Potential of Oil Palm for Ferulic Acid Cultivation

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ABSTRACT

Ferulic acid is a polyphenolic compound that has been found to exhibit various beneficial properties such as being antioxidant, anticancer, anti-inflammatory, etc. *It is a lesser-known phenolic compound in the oil palm. The presence of ferulic acid was detected in various parts of the oil palm and its products such as the fruits, mesocarp fibre, empty fruit bunch (EFB), palm kernel cake (PKC) and fronds. The amount of ferulic acid that could be recovered from these sources depends largely on the extraction methods. Nevertheless, the oil palm and its products are good sources for the cultivation of natural ferulic acid.*

Keywords: extraction, ferulic acid, oil palm

INTRODUCTION

Oil palm is one of the major contributors to the nation's income and is still fast growing. In 2020, the planting area of oil palm in Malaysia encompassed 5.87 million hectares, with production of 19.14 million tonnes of crude palm oil (CPO) (Ahmad Parveez *et al.,* 2021). Besides its oil, the oil palm is also known to contain many beneficial and valuable minor components, or better known to be the phytonutrients. These phytonutrients include both oil and water soluble compounds, namely, carotenes, tocols (tocopherols and tocotrienols), coenzyme Q and phenolic acids; among others, caffeic acid, protocatechuic acid, p-hydroxybenzoic acid and shikimic acid (Ng *et al.,* 2006; Ng and Choo, 2012; Sambanthamurthi *et al.,* 2011).

Many studies had been conducted on the oil soluble phytonutrients in palm oil. For instance, the carotenes had been reported to be anticancer as well as antioxidative while the tocotrienols had been proven to protect against neuro degenerative and cardiovascular diseases besides being a superior antioxidant than the tocopherols (Ng *et al.,* 2006; Ng and Choo, 2012). On the other hand, studies on the water soluble phenolics in oil palm were mostly focused on the shikimic acid which has been reported to be an ingredient for the production of Tamiflu, a type of drug used against avian flu in recent years. Recent studies have revealed that the oil palm also contains another valuable hydrophilic antioxidant, the ferulic acid, in various concentrations across various parts of the oil palm (Mohd Aanifah, 2014; Ng, 2020; Tang *et al.,* 2015; Tsouko *et al.,* 2019).

CHARACTERISTIC AND USES OF FERULIC ACID

Ferulic acid (4-hydroxy-3-methoxycinnamic acid) is a flavonoid polyphenolic compound exists naturally in almost all plant cell walls, ranging from vegetables, spices and medicinal plants to agricultural residues (*Figure 1*) (Roby *et al.,* 2013; Zhao *et al.,* 2014). Its concentration ranges from 5 g kg^{-1} in wheat bran to 9 g kg^{-1} in sugar-beet pulp

and 50 g kg^{-1} in corn kernel, as well as being present in some oils / oil seeds (*Table 1*). Ferulic acid can mostly be found in seeds and leaves being covalently linked to lignin and other biopolymers or as free ferulic acid (rarely). It is usually found as ester cross-links with polysaccharides in the cell wall, such as arabinoxylans in grasses, pectin in spinach and sugar beet and xyloglucans in bamboo.

Although there are many sources of ferulic acid in nature, its bioavailability depended on the form in which it is present. Free ferulic acid has limited solubility in water, and hence poor bioavailability. However, its solubility increased with increasing water temperature and alkalinity. Besides that, ferulic acid is soluble in polar organic solvents such as ethanol, methanol, dimethyl sulfoxide (DMSO), and dimethyl formamide (DMF).

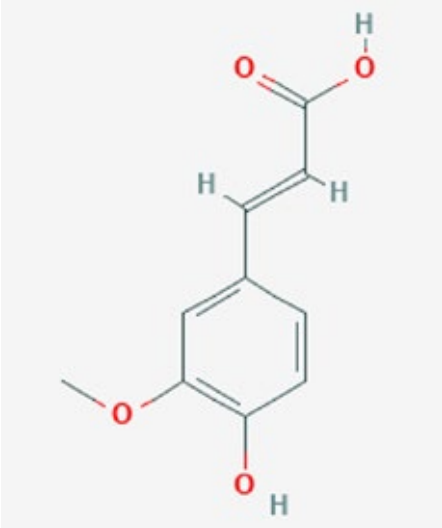

Figure 1. Chemical structure of ferulic acid.

TABLE 1. CONTENT OF FERULIC ACID IN DIFFERENT OILS / OILSEEDS

Source	Ferulic acid (mg 0.1 kg^{-1})
Soy bean	12
Peanut	8.7
Extra virgin olive oil	22.8
Rice bran oil	NA

Source: Kumar and Pruthi, 2014; Caponio et al., 1999; Perez-Ternero *et al.,* 2017

Studies have reported the beneficial properties of ferulic acid being anti-microbial, anti-inflammatory and antioxidant, making it a highly sought after compound in medical, pharmaceutical and cosmetics industries (Aarabi *et al.,* 2016; Neo *et al.*, 2010; Ou and Kwok, 2004). Besides scavenging free radical, ferulic acid also prevents free radical generation through enzymes inhibition (Masella *et al.,* 2004). Ferulic acid, being a strong free radicals scavenger [reactive oxygen species (ROS)], is able to attenuates oxidative stress, which is responsible for blood-pressure lowering (Alam, 2019).

Ferulic acid, with its beneficial biochemical properties which include antioxidative, antiallergies, hepatoprotective, anticarcinogenic, anti-inflammatory, antimicrobial, antiviral, vasodilatory effect, antithrombotic, and helps increasing spearm' viability, is used in food preservation application as cross linking agent as well as photoprotective component in sunscreens and skin lotions (Saija, 2000). Ferulic acid's amide derivative which is formed by the condensation of ferulic acid with tyramine may be used to indicate environment stress in plants. In the baking industry, amides of ferulic acid with amino acids or dipeptides are commonly used as preservative (Graf, 1992). In many countries, use of ferulic acid as food additive has been approved by their governments as it effectively scavenges superoxide anion radical, and inhibits lipid peroxidation (Srinivasan *et al.,* 2007). In addition, ferulic acid also plays a role in the production of biovanillin (bio-flavour) (Torres-Mancera *et al.,* 2011). Food supplemented with ferulic acid with curcumin is reported to be able to reduce oxidative damage and amyloid pathology in Alzheimer's disease (Kikuzaki et al., 2002; Ou and Kwok, 2004).

Ferulic acid cultivation from natural resources could offer business fortuity and supplements environment and economic encouragement as it is needed as ingredients in many drugs, functional foods and nutraceuticals. The value of ferulic acid however, depended mainly on its purity (*Table 2*) and whether it is natural or synthetically produced.

TABLE 2. PRICE OF FERULIC ACID FROM VARIOUS SOURCES

Source	Purity / grade	Price (USD) kg^{-1}
Wheat bran	Mixed	80 - 280
Chuan xiong (chinese herbs)	Mixed	99
Synthetic	Mixed	30 – 120
Synthetic	Cosmetic	10 500

FERULIC ACID IN OIL PALM

As the ferulic acid could exist in free form as well as ester and ether through cross-linking with polysaccharides in plant materials, quantification of ferulic acid in oil palm depended largely on the method used for its extraction (*Table 3*). Ng (2020) analysed the free ferulic acid in various parts of the oil palm such as, empty fruit bunches (EFB), fruits, fronds and mesocarp fibre, that was obtained through a simple methanolysis (*Figure 2*). These figures were generally low as they reflected only the ferulic acid in its free form. Alcoholysis is not able to break the cross-link between the ferulic acid and polysaccharides, thus these ferulic acid are not accounted for in the study by Ng (2020).

Tsouko *et al.* (2019) reported the presence of 560 mg kg^{-1} free ferulic acid in palm kernel cake (PKC), which was obtained via ethanolic extraction. Similarly, this figure did not include the covalently linked ferulic acid.

As much as 3800–4200 mg kg^{-1} ferulic acid could be extracted from oil palm EFB through alkaline hydrolysis (Aanifah *et al.,* 2014). However, ferulic acid that has gone through chemical process such as alkaline hydrolysis is not considered as natural. Thus, efforts were made to release the ferulic acid from natural sources enzymatically. This is a challenge as ferulic acid is mostly covalently linked with lignin and other biopolymers in plants. Tang *et al*. (2015) managed to achieved this whereby ca. 5 mg kg^{-1} ferulic acid were obtained from EFB through enzymatic hydrolysis. This shows that the amount of ferulic acid that could be obtained depended largely on its extraction method. Critical parameters for the isolation such as time of extraction, pH and temperature need to be optimised for high yield.

Most of the reports on ferulic acid in oil palm and its products were based on its biomass and by-products from the oil palm milling. There has not been any report on the presence of ferulic acid in palm oil itself, mainly because ferulic acid is not oil soluble. However, due to its covalent cross link lignin and biopolymers, most of the ferulic acid were found in the biomass instead. Considering the price or value of ferulic acid, recovering it from the biomass of oil

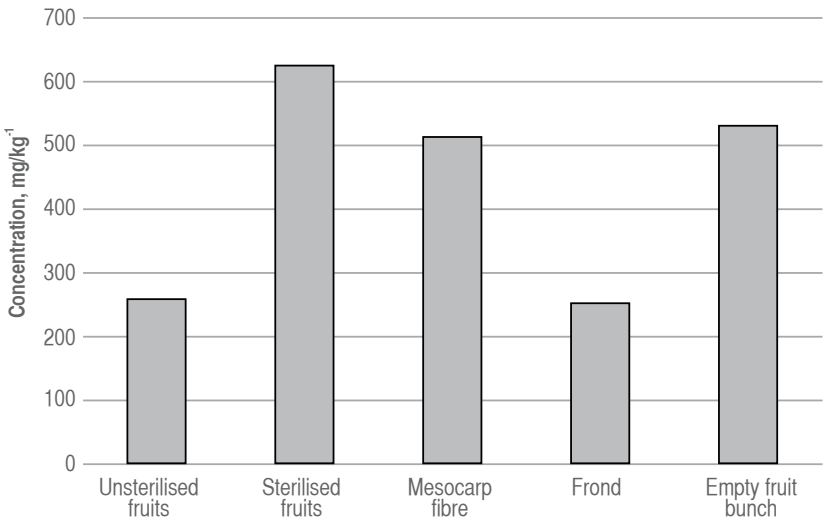

Figure 2. Concentration of free ferulic acid in various parts of oil palm.

TABLE 3. FERULIC ACID SOURCED FROM DIFFERENT PARTS OF OIL PALM THROUGH VARIOUS METHODS

No.	Reference	Source	Method	Outcome
1.	(Stavova *et al.,* 2017)	Oil palm leaves	Liquid-liquid extraction followed by column adsorptive chromatography	Ferulic acid content in oil palm leaves ca. 1.5% w/w
2.	(Aanifah *et al.,* 2014)	Oil palm empty fruit bunches	Alkali hydrolysis	3.84 mg and 4.24 mg ferulic acid solubilised from 1g OPEFB when treated with NaOH and KOH respectively
3.	(Khongkhaem *et al.,* 2016)	Palm oil mill effluent	Bacterial immobilised silica	Up to 1000 mg litre^{-1} phenolic (caffeic acid, 4-hydroxybenzoic acid, ferulic acid, catechol, 3-methyl catechol) recovered.
4.	(Ng 2020)	Oil palm fruits. Empty fruit bunch, mesocarp fibre, frond	Methanolysis	262–628 mg kg^{-1} (*Figure 2*)
5.	(Tang *et al.;* 2015)	Empty fruit bunch	Emzymatic hydrolysis	ca. 5mg kg^{-1}
6.	(Tsouko *et al.;* 2019)	Palm kernel cake	Ethanolysis	ca. 560 mg kg^{-1}

palm could add value to the industry.

CONCLUSIONS

Based on the various studies reported for the cultivation of ferulic acid, the oil palm and its products have the potential to be a source for the recovery of natural ferulic acid. However, in depth studies are needed to find the optimal method and route for its recovery.

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