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EXPLORING THE LUBRICATING PROPERTIES OF VIRGIN COCONUT AND PALM OIL BLENDS FOR ECO-FRIENDLY APPLICATIONS

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ABSTRACT
Coconut and palm oils have great potential to be used as bio-lubricants due to their eco-friendly, non-toxic, and biodegradable properties. Coconut oil offers high oxidative stability, while palm oil enhances lubricity due to its unsaturated fatty acids. Blending these oils can combine their benefits for industrial applications, but further research is needed to optimize the mixture for different conditions and performance requirements.

KEYWORD
Coconut oil, palm oil, bio-lubricants, unsaturated fatty acids, oxidative stability

INTRODUCTION
Lubricants are used to lower friction and reduce wear between two sliding solid surfaces, thereby minimizing wear and tear (Persson, 2000). By reducing lateral friction forces, lubricants help decrease overall friction and surface damage (Klein et al., 1994). Excellent lubricity can be provided by vegetable oils due to their polar ester groups which enable them to adhere effectively to metal surfaces. Chemically modifying vegetable oils to create alternatives to petroleum-based materials has gained attention due to the environmental damage caused by petroleum products and the depletion of petroleum resources. Vegetables-based bio-lubricants are eco-friendly, non-toxic, biodegradable, and generate zero greenhouse gas emissions. Additionally, they offer enhanced lubricity, high viscosity, and can increase equipment service life, making them suitable for automotive and industrial applications.

Palm oil is widely recognized by the industry and has become the preferred choice for lubricants in engines and machinery, reducing the reliance on mineral oil. In a southern state in India, coconut oil is commonly used as a lubricant for two-stroke engines in auto rickshaws and scooters (Jayadas, 2007). Both coconut oil and palm oil possess unique properties beneficial for lubricants, making them popular choices. This paper will focus on these two oils and explore the advantages of blending them, as mixing different oils has been shown to enhance performance.

BACKGROUND
Coconut oil is derived from the kernel of the coconut (*Cocos nucifera L.*), commercially obtained from copra, the dried kernel or "meat" of the coconut. If standard copra is used, the unrefined coconut oil must be purified before it is suitable for consumption, as unsanitary handling and harsh processing can lead to aflatoxin contamination and oxidative rancidity. Virgin coconut oil (VCO), on the other hand, is extracted directly from coconut milk through a wet process under controlled temperatures.

Palm oil, derived from the flesh or mesocarp of the fruit of *Elaeis guineensis*, is obtained through a multi-step process. Ripe fruit bunches are harvested and brought to the oil mill, where the fruit is sterilized, mechanically separated from the bunch, and then broken down. The oil is extracted using a screw press.

VCO and palm oil are primarily composed of fatty acids, which are long chains of carbon and hydrogen atoms. The presence of different fatty acids, and their saturation levels, gives the oils distinct characteristics. The fatty acids content in VCO and palm oil are described in percentage in Table 1 based on CXS 210-1999. These fatty acids are bonded to a glycerol backbone, forming

Triacylglycerols (TAG), the main molecular structure of most fats and oils. This structure of Triacylglycerols (TAG), a glycerol molecule bound to three fatty acid chains, forms the basis of both coconut and palm oils.

VCO is high in medium-chain fatty acids around 60.5% - 63.6% while the rest is long chain fatty acids. Coconut oil contains about 87% saturated fatty acids in the form of 44.6% lauric acid (C12: 0), 16.8% myristic acid (C14: 0), 8.2% palmitic acid (C16: 0), 7.5% caprylic acid (C8: 0), 6.0% capric acid (C10: 0). The unsaturated fatty acids in coconut oil are 5.8% oleic acid (C18: 1) and 1.8% linoleic acid (C18: 2). The major triacylglycerols obtained in the virgin coconut oil are LaLaLa, LaLaM, CLaLa, LaMM and CCLa (La, lauric; C, capric; M, myristic). The TAG composition reflected the high saturation of coconut oil (Marina et al., 2009). Palm oil is composed of about 44% palmitic acid (C16: 0), 40% oleic acid (C18: 1) and 10% linoleic acid (C18: 2). Palm oil is thus a balanced oil as it contains roughly equal amounts of saturated (C16: 0) and unsaturated fatty acids (C18:1 and C18:2). The major triacylglycerols in palm oil are POO, PPO, POL, PPL, and PPP (P, palmitic; O, oleic; L, linoleic).

The different fatty acids and TAG composition in coconut and palm oil supported different properties of the oil. Some comparable properties of coconut and palm oil are provided in Table 2.

Table 1: The fatty acids percentage composition in VCO and palm oil

Fatty acid	Trivial name	Category	VCO	Palm oil
C6:0	Caproic acid	Medium-chain fatty acids (MCFAs)	≤ 0.05-0.7	≤ 0.05
C8:0	Caprylic acid		4.6-10.0	≤ 0.05
C10:0	Capric acid		5.0-8.0	≤ 0.05
C12:0	Lauric acid		45.1-53.2	≤ 0.05-0.5
C14:0	Myristic acid	Long-chain fatty acids (LCFAs)	16.8-21.0	0.5-2.0
C16:0	Palmitic acid		7.5-10.2	39.3-47.5
C16:1	Palmitelaidic acid		≤ 0.05	≤ 0.05-0.6
C17:0	Margaric acid		≤ 0.05	≤ 0.05-0.2
C18:0	Stearic acid		2.0-4.0	3.5-6.0
C18:1	Oleic acid		5.0-10.0	36.0-44.0
C18:2	Linoleic acid		1.0-2.5	9.0-12.0
C18:3	Linolenic acid		≤ 0.05-0.2	≤ 0.05-0.5
C20:0	Arachidic acid		≤ 0.05-0.2	≤ 0.05-1.0
C20:1	Gondoic acid		≤ 0.05-0.2	≤ 0.05-0.4
C22:0	Behenic acid	Very-long-chain fatty acids (VLCFAs)	≤ 0.05	≤ 0.05-0.2

Table 2: Comparing the properties of coconut oil and palm oil (Marina et al., 2009)

Factor	VCO	Palm oil
Melting point	24°C – 26°C	31°C – 38°C
Pour point	23°C	-4°C
Viscosity at 40°C	27.82	106.80
Viscosity at 100°C	7.07	12.07
Relative density (x°C/water at 20°C)	0.908-0.921 at x=40°C	0.891- 0.899 at x=50°C
Iodine value	6.3-10.6	50.0-55.0
Peroxide value (mequiv oxygen/kg)	0.21-0.63	6.33
Saturation	87%, high	49%, moderate
Saponification value (mgKOH/g oil)	248-265	190-209

ADVANTAGES FOR LUBRICATION

Coconut oil possesses impressive lubricant properties, including a high viscosity index, excellent lubricity, a high flash point, and minimal evaporative loss. It has a relative density of 0.908–0.921 g/cm^3 at 40°C, making it less dense than water but denser than palm oil at 50ºC. Coconut oil mixes well with non-hydroxyl-containing liquids, such as light petroleum, benzene, and carbon tetrachloride, and dissolves more easily in alcohol compared to other fats and oils.

Iodine value reflects the degree of unsaturated fatty acids present. Unsaturated fatty acids easily react with oxygen to form peroxides. The number of peroxides present in vegetable oils reflects its oxidative level and thus its tendency to become rancid. Hence, low iodine and peroxide value is desired as it reflects fewer unsaturated bonds, and doesn't spoil or go bad as easily. Coconut oil has a low iodine value, typically ranging from 6.3 to 10.6, which confirms its high saturation and oxidative stability. This characteristic ensures it remains effective under heat, making it suitable for high-temperature applications.

Palm oil is a standout among vegetable oils due to its low production cost and relatively simple extraction process compared to other oils, with Malaysia being one of the world's largest producers (Mahat, 2024). Numerous researchers have provided evidence supporting the reliability of palm oil as a lubricant, as demonstrated by Syahrullail et al., (2011). Their experimental findings show that palm oil offers satisfactory lubrication performance compared to paraffinic mineral oil and has the added benefit of reducing the extrusion load in the cold forward extrusion process. This performance is linked to palm oil's low pour point, which is the temperature at which a liquid becomes too thick to flow easily. The low pour point is particularly important for oils used in machinery, as it defines their temperature limits in cold conditions.

Additionally, palm oil is more unsaturated than coconut oil. Unsaturated fatty acids are better for lubrication because they have certain chemical characteristics that make them stick well to surfaces, especially metals. This ability to cling to surfaces helps form a strong protective layer or "film" that reduces friction and wear. The structure of unsaturated fatty acids includes bends in their chains, due to double bonds, which make them more flexible and better at spreading across surfaces. Additionally, they have polar groups (parts of the molecule that are slightly charged), which helps them bond more strongly to metal surfaces compared to petroleum-based oils, which are less polar. Its stability at high temperatures further enhances its suitability for various industrial applications.

COMPLEMENTARY PROPERTIES AS OIL BLEND

Study by Gasni et al. (2020) has shown that the addition of a specific percentage of oleic acid, which dominates the unsaturated fatty acid composition in palm oil, to coconut oil decreases the coefficient of friction and reduces ball bearing scar width. Another study highlighted that the unsaturated fatty acids in palm oil, oleic and linoleic acid, are primarily responsible for better lubricity when compared to stearic acid which is saturated fatty acids. The faster adsorption of unsaturated fatty acids on metal surfaces enhances their lubricating properties, making them more effective as boundary lubricants (Loehlé et al., 2013). This showcases the possibility of the unsaturated fatty acids in palm oil may complement coconut oil in terms of the lubricating properties. Studies also show that modifying palm oil through processes like partial hydrogenation can selectively reduce multiple unsaturated fatty acids, improving oxidation stability while maintaining good lubricity. This balance is crucial for industrial applications where both stability and lubrication performance are needed (Shomchoam & Yoosuk, 2014).

The blend mixture however needs to be studied further to find the optimal composition that can achieve lubricant with the best desired properties. The blend not limited to only VCO and palm oil, but can also by adding the blend to engine oil as the base lubricant for example. Different applications may require different mixture composition as properties of the oil may change depending on parameters such as the temperature or speed.

CONCLUSION

Coconut oil (VCO) and palm oil possess unique fatty acid compositions that make them suitable for different lubrication applications. Coconut oil is highly saturated, providing excellent oxidative stability and high-temperature performance, while palm oil, with its higher unsaturation, offers enhanced lubricity due to its ability to form a strong protective film on metal surfaces. Blending coconut and palm oils could potentially combine their strengths, enhancing both oxidative stability and lubricity, although further research is needed to optimize the blend composition for specific industrial applications. Modifications, such as partial hydrogenation, can further enhance palm oil's stability without compromising its lubricity, making it an excellent candidate for automotive and industrial uses. Overall, the combination of coconut oil and palm oil offers a promising, eco-friendly alternative to traditional lubricants.

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