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Comparison of nutrient composition in kernel of tenera and clonal materials of oil palm (*Elaeis guineensis Jacq.*)

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ABSTRACT

Nutritive information about oil palm kernel is scarce, especially on the composition of sugars and water-soluble vitamins. This study aims to evaluate both tenera and clonal materials for their proximate composition, fatty acid profile, amino acid composition, sugar, mineral and water-soluble vitamin contents. The tenera material had a higher moisture, fat and fibre content as compared to the clonal material, whereas protein, carbohydrate and ash content were higher in the clonal material. The major fatty acid constituents in palm kernel oil were lauric acid, myristic acid and oleic acid. The palm kernel proteins were deficient in lysine and tryptophan but rich in glutamic acid, arginine and aspartic acid. Sucrose was the most abundant sugar in palm kernel. The mineral analysis of the samples showed high levels of potassium, phosphorus, magnesium, calcium and manganese, while niacin was the water-soluble vitamin present at the highest concentrations in palm kernel.

1. Introduction

Oil palm belongs to the Arecaceae family, in the order of Arecales (Corley & Tinker, 2003). The oil palm is anatomically similar to, and is grouped with *Cocos* (the coconut) and other genera in the subfamily of Cocosoideae. It is a monocotyledonous plant which has a single stem and possesses a single apical meristem. It produces female and male inflorescences successively on the same plant. Oil palm is the highest yielding oil crop; it originates from West Africa and has been commercially planted in Malaysia since 1917. Commercial oil palms in Malaysia (*Elaeis guineensis*) are tenera hybrids which are cross products of dura (thick shell palm) and pisifera (shell-less palm).

The oil palm fruit provides two types of oil; palm oil (extracted from the mesocarp) and palm kernel oil (extracted from the kernel), which dramatically differ in their fatty acid composition (Rival, 2007). The major fatty acids in palm oil are palmitic acid, oleic acid and linoleic acid, while the palm kernel oil is rich in lauric acid, and is similar to coconut oil. Almost 90% of the world's palm oil is used for edible purposes (Sambanthamurthi, Sundram, & Tan, 2000). The palm oil and its fraction are used in manufacturing cooking oil, margarines and softeners, ice creams and dairy products. The palm kernel oil is used for simulated dairy products and shortenings. Besides being edible, the palm kernel oil is also used for medicinal purposes. For instance, the people of Eastern region of Nigeria use kernel oil as body ointment to minimise infection (Ugbogu, Onyeagba, & Chigbu, 2006). The oil palm industry not only provides palm oil and palm kernel oil, but also produces palm kernel cake for feed applications.

Oil palm is a species of particular economic importance as it provides one of the most important sources of edible oil for use in a wide range of edible products (Nakkaew, Chotigeat, Eksomtramage, & Phongdara, 2008). Besides its use in food and feed, palm oil is also one of the most cost-effective feedstock for biodiesel (Lim & Teong, 2010). Due to the global demand and versatile usage of palm oil, elite oil palm clones have been generated to increase the oil yield. The elite clones are developed from highly productive individual palms of tenera hybrid, *via* tissue culture techniques. Cloning of oil palm is carried out by inducing somatic embryogenesis on calli derived from various tissue sources (Jouannic et al., 2005). In future, clonal palms are expected to replace seed-derived planting material on a commercial scale (Abdullah, Zainal, Li, Beng, & Lee, 2005).

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A few studies have evaluated the chemical and nutritional values of oil palm (Akpanabiatu, Ekpa, Mauro, & Rizzo, 2001; Bora, Rocha, Narain, Moreira-Monteiro, & Moreira, 2003). However, little is known about the nutritional composition of oil palm planted in Malaysia, in particular the seed-derived and clonal palms of the tenera hybrids. The aim of this study was to investigate and compare the nutrient composition of palm kernel from two different planting materials, namely tenera hybrid and clonal material.

2. Materials and methods

2.1. Materials

The oil palm fruit bunches of seedling-derived and clonally-derived tenera were obtained from the Bangi (Selangor) and Ulu Paka (Terengganu) research stations, respectively. Four bunches of maturing palm fruits from each material were collected at 16 weeks after anthesis (WAA) in order to obtain the mature kernel. Each bunch was considered as an independent analysis. The individual fruits were manually detached from the bunch and the endosperm collected. A portion of the samples were stored at −20 °C for vitamin analysis. The rest of the kernels were lyophilised. The dried samples were ground in a blender and sieved through a screen of 30 mesh in size. The sieved samples were stored in a tightly screwed glass bottle at −20 °C until analyses.

2.2. Proximate composition

Moisture, crude fat, crude protein (%N × 6.25), ash and crude fibre content of the samples were determined in accordance with the standard methods of AOAC (2000). Carbohydrate content was estimated by the difference method. Data were expressed as percentage of dry weight (DW).

2.3. Fatty acid analysis

The fatty acids were converted to fatty acid methyl esters (FAME), according to the method of Ainie et al. (2005) and detected using gas chromatography (HP 6890; Agilent, Santa Clara, CA) with a flame ionisation detector. Separation of fatty acids was carried out on a BPX-70 capillary column (30 m length, 0.32 mm i.d., 0.25 μm film thickness; SGE, Ringwood, Australia). Helium was used as the carrier gas at a flow rate of 1.2 mL/min. The oven temperature was held initially at 140 °C for 5 min and then increased to 240 °C for 5 min with a gradient of 4 °C/min. The temperature of injection port and detector was set at 260 °C. One microlitre of sample in *n*-hexane was injected. Identification of FAME was achieved by comparing the retention times of the peaks with those authentic standard mixtures (Supelco, Bellefonte, PA). The results were expressed as relative percentages of total fatty acids.

2.4. Amino acid composition

The amino acid composition of the kernel protein was determined after hydrolysis of defatted sample with 6 N HCl (containing 1% phenol w/v) at 110 °C in a Pyrex® glass tube fitted with Teflon®-lined screw cap for 24 h under vacuum (Salchert, Pompe, Sperling, & Warner, 2003). The amino acid composition was measured using high-performance liquid chromatography (HPLC) (Agilent 1100, Böblingen, Germany). Samples and standard solutions were derivatised with *o*-phthalaldehyde and 9-fluorenylmethyl chloroformate. Chromatographic conditions used were in accordance with Agilent's recommended method (Schwarz, Roberts, & Pasquali, 2005). The separation was performed with a Zorbax Eclipse AAA column (150 × 4.6 mm, i.d. 4 μm). The derivatised amino acids were detected by variable wavelength detector at 338 nm and 262 nm. Mobile phase A, buffer solution of 40 mM phosphate buffer (pH 7.8) and mobile phase B, acetonitrile/methanol/water (45:45:10), were used at 2.0 mL/min flow rate with gradient elution. The column temperature was set at 40 °C. Tryptophan content was measured by the acid ninhydrin method of Pintér-Szakács and Molnár-Perl (1990). The results were expressed as mg/g of dry weight. Chemical score of amino acids was estimated according to the FAO/WHO (1991) reference pattern.

2.5. Sugar analysis

Sugar analysis was according to the method of Wall and Gentry (2007) with minor modifications. Sugars were extracted with methanol (80:20, v/v) and finally diluted to a volume of 10 mL. The extract was cleaned up with C_{18} cartridge (Agilent AccuBond) before injection. HPLC (Jasco, Tokyo, Japan) was used to separate and quantify fructose, glucose, sucrose and maltose in palm kernel samples. A Zorbax carbohydrate analysis column (150 × 4.6 mm, 5 μm) was used for the chromatographic determination. The mobile phase was acetonitrile/water (75:25). The separation was conducted by isocratic elution with 1.4 mL/min flow rate. The sugars were detected by refractive index detector. Results were expressed as mg/g of dry weight.

2.6. Mineral analysis

The levels of Ca, Mg, K, P, Na, Mn, Zn, Fe and Cu in the oil palm kernel were quantified by inductively-coupled plasma spectrophotometry. Wet digestion of samples was according to the method of AOAC (2000) with minor modifications. The organic matter in the sample was digested using a mixture of concentrated HNO_3 and 60% (v/v) $HClO_4$. The sample was then diluted to a final volume of 25 mL with deionised distilled water. Reagent blank was included throughout the entire procedure along with the samples. The mineral content of each sample was determined using Perkin–Elmer 2000DV ICP-OES (Perkin–Elmer Life And Analytical Sciences, Inc., Waltham, MA). The mineral concentration was expressed as mg/100 g of dry weight.

2.7. Water soluble vitamin content

The water-soluble vitamins were extracted from the samples by acid and enzyme hydrolysis, according to the protocol of Viñas, López-Erroz, Balsalobre, and Hernández-Córdoba (2003). HPLC (Ultimate 3000) was used to analyse vitamins B_1, B_2, B_6 and niacin. Separation of vitamins was conducted by an Acclaim PA2 C_{18} column (150 × 4.6 mm, 5 μm). Vitamins were detected by diode array detector (DAD) at three different wavelengths: 245 nm for B_1, 265 nm for B_2 and niacin, and 326 nm for B_6. Gradient elution was performed with two different mobile phases, namely solvent A, buffer solution of 25 mM sodium phosphate, pH 2.6, and solvent B, acetonitrile, at a flow rate 1.0 mL/min. Vitamin content was expressed as mg/100 g wet weight.

2.8. Statistical analysis

Four independent biological replicates were analysed in duplicate, except for the proximate contents that were determined in triplicate. Data were analysed by using SAS software Version 9.0 (SAS Institute Inc., Cary, NC). Significant differences between means were calculated by *t*-test at $p < 0.05$.