



Palm fatty acid distillate (PFAD) is a by-product of palm oil refinery process, comprising mostly fatty acids (70% as palmitic acid) and some valuable minor components such as vitamin E, sterols, and squalene (Table 1). PFAD has various food and non-food applications such as animal feed, feedstock for laundry and toilet soaps. PFAD can be converted to the ester form and used as a feedstock for oleochemical and biodiesel production (Ab Gapor, 2010). Previously, MPOB had transferred the technology on producing biodiesel from PFAD (Lau *et al.*, 2009) and patented the process of converting high free fatty acid to methyl ester (Lau *et al.*, 2011).

TABLE 1. TYPICAL COMPOSITION OF PALM FATTY ACID DISTILLATE (PFAD)

Components	Composition (% , w/w)
Free fatty acid	81.7
Glycerides	14.4
Vitamin E	0.5
Sterols	0.8
Squalene	0.4
Others	2.2

Source: Ab Gapor (2010).

PFAD can be a starting material for vitamin E production. MPOB has commercialised and patented the technology on vitamin E extraction from PFAD (Ab Gapor *et al.*, 1993). By-products from the vitamin E extraction plant contain unrecovered minor components currently regarded as scheduled wastes. The solid by-product, called phytosterols resources (PSR), was found to be rich in sterols in the range of 2% - 14%. Extraction of phytosterols (plant sterols) will give additional value up to USD 100 per kg. In 2014, Malaysia produced about 660 000 t of PFAD (MPOB, 2015). Thus, an estimated 3300 t of sterol with 80% purity can potentially be extracted from PFAD, worth USD 30

million. Extraction of these minor components in palm oil adds value to the oil palm industry.

PHYTOSTEROLS: BENEFITS AND APPLICATIONS

The major components of palm phytosterols are β -sitosterol, campesterol and stigmasterol. Several studies have demonstrated that consumption of phytosterols reduces cholesterol absorption and lowers both total serum and LDL cholesterol levels in animals and humans (Malini and Vanithakumari, 1990; Jones *et al.*, 1998; Plat *et al.*, 2000; Katan *et al.*, 2011). Phytosterols may also offer protection from colon, breast and prostate cancers (Berger *et al.*, 2004). Since phytosterols is anti-cancer and cholesterol-lowering, it has wide applications in nutraceuticals and functional food. Many margarine, butter, cereals, milk and spreads products are now enriched with plant-derived sterols and their ester; well-accepted by consumers (Corowise, 2015). Further purification and isolation of individual sterols such as β -sitosterol gives higher value to the product. The β -sitosterol showed protective effects in the incident of large bowel cancer, which was reduced from 54% to 33% (Shamberger, 1984).

DESCRIPTION OF THE PROCESS

Sterols content in a typical PFAD is in the range of 0.2% - 0.8 %. After the removal of vitamin E fraction, sterols content in the residue increases to 2% - 14%. The extraction and concentration processes of phytosterols are multi-staged, namely solid-liquid extraction, saponification, liquid-liquid extraction and fractionation. These processes yield sterols concentrates up to 80% purity. Phytosterols crystals called Phytosterols Mix comprises of campesterol (23%), stigmasterol (13%) and β -sitosterol (64%) are produced using these processes (Table 2). The flow diagram of the extraction process is shown in Figure 1.



TABLE 2. COMPOSITION OF PHYTOSTEROLS MIX PRODUCED IN LABORATORY AND MINI PLANT SCALE

Individual sterols	Composition (%)		
	Laboratory	Mini plant	Commercial sterols*
Campesterol	23	23	20-28
Stigmasterol	16	13	16-23
β -sitosterol	61	64	40-58

Note: *Typical specification for Corowise™ plant sterols (Cargill, 2014).

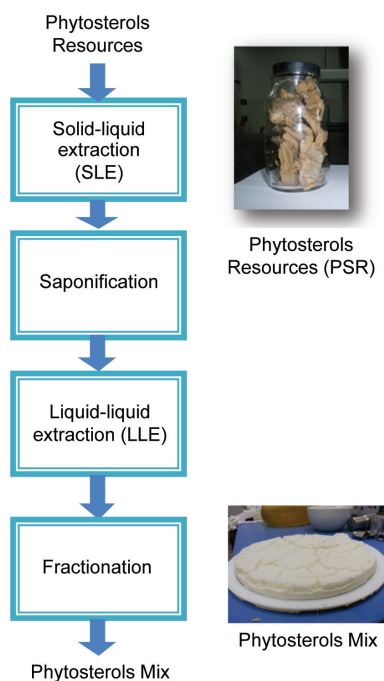


Figure 1. Flow diagram for phytosterols extraction process.

ECONOMICS

Sterol extraction from PFAD will add value to the Vitamin E Extraction Plant. In 2015, the estimated crude sterols price is up to USD 20 per kg, while that of pure sterols is USD 100 per kg. The capital investment for a phytosterols extraction plant with a capacity of 1 t per month is about RM 3 million. The projected payback period would be less than seven years depending on the sale price of the end product.

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