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# THE USE OF VEGETABLE OIL IN LUBRICANT AS BASE OIL: A REVIEW

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## ABSTRACT

This paper is a review of vegetable oil in lubricant industry. Vegetable oils already used as lubricant since ancient time. The suitability of vegetable oils as lubricant is mainly influenced of its composition and stabilization towards oxidation. The addition of suitable anti-oxidant is believed significantly enhanced the stability of vegetables oil. Therefore the modification of vegetable oil structure is necessary to enhance its performance as a better lubricant.

***Keywords:*** Vegetable Oil Based Grease, Lubricant Base Oil, Oxidation Stability

## INTRODUCTION

Environmental concern and regulation has increase the need of renewable and biodegradable lubricants such as oil lubricant, grease or solid lubricants. Thickener and base oil determine the greases' biodegradable properties and lubricating ability. Recent environmental awareness has put mineral oils; as the most widely used lubricant base fluid into consideration by the use of biodegradable fluid like vegetable oils and other synthetic fluids into new grease formulation (Sharma et al., 2005). The lubricant made of vegetable oil already be used by human since ancient time. For example olive oil was used as lubricant since 1650BC (Gawrilow, 2003).In this world many type of vegetable oils are produced commercially as it is being used in many applications especially in industry and also as foods. Nowadays mineral oil which is derived from petroleum and synthetic oil from petrochemical are mainly used as base oil in lubricant. In recent years there has been serious concern of the remaining of the world petroleum resources. For over 100 years mineral oils have dominated lubrication and nowadays the environmental issue start to arise as the mineral oil and synthetic oil is not readily biodegradable (Bartz, 1998). Today vegetable oil are gaining popularity because of the significant advantages to environment as the vegetable oil is a renewability resource, biodegradability, and posse's adequate performance in a variety of applications (Gawrilow, 2003). In household and industrial lots of edible oil waste of vegetables oil wasted to environment. This review will particularly try to review how we can benefit these wastes into wealth by turning the edible oil waste as one source of lubricant and its suitability.

## COMPOSITION OF VEGETABLE OILS

Basically vegetable oil is made of two simple building blocks which are glycerol and fatty acids. Based on the Handbook of Vegetable Oils and Fats (Alender et al., 2007) there is only one type of glycerol but the fatty acids can vary widely in their structure. Glycerol consists of three alcohol groups where fatty acids can be attached and the resulting products are termed monoglycerides (one fatty acid), diglycerides (two fatty acids) or triglycerides (three fatty acids). Quality and the stability of vegetables oil is a main factor to be accepted in market (Smouse, 1995). Vegetable oils in general have excellent properties such as high viscosity index, high lubricity, high flash point, low evaporative loss, high bio-degradability and low toxicity with regard to their use as base oil for lubricants (Adhvaryu, 2002; Sevim, 2000; Philip et al., 2004). In contra, vegetable oil also infamous of its low thermal, oxidative, and hydrolytic stabilities and poor low-temperature characteristics (Adhvaryu, 2002; Zeman et al., 1995).

## Used Cooking Oil

Used cooking oil is produced daily either by household user or by commercial and industry use worldwide. The used cooking oil usually is dump into the drain even though it is still has many use. Currently intensive research is being made world wide of the use of vegetable oil including cooking oil and used cooking oil in biodiesel application as one of the main world's energy contribution. Several researches also find that with some refinery and modification process used cooking oil also can be used as multi-purpose lubricant. In deep frying some complex chemical reaction take place as the vegetable oil undergo structure modification. Based on the research made by Melton et al. (1994) during frying, oils degrade mainly via thermal oxidation and form volatile and nonvolatile decomposition products. While volatile are responsible for deep-fried flavor, measurement of nonvolatile provides better methods degradation of a frying fat. Deep frying increase aeration of oil as a result of water vaporization process of food thus increase oxidation of oil. The oxidation process let the formation of primary oxidation product, the hydroperoxides which is extremely unstable and decomposes via fission, dehydration and formation of free radicals to form a variety of chemical products both volatile and nonvolatile.

## Properties of Used Vegetable Oil

### *Oxidation*

Fundamental knowledge of the oxidative properties of lubricants is necessary to predict the long-term thermal stability of vegetable oil as it is critically important for lubricant property (Jayadas, 2006). Generally the oxidation stability of vegetable oil is determined by the degree if unsaturation, the presence of natural and synthetics antioxidants, the presence of pro-oxidants such as metal and availability of oxygen。Triacylglycerols oxidation normally takes place at the double bond proceeding via a formation of hydroxides to ketones and aldehyde (Alender et al., 2007). Fox and Stachowiak (2007) mentioned that the fatty acids in vegetable oil triglycerides are all of similar length, between 14 and 22 carbons long, with varying level of unsaturation. The triglyceride structure of vegetable oils provides qualities desirable in a lubricant since the long, polar fatty acid chains provide high strength lubricant films that interact strongly with metallic surfaces and reduce friction and wear. Indeed the strong intermolecular interactions are resilient to changes in temperature that providing a more stable viscosity.

Low oxidation stability contributes to major factors that hinder the industry to accept vegetable oil based as lubricants. However the oxidation stability of vegetable oil can be improved through selective breeding programs and genetic modification, and also by chemical modification of oil structure by techniques such as blending, interesterification, hydrogenation and epoxidation. Oxidation properties evaluated experimentally are often used to predict actual lubricant service life in high temperature and other extreme applications. The more resistant a lubricant is to oxidation, the fewer tendencies for the lubricant to form deposits, sludge, and corrosive byproducts in grease, engine oil and industrial application (Jayadas, 2006).

*Anti-Oxidant*

A study made by Merrill et al. (2008) measure the oxidative stability of conventional and high-oleic varieties of commercial vegetable oils, with and without added antioxidant. The variety study of vegetable oil is soybean, partially-hydrogenated soybean, corn, sunflower, canola, high-oleic canola, very high-oleic canola, oleic safflower and high-oleic sunflower. One or more anti-oxidant was added to the selected vegetable oils at recommended level from supplier. Among the antioxidants use such as rosemary extract, ascorbyl palmitate, tert-buthylhydroquinone and mixed tocopherols.  The anti-oxidant effect is evaluated use oil stability index. Oxidation determines the service life of a lubricant. Oxidation resistance and operating temperature will measure the oxidation resistance of the oil (Landsdown, 2004). It is also stated by Landsdown that certain metals increased the oxidation. The rate of oxidation can be reduce with the presence of anti-oxidants either natural or additives.

**Modification of Vegetable Oil**

There are many study made by several researchers of how to improve the quality of vegetable oil to be used in as lubricant base. In a study made by Campanella et al. (2009) explain that even though vegetable oil possess most of the desirable lubricity properties such as good contact lubrication, high viscosity index, high flash point and low volatility vegetable oil also have some drawbacks that must be overcome. Gawrilow (2003) suggested few solutions of improving low temperature and pour points. These include interesterification with other potential vegetable oils such as high oleic canola oil, blending with synthetic esters to improve low temperature properties such trimethylol propane trioleate or trimethylolethane tetraoleate, transesterfication with various polyols and genetic engineering to reduce saturates and increase monounsaturates. A study on vegetable oil blends was conducted by Chu and Kung (1997). They used the oil stability index (OSI) and peroxide value (PV) to determine the quality of oil blends. Soybean oil was blended with other refined, bleached and deodorized (RBD) oils where the quality of mixture oil was between of soybean oil and the RBD oils used. By blending the high quality oils with lower quality of oils in term of anti-oxidants can improve the quality of anti-oxidants of the lower quality oils.

## TEST EQUIPMENTS AND METHODS

A lot of methods and equipments have been developed throughout the year to study and to measure the chemicals interaction and their influence on the physical properties of vegetable oils. A study done by Jayades and Nair (2006)  make use of  thermo-gravimetirc analysis (TGA) under nitrogen and oxygen environment to vegetables oil thermal and oxidative degradation and the use of differential scanning calorimetry (DSC) to analyze the low temperature properties of vegetable oils. They also use a molecular dynamics simulation software to study the effect of different saturated and unsaturated fatty acid such as lauric, oleic, linoleic chain and the effect on pour point. DSC also is an excellent method to measure wax appearance and crystallization temperature of vegetable oils (Adhvaryu et al. 2003). In their study they observe the turning fork conformation of fatty acid chains of a triacylglycerols molecule and undergo molecular stacking during the cooling process. Various chemical reaction mechanism based on free radicals are thought to be involved in the oxidative degradation of engine oils (Igarashi, 1990). ASTM D943 test method is very widely used in industry to assess storage and long term service oxidation stability of oils in the presence of oxygen, water, copper and iron at an elevated temperature (95°C).

Pressurized differential scanning calorimetry (PDSC) and FT-IR us used to measure oxidation performance of oils containing selective anti-oxidants such as Zinc dithiocarbamate (ZnDTC), zinc dialkyldithiopghosphatw (ZDDP) and the mixture of both. The oils containing the same additives at different concentrations and oils containing a single or mixture of additives were quite different from data obtained use PDSC. In the 3rd Global Oils and Fats Business Forum USA by Gawrilow (2003), stated that vegetable oils used for lubrication industry has its own testing protocols. It is included pour point test (ASTM 97), Brookfield Viscosity (ASTM D2983), Oxidative stability, Industrial Gear Oil High Temperature Test (ASTM D2893), Turbine Oil Oxidation Test (ASTM D943), Hydrolytic Stability （D2619）, Corrosion Testing, and Rotary Bomb Oxidation (RBOT) ASTM D2272. Abdulkarim et al. (2007) conducted a test to high-oleic *Moringa oleifera* seed oil frying quality and stability and compare the result to other type of conventional frying vegetable oils such as canola oil, soybean oil and palm olein oil. Standard methods for determination of used frying oil deterioration such as changes in color, viscosity, free fatty acids, peroxide value, p-anisidine value, iodine value, specific extinction and total polar compounds were used to evaluate the oils. At the end of the frying period which is 6 hours per day for 5day the change in percent of free fatty acids from initial to final day is observed.

## CONCLUSION

Vegetable oils naturally suitable to be used as lubricant base oils. With the co-operative of chemical modification methods to enhance its physical properties the vegetable oils are functioning as good as the mineral and synthetics oils or better. Selective addition of additives is crucial to increase its stability and provide the vegetable oils to work under wider range of temperature and pressure. With the outstanding performance, non toxic, and biodegradability advantages vegetable oil will be a better choice to be use yet it is still offer space for improvement and usefulness. The test methods such DSC, TGA and FT-IR provided alternative and multi-selection of vegetable oils properties instead of ASTM methods of how the chemical structures especially the unsaturated fatty acid components and its influence to the quality of a particular vegetables oil and the selective modification required. It is desirable to incorporated vegetable oil as greases' base oil where thickener will be added for non-Newtonian application.

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