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Potential Source and Extraction of Vitamin E From Palm-Based Oils: A Review

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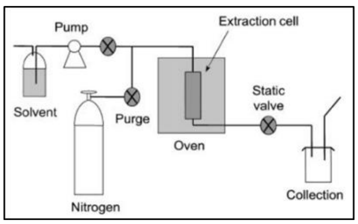
Graphical abstract



Abstract

Vitamin E is essential in the human body which naturally found in vegetable fats and oil and their derived products. Several palm-based oils obtained from palm oil mills and refineries were revised in this paper as the raw material for vitamin E. Tocopherols and tocotrienols isomers of the vitamin E content are found nearly comparable with crude palm oil. To obtain the tocopherols and tocotrienols, various developed technologies for the extraction were also reviewed. These include the solvent-based extraction, chemical modification, adsorption, enzymatic process, molecular distillation, microwave-assisted extraction and membrane technology. Each of the technologies has the advantages as well as limitations. Therefore, process design and selection for the chosen technology are crucial in order to determine recovery of vitamin E obtained, time efficiency, cost effectiveness, safety of products and environmentally friendly impacts. A green technology approach could be further diversified and manifested for sustainable process of vitamin E.

Keywords: Vitamin E; tocopherols; tocotrienols; palm-based oil; extraction

1.0 INTRODUCTION

Vitamin E which consists of tocopherols and tocotrienols is an essential vitamin and present a very important function for the human body. Tocopherol which was previously known as the main part in vitamin E family has the antioxidant and anti-aging activity[1]. On the other side, tocotrienols have higher antioxidant and anticancer activity in membrane tissues than tocopherols hence also provide the powerful neuroprotective function and cholesterol lowering properties that are not shared by tocopherols[2-4].

As the essential vitamin, Vitamin E cannot be self-produced by the human body and needs to be obtained from the food supplement. Palm fruit is one of the best sources for the tocopherols and tocotrienols besides the rice grain and annatto seed. Palm fruit was found not only contains tocopherols but also the unique tocotrienols. In fact, palm fruit is the richest source of tocotrienols among all vegetable oils. Tocotrienols make up almost 70% of Vitamin E in palm oil, with the remaining 30% beings tocopherols[4]. The vitamin E isomers present in palm fruit include α-tocopherol (α-T), α-tocotrienol (α-T3), γ-tocotrienol (γ-T3), and δ-tocotrienol (δ-T3)[2-4]. This review is articulated in paragraphs focusing on the presence of vitamin E (tocopherols and tocotrienols) in several of palm-based oil and several extraction technologies to extract the vitamin E.

2.0 PALM-BASED OILS SOURCES FOR VITAMIN E

Tocopherols and tocotrienols can be directly extracted from the oil palm fruits, or can be simultaneously obtained from crude palm oil (CPO) extraction process which being carried out in the palm oil mill. In terms of raw material costand availability, it would be more favourable to get the tocopherols and tocotrienols from CPO or its derivative products in comparison to direct extraction from oil palm fruits. It is because the CPO is the main commodity of oil palm fruits, thus it will be difficult to obtain the raw material supplies for Vitamin E production. By-products and residues from palm oil mills and palm oil refineries also can be used for the source of vitamin E, since they have similar characteristics and components with the CPO. Moreover, by-products and residues are inexpensive. Figure 1 shows the palm oil mill and palm oil refineries process. The composition of Vitamin E (tocopherols and tocotrienols) from several palm-based oil materials is shown in Table 1.

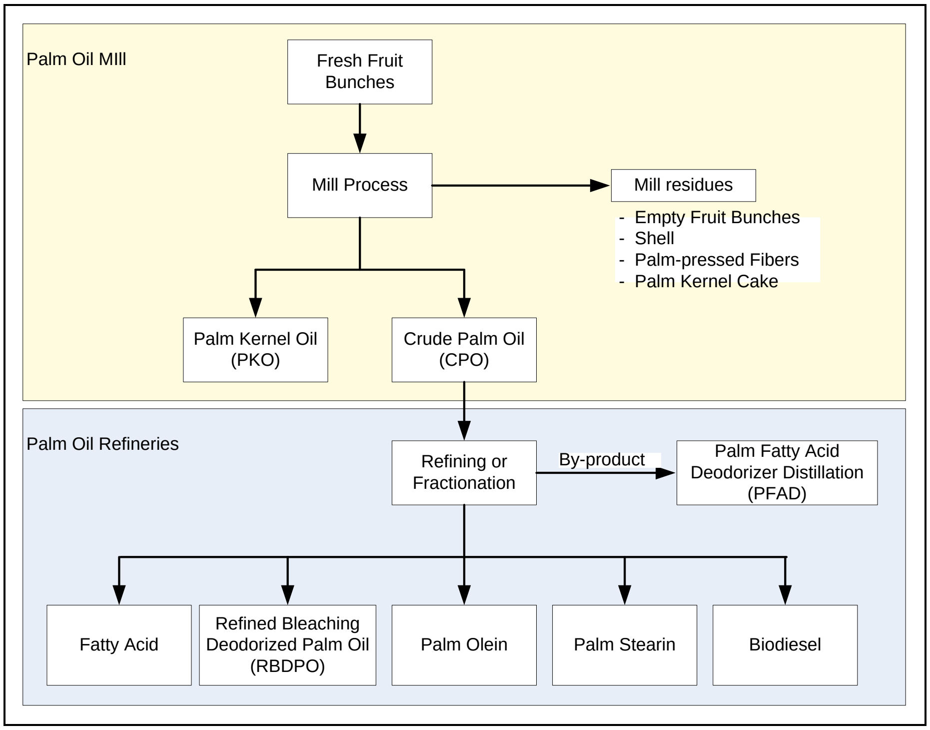


Figure 1 Process flow from palm oil mill and palm oil refineries

Table 1 Vitamin E content in the several palm-based oil materials

Raw Material	Range Composition (%)					Total Vitamin E (ppm)
	α-T	γ-T	α-T3	γ-T3	δ-T3	
Crude Palm Oil (CPO)[5, 6, 7, 8, 9, 10, 11, 12]	22 - 25	1 - 3	20 - 25	36 - 45	7 - 10	600 - 1000
Palm-pressed Fiber Oil (PFO)[10, 11, 13]	55 - 60	0 - 3.5	13 - 20	18 - 23	8 - 10	2000 - 4000
Refined Bleaching Deodorized Palm Oil (RBDPO)[7, 12]	21 - 25	-	23 - 29	36 - 50	6 - 10	500 - 1000
Palm Fatty Acid Distillate (PFAD)[5, 14]	23 - 24	-	23 - 24	36 - 38	13 - 15	4000 - 5000
Palm Olein [8, 15]	21 - 24	-	26 - 28	25 - 40	6 - 10	500 - 1000
Palm Phytonutrient Concentrate (PPC) [10, 16]	8 - 10	0 - 4	17 - 21	55 - 60	6 - 7	14000 - 15000

Abbreviations: α-T, α-tocopherol; γ-T, γ-tocopherol; α-T3, α-tocotrienol; γ-T3, γ-tocotrienol; δ-T3, δ-tocotrienol.

Crude palm oil (CPO), refined bleaching deodorized palm oil (RBDPO) and palm olein are the major products in palm oil milling and refinery, whereas palm-pressed fibre oil (PFO) and palm fatty acid distillate (PFAD) are the by-products of palm oil milling and palm oil refinery, respectively. Palm-pressed fibre is the fibrouswaste material from fruit mesocarp after extracted and separated from kernel in the palm oil mills. It is usually burned in the boiler as fuel to provide the energy in the palm oil mills. May *et al.*[17] reported about 5-7% of oil residue in palm-pressed fibre which can be recovered. Although the relative residue oil is lower, higher concentration of Vitamin E isomers and β-carotene content is obtained from PFO[24].

PFAD is a by-product resulted by deodorizing unit in palm refinery. The aim of this unit process is to remove the free fatty acid components in refined palm oil. However, thermal utilization in deodorizer unit also indirectly led to the elution of Vitamin E content, resulting 0.5% wt. of Vitamin E content in PFAD[14]. Similarly with PFAD, PPC is also a by-product of vacuum distillation which is obtained in refinery of biodiesel. Since it is derived from CPO, the occurrence of individual vitamin E components in CPO and the phytonutrient concentrate would be identical.

The refined product of palm oil mill and palm oil refineries contain only small amount of tocopherols and tocotrienols. It also tends to havea reduction in total vitamin E from the palm oil mill to product of palm refineries, as shown in Table 1. Wei *et al.*[12] (2007) also observed that there is degradation of tocopherol concentration from CPO to deodorizing product during the physical refining.

On the contrary, there is an accumulation of vitamin E in the by-product of each stage. It also seems an enhancement of total Vitamin E in the by-product from palm oil mills to palm oil refineries. The utilization of these products is also limited. Therefore, PFO, PFAD and PPC as the by-products and the residues from the palm oil mills can be effective sources as the raw material of Vitamin E.

3.0 VITAMIN E EXTRACTION FROM PALM-BASED OILS

Extraction of Vitamin E can be achieved by several methods as shown in Table 2. Solvent-based extraction is a conventional method and widely applied to extract the natural product. It usually uses organic solvents such as hexane, chloroform and short chain alcohols. For the food industries, short chain alcohols (ethanol and isopropanol) are preferred to be used than hexane and chloroform, due to the health hazard issues. Also, ethanol and isopropanol tend to extract more non-glyceride material than hexane due to their greater polarity[18]. Lee *et al.*[19] have found that direct solvent was the best method for extracting Vitamin E from peanuts and peanut butter, in order of quantify of yield.

Unfortunately, direct solvent is usually a laborious procedure which requires high purity and high cost of solvent. Its procedures also need a long time period[20-21]. Another report from Lim *et al.*[22] claimed that soxhlet extraction was the best method to extract Vitamin E which obtained yield of 13% higher than direct solvent. Later, Kasim *et al.*[23] used the modification in soxhlet extraction and could recover up to 83% of Vitamin E from soybean deodorizer distillate.

Recently, a new extraction procedure called pressure liquid extraction (PLE) was developed. This process uses organic solvents at high pressure and a temperature above their boiling point to extract the analyte from the sample matrices[24-25]. Pressure is used to increase the contact between the extracting fluid and sample,while the temperature is used to break the analyte-matrix bonds.Figure 2 shows the scheme of PLE apparatus.

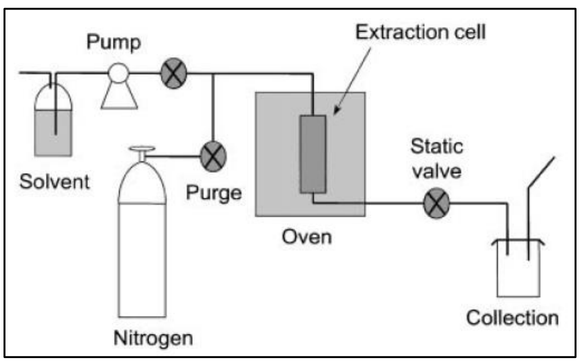


Figure 2 Scheme of pressure liquid extraction (PLE) apparatus

By increasing the temperature, the extraction efficiency also will be improved due to the enhancement of the diffusion rate and solubility of analyte in the solvent. Sanagi *et al.*[24] and Freitas *et al.*[26] claimed that higher concentration of vitamin E was obtained by PLE compare to soxhlet extraction. In addition of high yield achieved, PLE can reduce the organic solvent used and achieve rapid extraction process. Sanagi *et al.*[24] reported that PLE can reduce the organic solvent up to 77% in comparison with the soxhlet extraction. Although it may reduce the use of organic solvent, careful handling and safety is needed during this process due to the operation of high temperature and pressure.

The usage of organic solvent has a high risk for the human consumption. Organic solvent is partly toxic, inflammable and may cause explosive and also environmental unfriendly[21,27-28]. Based on this infirmity, suitable solvents which give less impact to environment and healthy are more preferred today. Supercritical fluid extraction (SFE) is chosen for this aim which using the gas as the solvent and operates at its critical point. Carbon dioxide (CO_2) is usually used as the solvent in this method because it can extract the lipid-soluble compounds and enables a high level recovery. Moreover, CO_2 is a low cost solvent, non-hazardous, non-flammable and safety to be used compare to highly flammable petroleum-based solvent. This method is suitable to decrease volatility and thermal degradation of component during the extraction[21,27-28]. The scheme of supercritical CO_2 extraction is shown in Figure 3.

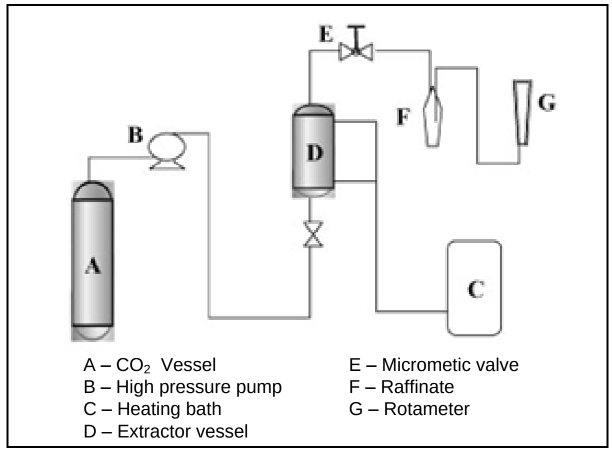


Figure 3 Scheme of supercritical CO_2extraction apparatus[26]

The SFE application to separate vitamin E had been done from different raw material such as soybean oil deodorizer distillate[29-33], rapeseed oil deodorizer distillate[34], sunflower oil deodorizer[35], and palm oil[36-38]. A rapid extraction can be achieved by SFE and the vitamin E recovery was obtained up to 80%[29,32]. Some modification to increase the vitamin E recovery has been studied, such as the continuous stage of SFE[31,39], dual column processing[33] and also the usage of co-solvent[30] which also can reduce the extraction time. Although SFE has been successful to obtain the high efficiency, clean environmentally process and solvent-freeresidue in the products[34,38], it needs a high investment cost in the equipment of SFE[21].

The use of high temperature for the separation process may degrade the vitamin E in the material. To avoid it, adsorption process can be purposed as the alternative methods. Adsorption involves separation of a substance (adsorbate) from one phase, accompanied by its accumulation or concentration on the surface of the adsorbing phase (adsorbent). The equilibrium, kinetics and desorption of vitamin E by using silica from PFAD had been studied by Chu *et al.*[40-42].Several researchers also have reported the parameters effects of chromatographic extraction[43] and several different methods of chromatography[10,16,24,44]. Chu *et al.*[42] reported that the percentage of vitamin E recovery from PFAD using silica adsorption ranged from 70% to 98%. The similar value was obtained from different raw material by Gimeno *et al.*[44] and Chandrasekaram *et al.*[16] which from olive oil (96%) and palm phytonutrient concentrate (94%), respectively.

Despite a high yield obtained, the adsorption process by chromatography also has the limitation. To result the high Vitamin E recovery from palm-based oil,it needs to do the pretreatments of the oils. The pretreatments involve the chemical modification which converts one component of the substance into different properties that allows for easier separation, such as saponification[16,44-46]. It will require a large amount of organic solvent, additional process equipment and also long-time stage process.

Table 2 Several extraction methods the separation of vitamin E

No	Methods	Authors	Information
1	Solvent Extraction		
	a. Direct Extraction	Lee *et al*. (1998)	Compare three extraction methods to determine vitamin E in peanuts and peanut butters. The extraction methods involve direct solvent extraction with hexane:ethyl acetate, saponification, and soxhlet extraction with hexane.
		Petterson *et al*. (2007)	Evaluate the saponificaton and direct extraction of tocopherols in oat.
	b. Soxhlet Extraction	Kasim *et al*. (2010)	Extraction of tocopherols and phytosterols from soybean oil deodorizer distillate by using modified soxhlet extraction with severals organic solvent.
		Yuong Lee *et al*. (2012)	Compare three extraction methods which involve soxhlet extraction, direct extraction and saponification to obtain tocopherols and tocotrienols from seeds and germinating seeds of soybean.
	c.PressureLiquid Extraction (PLE)	Sanagi *et al*. (2005)	Extraction of vitamin E and carotene in residue oil from palm pressed fiber using through pressurized liquid extraction with n-hexane
		Rangel *et al*. (2007)	Determine and optimize the pressure liquid extraction of tocopherols and tocotrienols from cereals
		Freitas *et al*. (2008)	Optimizethe pressurized liquid extraction of vitamin E from residue of grape seed oil in wine industry
	d. Supercritcal Fluid Extraction (SFE)	Chang *et al*. (2000)	Recovery the high value substances such as FFA, tocopherols, sterols and squalene from soybean oil deodorizer distillate by using the SC-CO_2 distillation-extraction.
		Nagesha *et al*. (2003)	Optimizethe SC-CO_2 extraction from chemically modified soybean oil deodorizer distillate to obtain the tocopherols
		Quancheng *et al*. (2004)	Evaluate the different organic cosolvents for the extraction of tocopherols from rapeseed oil deodorizer using SC-CO_2
		Gast *et al*. (2005)	Investigatethe tocochromanols extraction using SC-CO_2 from crude palm oil and soy oil deodorizer distillate.
		Mendes *et al*. (2005)	Optimizetheextraction of vitamin E from soybean oil deodorizer distillate using SC-CO_2
		Lau *et al*. (2006)	Evaluate the characteristic of SC-CO2 extraction from the palm oil
		Vazquez *et al*. (2006)	Recovery the tocopherols and phytosterols from sunflower oil deodorizer distillate using countercurrent SC-CO_2 extraction
		Fang *et al*. (2007)	Investigate the concentration of tocopherols from metyl esterified SODD using SC-CO_2
		Lau *et al*. (2008)	Evaluate the extraction of vitamin E from fresh palm-pressed messocarp fiber using three stages continous SC-CO_2
		Wei *et al*. (2008)	Studied the SC-CO2 extraction from esterified palm oil to obtain the carotenoids and tocols
		Shi *et al*. (2011)	Analyze and mass transfer modeling of the continous countercurrent SC-CO_2 extraction-distillation dual column to obtain the natural vitamin E from soybean oil deodorizer distillate.
2	Enzymatic Process	Ramamurthi and McCurdy (1993)	Extraction of sterols and tocopherols from severals oil deodorizer distillate through lipase-catalyzed modification
		Ghosh and Bhattacharya (1996)	Isolationthe tocopherols and sterols through process involved biohydrolysis, bioesterification and fractional distillation.
		Shimada *et al*. (2000)	Evaluate the enzymatic (lipase) esterification of soybean oil deodorizer distillate for the tocopherol purification.
		Chu *et al*. (2002)	Investigate the pre-concentration factor of tocopherols and tocotrienols from palm fatty acid distillate using lipase-catalysed hydrolysis
		Chu *et al*. (2003a)	Optimize the parameters of enzymatic hydrolysis parameters for the concentration of vitamin E in palm fatty acid distillate
		Chu *et al*. (2003b)	Investigate the effects of lipase hydrolyzed on vitamin E extraction of palm fatty acid distillate
		Watanabe *et al*. (2004)	Concentrate the tocopherols and sterols from soybean oil deodorizer distillate by using *Candida rugosa* lipase involving the esterification of sterols with FFA and methyl esterification of FFA.
		Nagao *et al*. (2005)	Tocopherols purification from soybean oil deodorier distillate through two step lipase esterification
		Torres *et al*. (2007)	Two step enzymatic esterification to obtain tocopherols, sterols esters and fatty acid ethyl esters from soybean oil deodorizer distillate
		Teixeira *et al*. (2013)	Simultaneous recovery of oil and bioactive compounds from oil palm fruit through several enzymatic treatment.
3	Chemical Modified		

	a. Saponification	Lee *et al*. (2000)	Optimize the parameters of saponification process on the extraction of vitamin E from tomato and broccoli
		Chu *et al*. (2003b)	Investigate the effects of saponification process on vitamin E extraction of palm fatty acid distillate
		Ryynanen *et al*. (2004)	Optimize the saponification process as the sample preparation for the solvent extraction of tocopherols and tocotrienol in cereals
		Peterson *et al*. (2007)	Evaluate the saponificaton and direct extraction for the analysis of tocopherols in oat. The saponification methods increased yields by 25% and less time consuming.
		Yuong Lee *et al*. (2012)	Compare the three extraction methods which involve soxhlet extraction, direct extraction and saponification to obtain tocopherols and tocotrienols from seeds and germinating seeds of soybean.
		Shammugasamy *et al*. (2013)	Pretreatment using saponification and reversed phase HPLC extraction for the determination of tocopherols and tocotrienols in cereals.
	b. Esterification	Jiang *et al*. (2006)	Recovery tocopherols from rapeseed oil deodorizer distillate though a process involving acid-catalysed methyl esterification and followed by molecular distillation.
		Nagesha *et al*. (2003)	Esterified modification of soybean oil deodorizer distillate as the pretreatment before SC-CO2 extraction to obtain the tocopherols.
4	Adsorption	Chu *et al*. (2003b)	Determination of tocopherols and tocotrienols from palm fatty acid distillate using hydrolysis, neutralization, adsorption and chromatography methods
		Chu *et al*. (2004a, 2004b, 2004c)	Investigate the equilibriums and kinetics of batch adsorption of vitamin E from palm fatty acid distillate using silica.
		Han *et al*. (2004)	Extraction of vitamin E from palm oil through HPLC-flourescence method using a C30 silica stationary phase.
		Chandrasekaram (2009)	Extraction of Vitamin E from palm phytonutrient concentrates through the application of open column chromatography and HPLC with flourescence and semi preparative silica column.
		Gimeno (2000)	Extraction of tocopherols and carotene from olive oil through a reserved-phase HPLC which involve the saponification and extraction with organic solvent
5	Molecular Distillation	Martins *et al*. (2006)	Extraction of tocopherols using molecular distillation with the comparison of with and without preparation (saponification).
		Jiang *et al*. (2006)	Investigate the effects of molecular distillation parameters to obtain the tocopherols from rapeseed oil deodorizer distillate.
		Posada *et al*. (2007)	Studied the tocotrienol extraction's parameters from palm fatty acid distillates using molecular distillation
		Shao *et al*. (2007)	Optimization the parameters of molecular distillation for tocopherol extraction from rapeseed oil deodorizer distillate using response surface and artificial neural network method.
		Setyawan *et al*. (2011)	Investigate the tocopherol from crude palm oil biodiesel through molecular distillation.
6	Microwave-assisted Extraction	Zigoneanu *et al*. (2008)	Evaluate the fffect of temperatures on vitamin E extraction from rice brain using microwave-assisted method with solvent (isopropanol and hexane)
		Oufnac *et al*. (2007)	Comparison methods of solvent and Microwave-assisted solvent extraction from wheat bran
		Azadmard-Damirchi *et al*. (2010)	Evaluate the effect of Microwave pretreatment and cold press extraction on rapeseed oil extraction
		Anjum *et al*. (2006)	Research on the effect of microwave roasted on extraction process of sunflower oil seed
		Yoshida *et al*. (2002)	Investigate the effect of microwave roasted on extraction process of sunflower oil seed
7	Membrane Technology	Nagesha *et al*. (2003)	Determine the membrane selectivity for tocopherol using hexane dilution from esterified and crude soy oil deodorizer distillate

Molecular distillation could be another options to avoid problems with the toxicity concern in variety of organic solvent methods on extraction of Vitamin E. Molecular distillation is a separation process fraction of different molecular weights at temperatures as low as possible to avoid damage. The advantage of this technique is operation under vacuum, thus the temperature for the extraction can be kept at the minimum possible to avoid damage to materials[47]. Moreover, the stage of the process in this method is relatively short[48]. Figure 4 show the apparatus of molecular distillation.

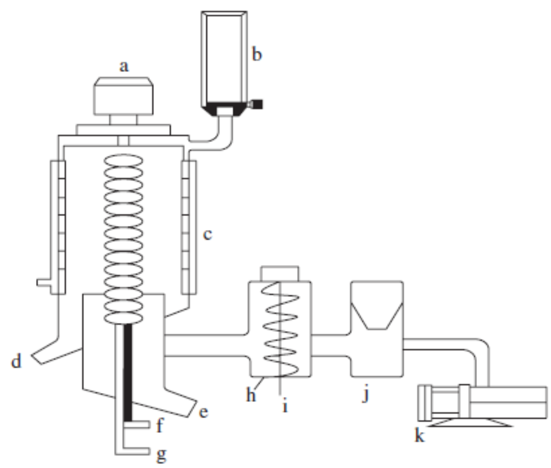


Fig. 1. Schematic diagram of wiped-film molecular still: (a) motor drive; (b) feed flask; (c) wiper; (d) residue receiver; (e) distillate receiver; (f) one-stage condenser inlet; (g) one-stage condenser outlet; (h) two-stage condenser inlet; (i) two-stage condenser outlet; (j) cold trap; (k) rotary vane vacuum pump

Figure 4 Schematic diagram of wiped-film molecular distillation[20]

Several researchers have studied on the parameters in the molecular distillation process[14,47,20]. However, almost all reported the low recoveries of Vitamin E which is about 35 to 58 percent[14,20,48]. Process modification by five molecular distillation stages then has been done by Martin *et al*.[49] to improve the vitamin E recovery.

Molecular distillation also has the limitation in use. Some problems have been found in the commercial production of vitamin E using the molecular distillation. Despite its strict operation condition, it needs to perform the separation in multistage distillatory, which led to the relatively high investment cost[50]. Furthermore, this method usually involves a chemical modification as the pretreatment. The chemical modification includes the saponification[49] and esterification[20,48].

Chemical modification is used to convert one component of the substance into different properties that allow for easier separation. Due to the similar properties of sterols, vitamin E and free fatty acid (FFA), current works have proposed some reactions to facilitate the separation process[49,51]. The transformation of one molecule into another implies the alteration of some physical properties depending on the separation principles involved in the process. Saponification and esterification are the most used to achieve this purpose.

Saponification is employed to liberate the vitamin E from the sample matrices, to convert esterified derivatives of vitamin E into their free forms and to reduce the load of material extracted into organic phase[52-53]. Several studies about comparison in the saponification process with conventional extraction[52,54] and optimization of the saponification process for vitamin E purification[55-56] have been reported. Besides the less-time consuming process, saponification also can increase the vitamin E yield amount from 15 to 25 percent compare to direct extraction[54,56]. However, saponification can induce the problematic emulsion when the sample has high fatty acid content and if the conditions are not properly controlled[52-53]. Furthermore, harsh alkaline and high temperature condition during the saponification may partially degrade the unsaturated vitamin E[54-55].

Chemical modification by esterification also can be done other than using saponification. Esterification converted the large molecules of fatty acids and triglycerides into the smaller molecules of fatty acid methyl ester. The fatty acid esters are easier to be extracted compare to its fatty acids and triglycerides with the same corresponding molecular weight and carbon numbers[51,57]. Therefore, this can enhance the concentration of Vitamin E. Several researchers have studied the modified esterification as the pretreatment for the vitamin E separation. Combination of esterification with supercritical fluid extraction (SC-CO_2) will improve the solubility of fatty acids and enhance the vitamin E obtained[32-34,36]. Shi *et al*.[33] has reported that vitamin E contains in esterification of soybean oil deodorizer increased from 5wt-% in SODD to 20wt-% in their ester forms. Although this method can improve recovery of vitamin E, the irreversible reaction in chemical modification could change the properties of the oil component and also up to the extent that can make it non-edible[36,49].

Enzymatic process is also another solution to overcome the weaknesses in the environmental aspects of the use of solvent. Selectivity of enzyme allows the production of high value products with less waste and unwanted material for disposal[58]. In addition, the low yield resulting from molecular distillation and adsorption which is based on the similar solubility of sterols, vitamin E and free fatty acid (FFA) can be covered by using the enzymatic process. Enzyme used for this process is usually the lipase, due to its ability to convert acyglycerols in vegetable oil into FFA[59] and to convert FFA become methyl esters[60-61]. Several studies have reported that more than 90% of vitamin E can be recovered from vegetable oil deodorizer distillate by involving lipase process[59-60]. Optimization of various parameters[51,62-63] and process modification involving the enzyme in vitamin E separation[46,57,61,64] also had been reported.

Although could obtain high recovery of vitamin E, the enzymatic reaction processes are generally slower and may require more equipment for an equivalent output of product[58]. The products also need to be further refined to ensure the enzyme used in the process completely separable. To eliminate the overall lipase, the process needs to be heated up to 90^{o}C. This condition allows the degradation of vitamin E in the product[64]. Furthermore, a high attention and safety precaution is necessary in the handling and storage of enzyme used.

In looking for the best separation technology to obtain high purity, excellent quality and health product, industries began to develop and apply clean technologies in line with the stringent environmental regulations and high requirement for the products. Minimization on the solvent used also developed due to its high cost and also harmful potential in consumption. The usage of microwave assisted-extraction has been studied to obtain high yield of oil and phytonutrient from wheat bran[65], rice bran[66] and rapeseed[67]. Oufnac *et al*.[65]and Zigoneanu *et al*.[66] reported that no significant different of total oil yield and tocopherols content of microwave-assisted extraction in comparison with solvent extraction. Contrast result obtained by Azadmard-Damirchi *et al*.[67] (2010) found that microwaved-assisted extraction followed by cold mechanical-press will increase the tocopherol content of 55% compared with conventional solvent extraction.

4.0 CONCLUSION AND FUTURE PROSPECT

Instant and quick choices of human's lifestyle, followed by rapid growth of the food industry are inclined to increase consumption of the vitamin supplement. The estimation of worldwide demand growth for vitamin and dietary supplement in 2007 to 2011 was approximate about3.6% per year, sharply increase from previous year which is only 0–0.5% per year[68]. Related to vitamin E function as anantioxidant, anti-aging and also has low-cholesterol properties as a good nutrition for dietary, it is also possible to further increase in the future. The demand of vitamin E in the future might be encountered in the wider form of supplements, food for tificationin the industry or in the cosmetic and pharmaceutical applications.

Vitamin E can be found in palm oil, which has the balance content of tocopherols and tocotrienols. Increased inplantation accompanied by the number of the mills, making the world's palm oil production is increasing. Therefore, the tendency of vitamin E production from palm oil and its derived products in the future will be higher.

There are several processes to extract the vitamin E from palm-based oil. However, the weakness of each method has not completely recovered the problems faced during the process of extraction. Rapid process and high recovery of vitamin E obtained are the desired achievement of the process. This achievement must be balanced against the cost for the process that involving the investment cost and the operational cost for the process (amount of solvent and energy used for the high temperature and pressure). Recently, environmental and health aspects have also been considered. Reduction in the use of organic solvents, combinations of various extraction processes, and prospecting environmental friendly methodare developed. Therefore, process design and selection for the chosen technology are crucial in order to determine the recovery of vitamin E obtained, time efficiency, cost effectiveness, safety of products and environmentally friendly impacts. A green technology approach could be further diversified and manifested for sustainable process of vitamin E.

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