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REVIEW PAPER

Physiochemical characteristics, nutritional properties and health benefits of palm oil: A review

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Abstract

Since some decades palm oil obtained from tropical plant, *Elaeis guineneensis* has become major concern due to its high yielding characters. It can solve many health-related issues of humans and also used as economic development tool by many countries. It is basically lipid, which is extracted from mesocrap, a flashy part of palm oil tree. This oil is higher in oleic acid and lower in palmatic acid, so it is easy to process into vegetable oil. In crude palm oil, there are approximately 11 distinct carotenoids. Amongst these, Alfa and beta carotenes are the two most important carotenoids in palm oil. Palm oil, as an antioxidant, is frequently used to treat cancer in addition to being a nutrient-rich source of food, making it very significant for human health. Palm oil's fatty saturated acid to unsaturated acid ratio is very near to one. There is discussion about its effects on the environment as well as human health, so we decided to review all the articles related physiochemical characteristics, nutritional properties and health benefits of palm oil. In conclusion, palm oil emerges as a versatile commodity with significant economic and nutritional value, highlighted by its high productivity and diverse applications. However, the balance between saturated and unsaturated fatty acids in palm oil necessitates careful consideration due to its implications for cholesterol levels and cardiovascular health. As research continues to unveil both benefits and concerns associated with palm oil consumption, further exploration and nuanced understanding are crucial for informed decision-making and sustainable utilization in various sectors.

Keywords: Cardiovascular diseases, Fatty acid profile, Nutrition, Palmitic acid, Palm oil

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Introduction

The oil palm, an ancient species, offers various applications in both domestic and commercial domains through its diverse tree components (Bazlul et al., 2010; Obahiagbon, 2012). The distribution of palm has recently expanded beyond West and Central Africa, where it was previously found in three distinct states: semi-wild, wild, and cultivated. The introduction of oil palm farming to Southeast Asian regions did not occur until the late eighteenth and early nineteenth century, which facilitated palm oil's entrance into the world market for oils and fats. It is still grown domestically in Africa to meet nutritional requirements for oil and vitamin A (Koushki et al., 2015). Palm oil stands among the 17 crucial oils and fats currently manufactured and traded worldwide. Over the past 40 years, it has demonstrated the most rapid global growth compared to all other oils. Despite currently holding the position as the world's second most produced oil following soybean oil, projections suggest that palm oil is self-assured to surpass soybean oil in the near future (Koushki et al., 2015). Palm plant was first introduced in South Asia in 19th century and these regions are the major contributors to oil manufacturing. About 85% of the global palm oil output originates from Malaysia and Indonesia, the primary leading producers. The success of Malaysia's palm oil industry is attributed to a combination of factors, including favorable climatic conditions, advanced milling and refining technologies, robust research and development, and proficient and adequate management capabilities. Almost all palm oil mills use co-generation technology to produce their own heat and electricity (Noor & Muneer, 2009; Abdullah & Sulemani, 2013).

Elaeis guineensis, a tropical plant, is used to produce palm oil. E. *guineensis* and E. *oleifera* are the two species that make up the genus *Elaeis*. Belonging to the Palmae family, the oil palm tree features an unbranched stem and can reach heights between 20 to 30 meters. Typically, it has an economic life span of 25 to 30 years. The fruitlets, which are originally black in colour before turning orange-red when they are ripe, can weigh up to 2000 fruitlets and weigh up to 30 to 40 kg in the female bunch that is produced (Edem 2002; Koushki et al., 2015). The seedlings are placed in plastic bags after germination, which takes approximately 3 months. They are then transported into the field when they are about a year old, and they start bearing fruit in less than 2 years (Abdullah & Sulemani, 2013). At the age of 5 to 6 years, an oil palm plant's leaf count increases from 30 to 40 in a year. Following then, the number of leaves produced declines to approximately 20 to 25 each year (Basiron, 2002), indicating the nation's substantial production and refining facilities as well as its modest domestic palm oil market (Basiron, 2002; Yean & Zhi Dong, 2012). Because of its relative affordability compared to soybean oil, its major rival, and the reasonable freight rates from Southeast Asian suppliers, palm oil is very popular throughout most of Asia. Furthermore, the tropical and subtropical regions have mild enough temperatures that refined bleached deodorised (RBD) palm oil can serve as a household cooking oil without concerns about clouding (Carter et al., 2007). The palm tree (*Elais guineensis*), an ancient tropical plant indigenous to several West African nations, is widely utilized by locals for cooking and various purposes. Malaysia and Indonesia are responsible for the 86% of global palm oil production, although other countries such as Nigeria, Thailand, Colombia, Papua New Guinea, Cote d'Ivoire, India, and Brazil are also main contributors.

Palm oil is obtained in two primary forms: palm kernel oil (PKO), extracted from the seeds, and palm oil (PO), derived from the mesocarp of the palm fruit. There are several ways to extract the edible oil from the mesocarp of a palm fruit, but the most popular ones are the wet and dry processes (Gee, 2007). Southeast Asia has exploited palm oil production as a vehicle for economic development and debate has erupted about the product's harmful environmental effects and the possibility that greater consumption may harm public health (Brown, 2005; Sheil et al., 2009).

Types of palm oil

At temperatures ranging from 20 to 30 degrees Celsius, palm oil typically forms heterogeneous crystals in a liquid state. Industrial-scale fractionation processes utilized to separate palm oil are based on this phase separation. These procedures are relatively straightforward to implement due to the clearer distinction between phases compared to other fats (Koushki et al., 2015). Due to its exceptional resistance to oxidation, palm oil is renowned for enhancing the quality and flavor of various food products. This investigation showcases the distinguishing characteristics of palm oil in comparison to other commonly utilized oils. In regions with milder climates, the oil exhibits a solid consistency due to its composition, containing 32-47% saturated fatty acids, primarily palmitic acid (Klonoff, 2007; Matthäus, 2007). While palm oil derived solely from red fruits, which are lower in palmitic acid but higher in oleic acid, is more suitable for vegetable oil production, the oil obtained from yellow fruits may present benefits in soap and detergent manufacturing (Ekpa et al., 1994). Palm oil remains semi-solid at room temperature and possesses a reddish-brown hue in its natural, unprocessed state. It's crucial for readers to discern between palm oil and palm kernel oil, the latter being a distinct product derived from the kernel of the oil palm fruit widely used in the oleochemical industry. Mesocarp, or fruit flesh, is used to make coconut oil, on the other hand, Margarine, shortening, deep-frying oil, and specialty fats are all food products that use palm oil. As ice cream coatings and fats, as well as to partially replace cocoa butter, confectionery products use palm kernel fats, fractions, or derived products (Maclellan, 1983). These oils have various qualities and characteristics (Deffense, 1985). PKO is utilized for nonfood goods, but the characteristics of CPO make it appropriate for food products (such as margarine and cooking oil) (e.g. cosmetics). Comparing food items to non-food products, product quality is extremely important. Oil (49%) makes up the majority of the kernel's ingredients, which are then followed by carbohydrates (26.1%), protein, and crude fibre (each 8%) (Arami-Niya et al., 2011). Two major fractions of palm oil can be separated: a liquid fraction of palm olein (65–70%) that is liquid at 18–20 °C and a solid portion of stearin (35–40%) that is solid at 48–50 °C. The fractions left over after palm oil has been refined, bleached, and deodorized are known as palm olein.

At the operational temperature, glycerides that solidify undergo crystallization and subsequent separation from the remaining liquid glycerides during the fractionation process. According to Ekwenye (2006), the higher melting segment of this fraction is termed as olein, characterized by an increased presence of monounsaturated oleic acid alongside a decrease in palmitic acid. Palm oil contains substantial amounts of oleic and linoleic acids in addition to a significant proportion of palmitic acid. Palm olein is deemed suitable for use in infant formula and as a dietary fat. Multiple articles extensively discuss the efficacy of palm oil and palm olein in frying various dishes (Maclellan, 1983; Deffense, 1985; Noor, 2009). Palm oil and palm olein are subject to hydrogenation processes that transform them into solid fats with diverse characteristics. These modifications take advantage of the considerable presence of palmitic acid in palm oil and its derivatives, providing intriguing polymorphic attributes that blend effectively with other oils and fats. Food manufacturers choose palm oil because it has a distinctive quality, needs little to no hydrogenation, and increases the shelf life of many products (Mukherjee & Mitra, 2009). Meanwhile, the region where palm shell, a byproduct of the palm oil industries, is most widely accessible is South East Asia. As an illustration, Malaysia produces more than 2 million tonnes of palm shell annually, making it the nation that produces the most palm oil globally. For the most part, steam is currently produced by burning these agricultural wastes. Several studies reveal that palm shells are capable of generating high-quality AC owing to their elevated density, substantial carbon content, and minimal ash content. Furthermore, compared to other byproduct sources utilized in AC production with similar compositions, such as coconut shells (Adinata et al., 2007), AC derived from palm shells exhibits superior adsorption capacity and better development of micropores. In the realm of palm oil, it is observed that fungi and bacteria thrive, particularly in the presence of moisture. The production of palm oil seldom yields free fatty acid content (FFA) below 2% due to the potent nature of their lipolytic enzymes. In ideal processing conditions, the FFA percentage in this oil can exceed 20%. Fruit is smashed, which causes lipolytic action. After 40 minutes, a practically maximum FFA (8–10%) is obtained. Over a four-day period, the FFA of unblemished fruit may only increase by 0.2% or less (Ekwenye, 2006).

Physiochemical properties of palm oil

Predominantly, palm oil, like all oils and fats, consists of glyceridic compounds, accompanied by a minimal presence of non-glyceridic molecules at trace or minute levels. The chemical makeup of palm oil determines its physical and chemical characteristics, which in turn influences whether the oil is suitable for use in specific processes and applications. Hardened groundnut oil and palm oil have demonstrated superior oxidative stability at high temperatures concerning both chemical parameters and sensory evaluations (Myat et al., 2009). Fractionation of palm oil, achieved by crystallizing it partially or by separating it into distinct fractions known as stearin (high melting) and olein (low melting), is a straightforward process due to the oil's fatty acid composition. The high-melting stearin and low-melting olein find diverse applications in lubricants, soaps, food emulsifiers, oleochemical applications, and various industrial processes (Timms, 1985).

Nutritional benefits of palm oil

Palm oil contains substantial natural carotenoids, typically ranging between 500 to 700 parts per million (ppm) (Maclellan, 1983; Ooi et al., 1994). The main carotenoids found in crude palm oil are alpha-carotene (35%) and beta-carotene (56%), both serving as precursors to vitamin A. During regular refining processes, all carotenoids are usually eliminated. However, refining techniques that preserve these carotenoids can be utilized for red palm oil. Crude palm oil contains around 11 different carotenoids, with alpha and beta carotene representing over 80% of the total carotenoid content (Delisle, 2018). Beta-carotene possesses pro-vitamin A properties as they are converted into vitamin A *in vivo*. Carotenoids are also recognized for their antioxidant capabilities. Research has indicated a notable association between beta-carotene and the potential prevention of certain cancers, including stomach, pharyngeal, lung, and oral cancers (Fattore & Fanelli, 2013). The extent of vitamin E reduction during the refining process varies based on different conditions and plant layouts, leading to a wide range of estimates within the industry. Approximately 90% of global palm oil production is used in food applications, necessitating a demonstrable display of the nutritional benefits of palm oil and its derivatives. Various nutritional studies conducted on both human subjects and animals have significantly contributed to our understanding of the physiological and nutritional impacts of palm oil.

Palm oil is vegetable oil enriched with phytosterols, carotene, vitamin E, and ubiquinones, offering versatility in various food products. As an additional edible oil supplement to that currently in use, palm oil requires a thorough assessment of its impacts on dietary intake and health (Rao, 1992). However, scientific support and widespread dissemination since the 1980s have emphasized the nutritional advantages of palm oil. Despite containing approximately 50% long-chain saturated fats, palm oil demonstrates a clear antithrombotic effect, as evidenced by animal studies on arterial thrombus development *in vivo*. Subsequent investigations reiterated these observations. It has been suggested that palm oil's composition, primarily comprising oleic acid at the Sn2 position in the primary triacylglycerols, mitigates its potential to increase cardiovascular risk (TAG). A recent Expert Consultation Report on fats and fatty acids in Human Nutrition hinted at potential evidence suggesting that the impact of palmitic acid on raising total cholesterol and LDL-C might be lower for vegetable sources than for animal sources due to its position primarily at Sn1 and Sn3 positions, in contrast to animal fats like lard, where it predominantly exists at the Sn2 position. Therefore, palm oil, like other vegetable oils such as olive oil, possesses beneficial oleic acid, positioning it on par with olive oil in terms of quality. The culinary industry widely employs palm oil, and DAG derived from palm oil facilitates the production of diverse healthful solid fat products (Ong & Goh, 2002).

Understanding the potential impact of various edible fats on blood cholesterol necessitates a thorough consideration of the typical diets in which these oils are consumed. Regular diets comprise numerous elements that can either encourage or hinder hypercholesterolemia. The quantities of these components in an individual's diet play a pivotal role in determining whether palm oil can elevate or lower cholesterol levels. Existing research has not extensively explored how the composition of regular diets influences the health implications of palm oil consumption (Rao, 1992). For instance, studies indicate that animals fed a combination of rice bran oil and palm oil exhibited notably lower serum cholesterol levels compared to those fed solely palm oil. Furthermore, compelling evidence indicates a correlation between dietary trans fatty acids and an increased risk of cardiovascular disease. Various large-scale epidemiological studies involving diverse age groups ranging from 667 to 80,082 men and women over periods of 6 to 20 years have linked trans-fat consumption to an increased risk of cardiovascular diseases. Controlled studies have demonstrated that compared to cis and saturated fats, the intake of trans fatty acids leads to elevated LDL cholesterol levels, reduced HDL cholesterol levels, and an increased TC: HDL ratio, a more precise indicator of cardiovascular risk. The interim report from the FAO/WHO Expert Consultation underscores substantial evidence indicating that the intake of trans fatty acids leads to a reduction in HDL cholesterol and an increase in the TC: HDL ratio, in comparison to other fats such as saturated fatty acids (C12:0-C16:0), cis monounsaturated fatty acids, and polyunsaturated fatty acids (Mozaffarian & Clarke, 2009).

A mere 2% increase in caloric intake attributed to partially hydrogenated fats or trans fatty acids corresponds to a significant 23% elevation in the risk of coronary heart disease. Recent research also underscores a potential correlation between trans fatty acids and the heightened risk of sudden cardiac death, as well as elements of metabolic syndrome. In response to escalating public apprehension regarding the utilization of artificially produced trans fats in food, more stringent global regulations have been instituted. Consequently, food manufacturers are actively seeking alternatives to commercially hydrogenated vegetable oils, particularly in frying, margarine, and baked products. Addressing concerns, the US Food and Drug Administration mandated the explicit labeling of trans fatty acids on packaged goods, a requirement effective since January 1, 2006. Palm oil emerges as a natural substitute for commercially produced hydrogenated vegetable oils, primarily due to its inherent solid form (Choo & Nesaretnam, 2014). In the industrial sector, high-fiber diets are attracting considerable attention for their pivotal role in human health and their potential to mitigate and prevent various diseases. The identification of new, cost-effective sources of dietary fiber is paramount. With the expansion of the oil palm industry in many Asian and African countries, the volume of palm kernel cake the residual waste post-extraction of palm kernel oilis on the rise. Research underscores that palm kernel with testa contains the highest overall dietary fiber concentration, comprising 63.06 g/100g of testa, 8.49 g/100g of crude fiber, 14.40 g/100 g of crude protein, and 4.43 g/100 g of ash. Notably, the mean moisture content of palm kernel with testa is 3.26, lower than other samples. Defatted palm kernel with testa emerges as a superior and more economical source of dietary fiber for humans when compared to both defatted palm kernel without testa and palm kernel cake.

Health benefits of palm oil

Diabetes mellitus ranks among the leading causes of mortality in middle- and high-income countries worldwide, as highlighted by the World Health Organization (Giri & Bhatia, 2020). To simulate the effects of diabetes in humans, diabetic rats were administered red palm oil and rooibos tea extract over a period of seven weeks. During this time, these animals exhibited symptoms of glycosuria and experienced weight loss due to reduced tissue protein and muscle mass. Following the seven-week trial, it was observed that oxidative damage, a common consequence of diabetes, was mitigated in the rats receiving red palm oil supplementation. These rats also showed a decrease in glycosuria. Conversely, diabetic rats that did not receive red palm oil supplementation demonstrated weight gain. The liver, which plays a critical role in oxidation, detoxification, and combating free radicals, typically exhibits heightened levels of oxidative stress indicators in the early stages of illness. Significant increases in markers of oxidative stress, such as plasma oxygen radical antioxidant capacity (ORAC), glutathione peroxidase, and superoxide dismutase, were noted in the liver subsequent to supplementation with red palm oil alone, rooibos extracts alone, or a combination of both. This suggests a promising potential for these supplements in mitigating the effects of diabetes-related oxidative stress in the liver (Ayeleso et al., 2014).

Anti-cancer properties palm oil

The World Health Organization has identified cancer as the primary cause of illness and mortality on a global scale (Giri & Bhattia, 2020). Among the most frequently impacted organs by cancer are the breast, colon/rectum, lung, cervix, and stomach. Interestingly, 70% of cancer-related deaths occur in regions across Africa, Asia, Central America, and South America. In a study examining the anticancer properties of palm oil, 32 rats induced with colon cancer through azoxymethane were divided into four groups. These rats were provided with diets including red palm oil or soybean oil, paired with either a 7% fat intake, considered average, or a 14% fat intake representing a high-fat Western diet. Over a span of 13 weeks, the impact of these dietary variations was observed. Notably, the supplementation of red palm oil led to a reduction in both the quantity and number of aberrant crypt foci compared to the effects of soybean oil. This result indicates that red palm oil might contribute to impeding cancer growth and potentially assist in its treatment (Snel et al., 2011).

Conclusion

The article provides an in-depth examination of palm oil, covering its physical and chemical properties, nutritional value, and potential health benefits. Palm oil has garnered attention due to its high productivity, posing as a solution for health concerns while also contributing to economic progress. Nutritionally, it contains valuable carotenoids and vitamin E, showcasing promise in thwarting certain cancers and offering essential nutrients. The discussion underscores the significance of the ratio between saturated and unsaturated fatty acids in palm oil, underscoring its impact on cholesterol levels and cardiovascular well-being. Studies reveal palm oil’s potential in hindering the proliferation of cancer cells, notably in colon cancer research incorporating red palm oil supplements. Its richness in antioxidants exhibits promising health advantages but is also associated with concerns such as its saturated fat content and environmental repercussions. This comprehensive evaluation stresses the necessity for further research and a nuanced understanding of the multifaceted effects of palm oil on human health, advocating for an informed comprehension of its role in our daily lives.

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