ChemSearch Journal 13(1): 70 – 75, June, 2022
Publication of Chemical Society of Nigeria, Kano Chapter

Received: 11/03/2022 Accepted: 29/04/2022
http://www.ajol.info/index.php/csj

Comparative Analysis on Physicochemical Properties and Chemical Composition of Coconut and Palm Kernel Oils

[1*]Osahon K. Ogbeide, [1]Ephraim A. Omorotionmwan, [1]Osakpolor D. Igenumah, [2]Hilary I. Ifijen and [1]Isaac U. Akhigbe
[1]Department of Chemistry, University of Benin, Benin, Nigeria
[2]Department of Chemistry, Rubber Research Institute of Nigeria, Benin
***Correspondence Email:** kennedy.ogbeide@uniben.edu

ABSTRACT
Coconut and Palm kernel oils are important edible oils in food and in manufacturing industries. Their biological importance, particularly their antimicrobial and antioxidant properties have been traced to the presence of fatty acids. This study is a comparative analysis on the physicochemical properties and chemical composition of coconut oil and palm kernel oil. The extraction of the oils and determination of physicochemical properties were done employing established methods. The chemical compositions for both oils were ascertained with a Gas chromatography-mass spectrometry (GC-MS). The results from the physicochemical properties for coconut and palm kernel oils are specific gravity (0.91, 0.92), refractive index (1.45, 1.45), acid value (0.62 mgKOH/g, 1.824 mgKOH/g), iodine value (10.72 g/100g, 12.69 g/100g), peroxide value (2.94 meq/kg, 1.5 meq/kg) and saponification value (323.85 mgKOH/g, 308.55 mgKOH/g) respectively. The GC-MS revealed 10 and 12 chemical compounds in coconut and palm kernel oil respectively, typically dominated by fatty acids. The results attest to its usefulness in food and in manufacturing industry.

Keywords: Coconut oil, Fatty acids, GC-MS. Palm kernel oil

INTRODUCTION

Oils along with fats are generally considered as lipids. Depending on room temperature and the degree of unsaturated fatty acids present, a lipid can either be liquid (oil) or solid (fats). Chemically, they are products of an esterification process, formed from a combined reaction between tri-glycerols and fatty acids (Aremu *et al.*, 2015). Naturally they occur abundantly in animal and plant sources. Animal sourced oils are known as animal oil (liver oil), and those from plant are referred to as vegetable oils, like cotton seed oil sun flower and palm oil (Aremu *et al.*, 2015).

Edible oils from plant source are important in food applications and industries. They are unique in the characteristic texture and flavours they provide to food. Vegetable oils contribute an important amount of dietary proteins, lipid and fatty acids to humans all over the world. It is a good source of energy and also aids in new cell formation and repair of worn-out tissues. (Gaydon *et al*. 1983; Grosso and Guzman, 1995; Grosso *et al*. 1997; 1999; Aremu *et al.*, 2015).

Coconut (*Cocos nucifera*) belongs to the family *aracaceae*. It is native to the tropical countries and plays an essential role in diet (Kappally and Shirwaikar, 2015). Coconut is sweet in taste and is chemically composed of mainly saturated fatty acids (Krishna *et al*. 2010). The trees are long and could attain a height of 100 ft but are generally 20-50 ft upon cultivation. The leaves are large with a life span of about 3 years. (Pal *et al*., 2020). The kernel of coconut fruit is highly rich in oil, which is widely used for domestics and industrial purposes including, food preparation, baking, cosmetics and pharmaceutics (Kumar and Krishna 2015). Pal *et al.* (2020) and Lima *et al.* (2015) highlighted biological activities (healing therapy, antimicrobial, anti-obesity, anti-inflammatory, antioxidant, antimalarial, antioxidant) possessed by coconut. Phytochemical studies on coconut plant revealed the presence of active secondary metabolites of alkaloids teroenoidds flavonoids, glycosides, phenols, saponinjs, steroids, steroids and tanins (Kendeson *et al*., 2019). Research on several parts of the plant has led to the isolation of compounds such as catechin (Freitas *et al*., 2011), *a*-tocopherol (Arlee *et al*. 213) vitamin C lauric acid (Yong *et al*. 2009) skimmiwallin, isoskimmiwallin and lupeol-methylether (Erosa *et al*., 2002).

Coconut oil is often classified based on their mode of preparation as unrefined (virgin coconut oil; hot pressed and cold) or as refined. The hot (heated to about 40 °C) and cold method (room temperature) typically involves extracting oil from fresh wet coconut (Pal *et al*. 2019).

Oil palm (*Elaeis guineensis*) of the family *Palmae*, is also a tropical tree crop typically grown for its use in industrial production of vegetative oil, it is the major source of palm oil and palm kernel oil. The tree plant is void of branches and can grow to a height of 20 to 30m high. The leaves produced increases by 30-40 yearly with a life span of 2 years after maturity. It is used traditionally in the treatment of many ailments particularly gastrointestinal disorders and poisons (Owoyele and Owolabi 2014). The plant contains active metabolites including alkaloids saponin, flavonoid, phenolic, tannin (Yin *et al*., 2013), with isolated compounds principally the phenolics and fatty acids. Parts of the plants has been reported to exhibit biological activities such as antimicrobial and antioxidant (Yin *et al*., 2013), antidiabetic (Jaffri 2011) anticancer (Ebong *et al*., 1999) and anti-inflammatory (Wu *el al*., 2008).

This study was aimed to investigate the comparative physicochemical properties and chemical composition of coconut oil and palm kernel oil.

MATERIALS AND METHODS

Sample collection

Fresh fruits of *Cocos nucifera* and *Elaeis guineensis* were collected in September, 2021 at Uroho Community, Ikpoba Okha Local Government Area, Benin and a farm in Iguikpe, Egor Local Government Area, Benin respectively, both in Edo state.

Extraction of Cocos nucifera oil

Extraction of *Cocos nucifera* oil was carried out using fermentation method. The *Cocos nucifera* fruit was broken, washed, sliced into small pieces and blended. After blending, the liquid milk was stored at room temperature for 18hours for fermentation to occur. Thereafter, layers of water and milk were formed and the mixture was then transferred to a refrigerator to allow for easy separation.

Upon refrigeration for 3hours, the layered milk and oil solidified leaving the water at the bottom. The solid layer was then handpicked and transferred into a cooking pot. Mild heat was applied to denature and destabilized the milk to allow for more extraction of oil. The excess water left evaporated during this process. After extraction, the oil was filtered and stored in a cool and dry environment pending further analysis (Agarwal and Bosco, 20017).

Extraction of palm kernel oil

The palm fruits were dried for 7 days and the nuts were taken to the mill and hulked after which the palm kernels were separated from the broken shells. The separated palm kernels were dried at an average temperature of 35 to 40^{o}C for about 4 days. The dried palm kernels were then taken to the mill and blended.

The extraction method used was the wet heat traditional method. The milled palm kernel was put in a large pot, mixed with sufficient amount of water and boiled for about 2 hours, the boiled mill was removed from the pot, taken to a wide bow and mixed with sufficient amount of cold water and left to settle for 24 hours. This was done to aid separation. After 24 hours, three layers consisting of the oil (at the top layer), water (at the middle layer) and the mill were formed. The oil at the top layer was then scooped and taken to a heating vessel to boil off the excess water and stored in a cool and dry environment for further analysis (Ezeoha *et al*. 2012).

Physicochemical analysis of palm kernel and coconut oil

The physical and chemical analysis of the oil was carried out by methods described by AOAC (2005).

RESULTS AND DISCUSSION

Physicochemical properties of Coconut and Palm kernel oils

The results for the physicochemical properties of the oil are presented in Table 1. The values reported for the specific gravity of coconut (0.91) and palm kernel (0.92) are somewhat same and are in concordance with 0.919 and 0.904 for coconut and palm kernel oil respectively (Ichu and Nwankama, 2019; Amira *et al*., 2014). The specific gravity for typical edible oils indicates the composition level of fatty acids present in the oil.

The refractive index of an oil indicates the possible chances of rancidity development in oil. It is mostly used as a quality control measure for the purity of an oil material (Hoffman, 1986). It is often determined as a ratio of light speed at a defined wavelength to its speed in the oil/fat itself.
When an oil is contaminated with particulates and chemical substances like potassium hydroxide (KOH), a chemical reaction occurs between KOH and fatty acids of the oils to produce soap. This changes the oil's physical and chemical properties making it greatly susceptible to spoil (Willams 1990). The higher the refractive index the higher the chances of spoilage due to oxidation. The refractive indexes for both coconut and palm kernel oils (1.45), indicate that the oils are resistant to oxidative rancidity when exposed to light. A similar trend was reported by Sarkar *et al*. (2020) for almond seed oil (1.45), sunflower oil (1.47), and soybean oil (1.47).

The acid value of oil indicates the level of spoilage that has occurred in an oil sample, and is usually indicated by the presence of free fatty acids formed as caused by enzymatic hydrolysis. The acid value observed for the coconut oil (0.62 mgKOH/g) is three times lower than the palm kernel oil (1.824 mgKOH/g). The observed high acid values for palm kernel oil indicate the presence of high free fatty acid formation than the coconut oil. This is a non-desirable property of oils as it indicates the low stability of the oil to hydrolysis by enzymes, and its susceptibility to attack during processing and/or storage conditions (Vitz *et al*., 2020; Ogbeide *et al*., 2021).

The iodine value of an oil sample gives an index of the level of unsaturated fatty acid present in the oil. The lesser the iodine value for an oil, the more susceptible to oxidative rancidity. Coconut (10.72 g/100g) and palm kernel (12.69 g/100g) oils showed low iodine values. According to Maliki *et al*. (2020), an oil with iodine value above 100g/100g is a drying oil and below 100g/100g is non-drying oil. Non-drying oils are essential in skin care products because of their moisturizing effect. They do this by helping the skin maintain its water permeability barrier. Studies also show that applying nondrying oils on the skin may increase the production of collagen and decrease inflammation. The moisturizing properties of non-drying oils also help manage dry and itchy skin.

The peroxide value obtained for the coconut oil (2.94 meq/kg) is much higher than for the palm kernel oil (1.5 meq/kg). However, these values are lower to the permitted maximum limit (≤10 meq/kg) stated by the World Health Organisation (WHO) in 1994 (Aremu *et al*., 2015). Oil with high peroxide values indicates high susceptibility to oxidative rancidity and lower values are resistant to oxidative rancidity, which suggest high levels or presence of antioxidants (Kyari, 2008). Hence, palm kernel oil may contain more antioxidant and more resistant to oxidative rancidity compared to coconut oil.

The saponification value of an oil sample is the amount of KOH in mg required to completely saponify 1g of a fat. This value gives an index of the average fatty acid chain length present in the test oil. The saponification value of palm kernel oil 308.55mgKOH/g is close to coconut oil (323.85 mgKOH/g). Vidal in 2020 reported that high saponification value contains high proportions of low/medium chain fatty acids a unique characteristic that qualifies an oil for use in producing soaps and other skin care products. Apart from medium chain fatty acids being excellent oils for soaps production, they have been found useful in dietary and nutrition as they were reported to aid weight loss and has become popular supplement amongst athletes and body builders (Brown *et al.,* 2020).

Table 1: Physicochemical properties of coconut and palm kernel oils

S/N	**Properties**	**Analysis Results**	
		Coconut oil	**Palm kernel oil**
1	Acid value	0.62 mgKOH/g	1.824 mgKOH/g
2	Iodine value	10.72 g/100g	12.69 g/100g
3	Peroxide value	2.94 meq/kg	1.5meq/kg
4	Saponification value	323.85 mgKOH/g	308.55
6	Specific gravity	0.91	0.92
7	Refractive index	1.45	1.45

GC-MS analysis of coconut and palm kernel oils

A total number of 10 (Table 2- coconut oil) and 12 (Table 3- palm kernel oil) chemical constituents was identified by the GC-MS (Agilent technologies 7890A GC and 5977B MSD). Fatty acids were predominant in both coconut (9 fatty acids, 1 terpene) and palm kernel (11 fatty acids, 1 terpene) oil.

Dodecanoic acid (lauric acid) was observed to be highest by percent composition of 30.98% (coconut oil) and 20.23% (palm kernel oil). Dodecanoic (Lauric acid) acid is commonly recognized as a “healthier” saturated fat. Its molecules are easily absorbed by the body, due to their ability to hydrolyze completely into fatty acids and glycerol via enzymatic action of the pancreatic lipase (Sandhya *et al.*, 2016). It is usually blended in creams to help treat inflamed skin and prevent after shave burns. It also prevents diseases and has been demonstrated to possess antibacterial (Nakatsuji *et al.*, 2009), antifungal (Ogbolu *et al*., 2007) and anticancer (Fauser *et al*., 2013) activities. It also aids in body weight loss and cholesterol reduction (Sandhya *et al*., 2016).

The second dominant fatty acids next to the lauric acid in the coconut oil (Methyl 15-methylhexadecanoate (25%) and Hexadecanoic acid methyl ester or palmitic acid(12.5%)) and palm kernel oil(9, 12-octadecadienoic acid (17.46%) and Hexadecanoic acid methyl ester or palmitic acid (12.78%)) are reported. Their presence indicates the oils are fit in the manufacturing of soaps and detergents, cosmetics, shaving creams and shampoos (Diezel *et al*., 1993).

Aside from the fatty acids, the Lanostan-11-one, 3-(acetyloxy) -, (13.alpha., 14.beta., 17.alpha.) in coconut oil and squalene in the palm kernel oil are only the other class of compounds (triterpenes) found in the oils.

Terpenes are known for their attractive flavour and fragrance characteristics. They find wide applications in food, as well as in the perfumery and cosmetics industries. The presence of terpenes in both oils confirms their characteristic fragrance and flavour they add to food.

Table 2: Chemical composition of coconut oil

Compound name	Molecular formula	Molecular weight	Retention index	%Composition
2-Methyl octanoic acid	$C_9H_{18}O_2$	158	1208	3.18
Undecanoic acid	$C_{12}H_{24}O_2$	200	1506	3.81
Dodecanoic acid	$C_{13}H_{26}O_2$	214	1481	39.98
Methyl 15-methylhexadecanoate	$C_{18}H_{36}O_2$	284	1914	25.00
Hexadecanoic acid Methyl ester	$C_{17}H_{34}O_2$	270	1878	12.50
8-11-Eicosadienoic acid Methyl ester	$C_{21}H_{38}O_2$	322	2292	1.34
9-Octadecenoic acid Methyl ester	$C_{19}H_{36}O_2$	296	2085	8.97
Methyl Stearate	$C_{19}H_{38}O_2$	298	2077	4.31
Docosanoic acid, docosyl ester	$C_{38}H_{76}O_3$	648	4562	0.42
Lanostan-11-one, 3-(acetyloxy)-, (13.alpha.,14.beta.,17.alpha.)	$C_{32}H_{54}O_3$	486	3105	0.50

Table 3: Chemical composition of palm kernel oil

Compound name	Molecular formula	Molecular weight	Retention index	%Composition
Octanoic acid	$C_9H_{18}O_2$	158	1083	0.27%
Decanoic acid methyl ester	$C_{11}H_{22}O_2$	186	1282	0.65%
Dodecanoic acid	$C_{13}H_{26}O_2$	214	1481	20.23%
Hexadecanoic acid methyl ester	$C_{18}H_{36}O_2$	284	1914	16.78%
9, 12-octadecadienoic acid	$C_{18}H_{32}O_2$	280	2183	17.46%
9-octadecenoic acid	$C_{19}H_{36}O_2$	296	2085	6.79%
Oleic acid	$C_{18}H_{34}O_2$	282	2175	16.37%
6-octadecenoic acid	$C_{18}H_{34}O_2$	282	2175	3.71%
Eicosanoic acid methyl ester	$C_{29}H_{62}O_4Si_2$	530	2979	2.61%
9,12,15-octadecatrienoic acid	$C_{27}H_{52}O_4Si_2$	496	2804	0.43%
Tetradecanoic acid	$C_{15}H_{30}O_2$	242	1680	5.97%
Squalene	$C_{15}H_{30}$	410	2914	4.51%

CONCLUSION

The results from this study revealed both oils (coconut and palm kernel oils) contains principal amounts of fatty acids, particularly the dodecanoic acid (lauric), which is linked to have antimicrobial and antiviral properties. The study also affirms to its usefulness in food, soap manufacturing and in the cosmetics industries.

Competing Interest

The authors of this manuscript declare that they have no competing interests.

REFERENCES

Agarwal, R.K., and Bosco S.J.D. (2017): Extraction Processes of Virgin Coconut oil. MOJ Food Processing & Tech. 4(2):1-4.

Amira,P.O., Babalola, O.O. and Oyediran, A.M.(2014): Physicochemical properties of Palm kernel oil; *Curr. Res J of Biol Sci*. 6(5): 205-207.

AOAC International(2005): Official methods of analysis of AOAC international, 18th ed. USA: AOAC International. 2005.

Aremu,M.O., Ibrahim, H. and Bamidele, T.O.(2015): Physicochemical Characteristics of the Oils Extracted from Some Nigerian Plant Foods – A Review. 32:36-52.

Arlee, R., Suanphairoch, S. and Pakdeechanuan, P.(2013): Differences in chemical components and antioxidant-related substances in virgin coconut oil from coconut hybrids and their parentes. *Int Food Res J*. 20: 2103–2109.

Brown, M.J., Link R., and Seitz A. (2020): A Review on Medium Chain Triglycerides. https://www.healthline.com/nutrition/mct-oil-101 Assessed 27th April, 2022.

Diezel, W.E., Schulz, E., Skanks, M. and Heise, H.(1993): "Plant oils: Topical application and anti-inflammatory effects (croton oil test)". *Dermatologische Monatsschrift*. 179,173.

Ebong, P.E, Owu, D.U and Isong, E.U.(1999):Influence of palm oil (*Elaesis guineensis*) on health. *Plant Food Hum Nutr*. 53:209-222.

Erosa, F.E., Gamboa-León. M.R., Lecher, J.G., Arroyo-Serralta, G.A., Zizumbo-Villareal, D., Oropeza-Salín, C., Rodiguez, L.M.P. (2002): Major components from the epicuticular wax of *Cocos nucifera*. *Rev Soci Quı´mica México*. 46: 247–250.

Ezeoha, S.L., Akubuo, C.O., and Ani, A.O. (2012): Indigenous Design and Manufacture of Palm Kernel Oil Screw Press in Nigeria: Problems and Prospects. *Int. J. Applied Agric. Res*. 7(2):67-82.

Fauser, J.K., Matthews, G.M., Cummins, A.G. and Howarth, G.S.(2013): Induction of apoptosis by the medium-chain length fatty acid lauric acid in colon cancer cells due to induction of oxidative stress. *Chemotherapy*. 59(3):214-24.

Freitas, J.C.C., Nunes-Pinheiro, D.C.S., Pessoa, A.W.P., Silva, L.C.R., Girão, V.C.C, Lopes-Neto, B.E., Agostinho, M.S., Abreu, C.R.A. (2011):Effect of ethyl acetate extract from husk fiber water of Cocos nucifera in Leishmania braziliensis infected hamsters. *Rev Bras Farmacogn*. 21: 1006–1011, doi: 10.1590/S0102-695X2011005000138.

Gaydon, E.M., Bianchini, J.P. and Ratovogery, J.(1983): Triterpene alcohols, methyl sterols, and fatty acid five Malagasy legume seed oils. *J Agri & Food Chem*. 31: 833–836.

Grosso, N.R., and Guzman, C.A.(1995): Chemical composition of aboriginal peanut (Arachis hypogaea L.) seeds from Peru. *J Agri & Food Chem*. 43: 102–105.

Grosso, N.R., Zygadlo, J.A., Lamarque, A.L., Maestri, D.M., and Guzman, C.A.(1997): Proximate, fatty acid and sterol compositions of aboriginal peanut (Arachis hypogaea L.) seeds from Bolivia. *J Sci Food & Agric*. 73: 249–356.

Grosso, N.R., Lucini, E.I., Lopez, A.G., and Guzman, C.A.(1999): Chemical composition of aboriginal peanut (*Arachis hypogaea* L.) seeds from Uruguay. *Grasasy Aceites*. 50: 203–207.

Hoffman, G.(1986): Quality control in food industry, food science and technology series of monographs, 2nd edition, Academic Press, London, 2: pp. 407-504

Ichu, C.B. and Nwakanma, H.O.(2019): Comparative Study of the Physicochemical Characterization and Quality of Edible Vegetable Oils. *Int J Res InformSci Appli & Techn*. 3(2):1-10.

Jaffri, J.M., Mohamed, S., Rohimi, N., Ahmad, I.N., Noordin, M.M. and Manap, Y.A.(2011): Antihypertensive and cardiovascular effects ofcatechin-rich oil palm (*Elaeis guineensis*) leaf extract in nitric oxide-deficient rats. *J Med Food*.14:775-783.

Kappally, S. and Shirwaikar, A. (2015): Coconut oil – a review of potential applications. *Hygeia J Drug Med*.7(2): 34-41.

.Kendeson, A.C., Iloka, S.G., Abdulkadir, A.G., Ushie, O.A., Abdu, Z., Jibril, S., John, S.T.(2019): Phytochemical Screening, Antimicrobial and Elemental Analyses of Crude Extracts from *Cocos nucifera* (Coconut) Shell. *Dutse J Pure and Appl Sci*. 5(1): 237-243.

Krishna, A.G., Gaurav, R., Singh, B.A., Kumar, P.P., Preeti, C.(2010): Coconut oil: chemistry, production and its applications-a review. *Indian Coconut J*. 53(3):15-27.

Kumar, P.K.P. and Krishna, A.G.G.(2015): Physicochemical characteristics of commercial coconut oils produced in India. *Grasas aceites*. 66(1): 1-15.

Kyari, M.Z.(2008): Extraction and characterization of seed oils. *International Agrophysics*. 22: 139–142.

Lima, E.B.C., Sousa, C.N.S., Meneses, L.N., Ximenes, N.C., Santos, Júnior, M.A., Vasconcelos. G.S., Lima, N.B.C., Patrocínio, M.C.A., Macedo, D. and Vasconcelos, S.M.M. (2015): *Cocos nucifera* (L.) (Arecaceae): A phytochemical and pharmacological review. *Braz J Med Biol Res.* (11): 953–964.

Maliki, M., Ikhuoria, E.U. and Ifijen, I.H. (2020): Extraction and Physiochemical Characterization of Oils Obtained fromSelected Under-Utilized Oil Bearing Seeds in Nigeria. *ChemSearch Journal* 11(1):110 – 117.

Nakatsuji, T., Kao, M.C., Fang, J.Y., Zouboulis, C.C., Zhang, L., Gallo, R.L. and Huang, C.M.(2009): Antimicrobial Property of Lauric Acid Against *Propionibacterium acnes*:Its Therapeutic Potential for Inflammatory Acne Vulgaris. *J Invest Dermatol*. 129(10): 2480–2488.

Ogbeide, O.K., Eze, O.F., Akaeze, D.A., Akhigbe, I.U., Omoruyi, U., Iyekowa, O., Owolabi, B.J.(2021): Physico-Chemical Properties, Chemical Composition, Biodiesel Production and Antibacterial Potential of *Terminalia catapa* Seed Oil. *ChemSearch Journal*. 12(2): 2011– 2015.

Ogbolu, D.O., Oni, A.A., Daini, O.A. and Oloko, A.P.(2007): In vitro antimicrobial propertiesof coconut oil on Candida species in Ibadan, *Nigeria*. *J Med Food*. 10(2):384-7.

Owoyele, B.V. and Owolabi, G.O.(2014): Traditional oil palm (*Elaeis guineensis* jacq) and its medicinal uses: A review. Medicinal uses of oil palm. 4(3):1-9.

Pal, P., Rathva, D., Parmar, D., Patel, J., Upadhyay, S. and Upadhyay, U.(2020): A Review on Coconut oil: An Essential Oil for All. *J Pharmacog. and* Phytochem. 9(1)27-32.

Sandhya, S., Talukdar, J., and Bhaishya, D. (2016): Chemical and Biological Properties of Lauric acid. *Int. J Adv. Res*. 4(7)1123-1128.

Vidal, N.P., Adigun, O.A., Pham, T.H., Mumtaz, A., Manful, C., Callahan, G., Stewart, P., Keough, D., and Thomas, R.H. (2018): The Effects of Cold Saponification on the Unsaponified Fatty Acid Composition and Sensory Perception of Commercial Natural Herbal Soaps. *Molecules*. 23:2356.

Vitz, E., Moore, J.W., Shorb, J., Resina, X.P., Wendroff, T., and Hahn, A. (2020): Foods-Acid Value and the Quality of Fats and Oils. *LibreTexts*. pp1-7.

Sarkar, S.K., Miyaji, T., Sasaki, J., Biswas, S.N., Ali, S. and Salam, A. (2020): Fatty Acid Composition, Physico-Chemical and Anti-Oxidant Properties of Almond Seed (Terminalia Catappia L) Oil and Its Therapeutic Uses. J Glob Biosci. 9(5): 7419-7433.

Williams, K.A.(1990): Oils, Fats and Fatty Foods, Their Practical Examination (4thEdition). Longman Publishers: London, UK. pp41-33.

Wu, S.J., Liu, P.L. and Ng, L.T.(2008): Tocotrienol-rich fraction of palm oil exhibits anti-inflammatory property by suppressing the expression of inflammatory mediators in human monocytic cells. *Mol Nutr Food Res*. 52:921-929.

Yin, N.S., Abdullah, S., and Phin, C.K. (2013): Phytochemical Constituents from Leaves of *Elaeis Guineensis* and Their Antioxidant and Antimicrobial Activities. *Int J Pharm Pharm Sci*. 5(4):137-140.

Yong, J.W., Ge, L., Ng, Y.F., Tan, S.N.(2009): The chemical composition and biological properties of coconut (*Cocos nucifera* L.) water. *Molecules*. 14: 5144–5164, doi: 10.3390/ molecules14125144.