9 May 2007; accepted 15 May 2007
Available online 18 May 2007

Abstract

Fresh palm-pressed mesocarp fiber was subjected to supercritical carbon dioxide (SC-CO_2) extraction at 40 °C to produce two fractions of fiber oil enriched with vitamin E and carotene, respectively. The extraction was carried out in three stages using continuous extraction technique; firstly to extract vitamin E and squalene enhanced fraction at 10 MPa, secondly to remove bulk triglycerides at 20 MPa and thirdly to produce carotene enriched fraction at 30 MPa. Squalene was being selectively extracted at 10 MPa into vitamin E enriched fraction. Sterols were distributed throughout the extractions with two times enhancement in the latter fractions. The recoveries of carotene, vitamin E, sterols and squalene were more than 90%. The continuous SC-CO_2 extraction technique has been demonstrated for selective concentration of palm minor components, especially to separate vitamin E and squalene from carotene.

Keywords: Carotene; Palm-pressed fiber; Squalene; Supercritical CO_2; Sterols; Tocotrienols and vitamin E

1. Introduction

Malaysia, the world's leading palm oil producing country has produced 11.9 million tonnes of palm-pressed mesocarp fiber from 75.5 million tonnes of fresh fruit bunch (FFB) processed in 2005 (Malaysian Oil Palm Statistics, 2005). Palm-pressed mesocarp fiber constitutes about 15.7% of the solid biomass of FFB. It is an elongated cellulose material with 30–50 mm length which has been found to trap about 5–7 % of residue oil after screw-press extraction of crude palm oil (CPO). Traditionally, the fiber is mixed with kernel shell and being utilized as solid fuel to generate electricity for the mill. The excess fiber and empty fruit bunch are then transported to the plantation for field mulching. The process flow diagram of palm oil milling technology is shown in Fig. 1.

It is known that palm-pressed fiber oil is enriched with natural carotene, vitamin E, sterols, squalene, co-enzyme Q_{10}, and phenolic compounds (Choo et al., 1996; Lau, Choo, Ma, & Chuah, 2005a; Lau, Choo, Ma, & Chuah, 2006). These functional components have been determined to possess certain biological activities such as β-carotene having antioxidant activity and inhibiting growth of colon cancer cells (Di Mascio, Murphy, & Sies, 1991; Slattery et al., 2000); lycopene is particularly an effective singlet oxygen quencher (Di Mascio, Kaiser, & Sies, 1989); vitamin E (e.g., tocotrienols) as antioxidant, anti-cancer and having hypercholesterolemic effects (Pearce, Parker, Deason, Qureshi, & Wright, 1992; Salonen, Salonen, & Penttila, 1985; Tomeo, Geller, Watkins, Gapor, & Bierenbaun, 1995); β-sitosterol possesses cholesterol lowering effect (Hendriks, Westrate, van Vliet, & Meijer, 1999; Moghadasian & Frohlich, 1999); squalene as chemopreventive agent against some type of cancers (Rao, Newmark, & Reddy, 1998; Smith, Yang, Seril, Liao, & Kim, 1998), co-enzyme Q_{10} with protective effect against artherosclerosis and heart disease (Kontush, Hubner, Finckh,

* Corresponding author. Address: Malaysian Palm Oil Board, No. 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia. Tel.: +60 3 89259155; fax: +60 3 89262971.
E-mail address: harrison@mpob.gov.my (H. Lik Nang Lau).

0260-8774/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jfoodeng.2007.05.018

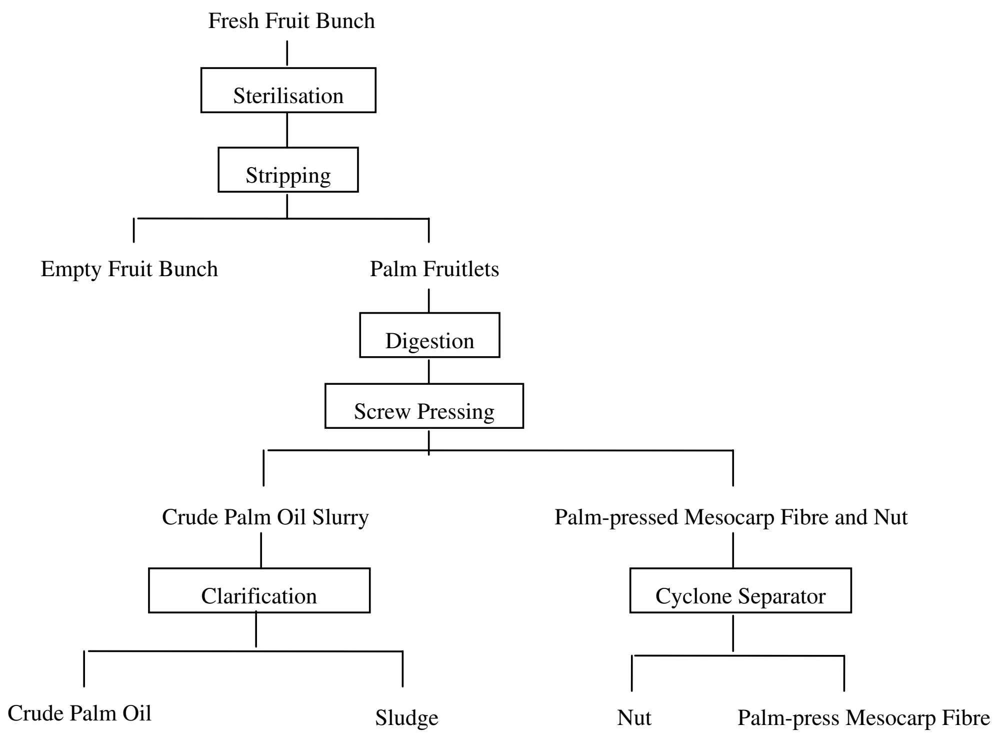

Fig. 1. Process flow diagram of conventional palm oil milling technology.

Kohlschutter, & Beisiegel, 1995; Mohr, Bowry, & Stocker, 1992) and phenolic components with superior antioxidant property (Lau et al., 2005a).

Many attempts have been made to recover the residue oil from palm-pressed fiber including solvent extraction and supercritical fluid extraction (Choo et al., 1996; Lau et al., 2006 and de Franca & Meireles, 2000). Application of supercritical carbon dioxide (SC-CO_2) extraction has advantages over the solvent extraction method as it uses non-hazardous and non-inflammable CO_2 when compared to highly flammable petroleum-based solvent such as hexane or acetone. SC-CO_2 extraction has been used to concentrate minor constituents from various oilseed and other products. These include the isolation of tocopherols from soybean and canola oil deodorizer distillates (Mendes, Pessoa, & Uller, 2002;Mendes, Pessoa, Coelho, & Uller, 2005), sterols and tocopherols from olive oil (Ibanez, Benavides, Senorans, & Reglero, 2002), squalene from olive oil deodorizer distillate and shark liver oil (Bondioli, Mariani, Lanzani, Fedeli, & Muller, 1993; Catchpole, von Kamp, & Grey, 1997), phenol and tocopherols from olive leaves (de Lucas, Ossa, Rincon, Blanco, & Gracia, 2002; Floch, Tena, Rios, & Valcarcel, 1998), phospholipids from soybean (Montanari, Fantozzi, Snyder, & King, 1999), sterols from canola, corn and cottonseed oils (Snyder, King, Taylor, & Neese, 1999) and carotene, vitamin E, sterols, squalene from palm-pressed fiber and palm leaves (Birtigh, Johannsen, Brunner, & Nair, 1995; Choo et al., 1996; de Franca & Meireles, 2000). Lau and co-workers (2006) have reported on the quality of fiber oil extracted using SC-CO_2 including the content of valuable functional components which were co-eluted with the oil. The present study reports on the simultaneous extraction and fractionation of fiber oil into respective fractions enriched with carotenes, vitamin E, sterols and squalene from fresh palm-pressed fiber using pure SC-CO_2.

2. Materials and methods

2.1. Materials

Palm-pressed mesocarp fiber was obtained from MPOB Palm Oil Mill Technology Center, Negeri Sembilan. It was packed with nitrogen blanketing and kept at −5 °C before used.

2.2. Reagents and standards

Cholesterol, α-tocopherol, stigmasterol, β-sitosterol, campesterol and squalene were purchased from Sigma–Aldrich Inc. (St. Louis, MO); α-tocotrienol, γ-tocotrienol and δ-tocotrienol were purchased from Calbiochem (San Diego, CA); bis-(trimethylsilyl)-trifluoroacetamide with 1% trimethylchlorosilane (BSTFA) was purchased from Fluka Chemicals (Bushs, Switzerland); methylene chloride, tetrahydrofuran (THF), 2-propanol (IPA), absolute ethanol and *n*-hexane were purchased from Merck (Darmstadt, Germany). The CO_2 with 99.995% purity was obtained from Malaysian Oxygen Berhad (Selangor, Malaysia).