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Chemical properties and nutritional factors of pressed-cake from tea and sacha inchi seeds

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ABSTRACT

A comparative study of pressed-cake made from tea and sacha inchi seeds was performed. Sacha inchi seeds contained the largest amount of protein (62.07%) and tea seeds contained the largest amount of carbohydrates (82.68%). Lysine, leucine, histidine, and phenylalanine were the main essential amino acids. High amounts of unsaturated fats with a number of omega fatty acids (ω-3, ω-6, and ω-9) were found in the residue oil following extraction. Both seeds are also good sources of mineral content (potassium, phosphorus, calcium, and magnesium). SDS-PAGE profiles showed that the main proteins had MWs of 35–63 and 11–20 kDa for sacha inchi and tea seeds, respectively, and contained glycoprotein with a MW of 35 kDa. Phytochemical analysis showed that both pressed-cakes are good sources for bioactive compounds with high antioxidant activities. However, anti-nutrients and toxic compounds were found in some content. Therefore, the chemical properties of the pressed-cakes indicate that this by-product of oil extraction is a good supplement to functional food ingredients.

1. Background

The oils extracted from different vegetables are quite distinct. Because of the desirable properties of plant-based oils, there has been growing interest and a continued increase in consumer demand not only in the food industry, but also in the pharmaceutical and cosmetic industries. Vegetable oils are derived from a variety of seeds, fruits, and nuts. The most common vegetable oils used in food preparation come primarily from soybeans, peanuts, peas, rapeseed, sunflower seed, corn, cottonseed, and safflower seeds (Hamm, Hamilton, & Calliauw, 2013; Sathe, Kshirsagar, & Sharma, 2012). However, new alternative oil seed crops have become of increasing interest for utilization.

Sacha inchi (*Plukenetia volubilis* L.) (also known as *Inca peanut*, *wild peanut*, *Inca inchi*, or *mountain peanut*) is a plant of the *Euphorbiaceae* family, which grows in the Amazonian forest (Gutierrez, Rosada, & Jimenez, 2011). This plant, widely cultivated in Peru, has long been a staple in the diet of various native tribal groups there (Hamaker et al., 1992). Now, it is also widely cultivated in the northern part of Thailand as well as in other countries of the Greater Mekong Sub-region (GMS) as a promising new valuable crop. The seeds of sacha inchi are of great interest because they contain a high quantity and quality of edible oil (41–54%) with a very high proportion of unsaturated fatty acids (Niu, Li, Chen, & Xu, 2014). The protein content of the seeds is also relatively high (ca. 33%) with the main component being 3 S storage protein, a water soluble albumin (Hanssen & Schmitz-Hubsch, 2011), which potentially could have promising applications in the food and pharmaceutical industries.

Camellia oleifera Abel. is a woody shrub that is used as an ornamental plant, for traditional medicines, and also commercially for edible oil production (Chaicharoenpong & Petsom, 2011). Tea seed contains a large number of compounds that can be utilized. Among them are oil content (29–34%), starch (17–20%), protein (10–16%), tea saponins (11–15%), and fiber (10–14%) (Demirbas, 2010). Oil extracted from nutrition-edible tea seeds normally contains a high amount of bioactive compounds. Green tea seed (*Camellia sinensis L. Kuntze*) oil contains more than 84% unsaturated fatty acid: oleic acid (62.5% by weight), linoleic acid (18.1% by weight), and linolenic acid (Demirbas, 2010). As the consumption of virgin oil has increased, the production of tea seed has also increased. Over one billion kilograms of tea seed is produced annually in China (Tian, Qiu, & Shi, 2004).

Oilseed cake is a by-product of traditional oil processing. The seeds are mechanically pressed in a process called “cold pressing”. Cold pressed oils are the highest quality vegetable oils when compared with expeller-pressed seeds or those produced by using chemical solvents. The obtained pressed-cake still contains various amounts of bioactive compounds such as free fatty acids, glycerides (mono- and diglycerides), phosphatides, sterols, tocopherols, as well as protein fragments (Chirinos et al., 2013; Li, Xu, Jin, Wu, & Tu, 2010; X. Wang, Xu, Wang, & Liu, (2012); Y. Wang, Mao, & Wei

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2012). Some research has reported the utilization of the residues, but none have explored the potential of those in oilseed pressed-cakes, particularly from sacha inchi. The objective of this study was to determine the chemical composition, nutritional quality, and some of the chemical properties of pressed-cake obtained from these oilseed crops, the same that are normally used as starting raw materials for virgin oil production. The information obtained will be useful for further value added possibilities of this by-product.

2. Materials and methods

2.1. Sample

Tea seed oil pressed-cake was obtained from the Tea Oil and Plant Oils Development Center, Chiang Rai, Thailand. Sacha inchi pressed-cake was obtained from Thai Rubber Land and Plantation Co., Ltd., Chiang Rai, Thailand (the samples were collected during March 2014 by the center and company, respectively). The samples were collected and air-dried at 60 °C overnight. They were then ground and sieved, and kept at −20 °C until used for analyses.

2.2. Chemical

β-mercaptoethanol (βME), *N,N,N′,N′*-tetramethyl ethylene diamine (TEMED), 2,2′-diphenyl-picrylhydrazyl (DPPH·), and gallic acid were purchased from Sigma Chemical Co. (St. Louis, MO). Casein from bovine milk, bovine serum albumin (BSA), Coomassie Brilliant Blue R-250, and Folin–Ciocalteu phenol reagent were procured from Fluka Chemica-Biochemika (Buchs, Switzerland). Sodium dodecyl sulfate (SDS), Tris, and ethanol were purchased from Ajax Finechem Pty. Ltd. (Auckland, NZ). The Gel Code Glycoprotein Staining Kit and standard protein marker were purchased from Pierce Biotechnology Perbio (Rockford, IL). NuPAGE®Novex®and SimplyBlue™ SafeStain were purchased from Thermo Fisher ScientificInc (Thailand). Other analytical grade chemical reagents used in this study were purchased from Merck (Darmstadt, Germany).

2.3. Chemical and nutritional components

2.3.1. Proximate composition

The moisture, ash, and fat contents of the different oilseed pressed-cakes were determined according to the AOAC method numbers 927.05, 942.05, and 920.38B, respectively (AOAC, 2000). The protein content was determined by estimating its total nitrogen content according to the Kjeldahl method, AOAC method number 984.13 (AOAC, 2000). The protein content was converted by using 5.70 as a conversion factor. Available carbohydrates were calculated by difference.

2.3.2. Amino acid profiles

The amino acid composition of the pressed cakes was determined according to the AOAC method number 994.12 (AOAC, 2000). Amino acids were liberated from the pressed-cakes by hydrolysis with 6 M HCl. Hydrolysates were diluted with a sodium citrate buffer, and the pH was adjusted to 2.2. Individual amino acid components were separated and identified by using gas chromatography-mass spectrophotometry. The content of each amino acid was reported as mg per 100 g sample.

2.3.3. Fatty acid profiles

Fatty acid profiles in the pressed-cakes were determined by gas chromatography according to the AOAC method number 996.06 (AOAC, 2012). For the present analyses, the samples were extracted with ether by Soxhelet extractor. The obtained oil was stored in Eppendorf tubes, and the air was removed and replaced with nitrogen. Fatty acid was identified by comparing the retention times to the known standards. The results were expressed as g fatty acid/100 g sample.

2.3.4. Dietary fiber, starch, and sugars content

The insoluble and soluble dietary fiber contents of the pressed-cakes were determined by AOAC method number 985.29 (total dietary fiber in foods-enzymatic gravimetric method) (AOAC, 2010). The starch in the pressed-cakes was determined according to the AOAC method number 920.44 (AOAC, 2010). Total sugar, fructose, glucose, maltose, lactose, and sucrose content in the pressed-cake were determined according to an in-house method (The laboratory of Central Laboratory (Thailand), Co., Ltd (Chiang Mai)) based on the compendium of methods for food analysis (2003).

2.3.5. Mineral contents

Calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, and zinc of the pressed-cakes was analyzed according to an in-house method (The laboratory of Central Laboratory (Thailand), Co., Ltd (Chiang Mai)) TE-CH-170, based on AOAC (2005) Ch.9 (984.27 and 990.10) by ICP-OES technique.

2.3.6. Electrophoretic analysis

The pressed-cakes were subjected to sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) in order to determine the protein patterns. The samples (2 g) were dissolved in 18 ml of 5% SDS solution and then heated at 85 °C for 1 h. Supernatant was mixed with a sample buffer (0.5 M Tris–HCl, pH 6.8 containing 4% SDS, 20% glycerol, 0.03% Bromophenol Blue with/without 10% βME) at a ratio of 1:1. The mixture was boiled for 3 min Protein samples (10 and 20 μg protein) were loaded into the NuPAGE®Novex® 4–12% gradient Bis-Tris protein precast gel. They were then moved to electrophoresis at a constant current of 15 mA per gel by using a PowerPac™ basic power supply (Bio-Rad laboratories). After electrophoresis, the gel was stained with 20 ml of SimplyBlue™ SafeStain and left for 1 h at room temperature with gentle shaking. The gel was washed with 100 ml of distilled water for 1–3 h. The water used for washing was changed every hour until the background was clear, at which point they were then dried.

Glycoprotein staining was conducted using the Pierce™ Glycoprotein Staining Kit as used in the method described in Wati, Theppakorn, Benjakul, and Rawdkuen (2009). The separated protein from the electrophoresis was fixed by immersing the gel in 30 ml of 50% methanol for 30 min The gel was then washed by gently agitating it with 3% acetic acid for 10 min (twice repeated). It was transferred to 25 ml of oxidizing solution and then washed with 3% acetic acid for 10 min before being stained for 15 min with 15 ml of GelCode1 Glycoprotein Stain. The gel was incubated for 10 min with 25 ml of reducing solution and washed with 3% acetic acid. The glycoprotein appears as magenta bands.

2.4. Phytochemical content and antioxidant activity determinations

2.4.1. Sample extraction

The pressed-cake samples were used as the starting materials for extraction according to the method described in Atala, Vsquez, Speisky, Lissi, and Lpez-Alarcn (2009). Briefly, 10 g of each powdered sample was extracted with 100 ml of extraction solvent (75:25, acetone: water). The extracts were shaken in a water bath at 25 °C for 90 min and centrifuged at 950 g for 15 min The supernatant was then stored at −20 °C until further analysis.