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Attendant Effects of X-Rays on the Physico-Chemical Properties of Grand Groundnut Oil

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ABSTRACT

Grand, a brand of groundnut oil was studied to investigate the effect of X-irradiation on its physicochemical properties. Different physicochemical parameters were characterized- the iodine value, free fatty acid (FFA) value, pH value and viscosity of the non-irradiated oil was obtained as 2.38, 1.83, 5.73 and 4.80 × $10^{-5}m^2/s$ respectively. The effect of X-irradiation on the oil showed a modification of the iodine value, Free Fatty Acid (FFA) value, pH value and viscosity to be 2.28, 2.86, 5.25 and 4.52 × $10^{-5}m^2/s$ when irradiated once. Also, 2.23, 3.25, 5.14 and 4.52 × $10^{-5}m^2/s$ when irradiated twice and 2.17, 3.70, 5.06 and 4.20 × $10^{-5}m^2/s$ when irradiated the third time. From the results of the investigated parameters, it was concluded that the oxidative deterioration level of the Grand oil can be used as a lubricant if the higher viscosity can be lowered and its oxidation stabilized appreciably.

Introduction

A vegetable oil is a triglyceride extracted from a plant. Such oils have been part of human culture for millennia [1]. The term 'vegetable oil' can be narrowly defined as referring only to plant oils that are liquid at room temperature [2] or broadly defined without regard to a substance's state of matter at a given temperature [3]. For this reason, vegetable oils that are solids at room temperature are sometimes called vegetable fats. Vegetable oils are composed of triglycerides, as contrasted with waxes which lack glycerin in their structure.

Although many plants may yield oil, in commercial practice, oil is extracted primarily from seeds. Oils extracted from plants have been used since ancient times. Unsaturated vegetable oils can be transformed through partial or complete hydrogenation into oils of higher melting points. The hydrogenation process involves 'sparging' the oil at high temperature and pressure with hydrogen in the presence of a catalyst, typically a powdered nickel compound [4]. As each carbon-carbon double bond is chemically reduced to a single bond, two hydrogen atoms each form single bonds with the two carbon atoms. The elimination of the double bonds by adding hydrogen atoms is called saturation; as the degree of saturation increases, the oil progresses towards been fully hydrogenated which increases resistance to oxidation or to change its physical characteristics. As the degree of saturation increases, the oil's viscosity and melting point increase [5].

Many vegetable oils have similar fuel properties to diesel fuel, except for higher viscosity and lower oxidative stability. If these differences can be overcome, vegetable oils may be used as substitutes for diesel/engine fuel or home heating oil. Vegetable oils are also promising substitutes for petroleum base oils in lubricant applications such as total loss lubricant, military application and outdoor activities. Although vegetable oil use as a lubricant may have some advantages, there low temperature stability and poor oxidation are major shortcomings [6].

One of the vegetable oils of interest is the grand groundnut oil. There has been a lot of interest in this oil because of its potential in been used as a lubricant and biodiesel. This oil is made up of what is scientifically known as "triglyceride molecules" which under the microscope look like the capital letter 'E'. The molecules are very similar in structure and contain multiple double bonds when exposed to high temperatures and oxygen from the air. They readily condense together, oxidize and sometimes break apart. At cold temperatures, the molecules easily stack together forming little crystals that join together eventually rendering the liquid oil a mass of solidified junk [7].

What Adhavaryu [8] and his colleagues did has chemically altered the symmetrical structure of the molecules so that they no longer stack together at cold temperatures. The result is an inedible vegetable oil product that is more stable at both hot and cold temperatures, which is a key requirement for using it as a stand-alone engine oil, industrial fluid and special grease. In addition, the chemical modification also improves the oils lubricity.

Biodiesel is a cleaner burning alternative fuel that can be used in any diesel engine. This could be domestically produced as a fuel made from groundnut oil. The use of biodiesel as a conventional diesel engine oil results in a substantial reduction of unburned hydrocarbons, carbonmonoxide and particulate matter [9].

This work is designed to study different physicochemical properties of grand groundnut oil, irradiate the oil with X-rays and observe the effect of radiation on the physicochemical properties of the groundnut oil and investigate its suitability for industrial application as either a lubricant or biodiesel.

Materials and Methods

The oil used for the research was purchased locally in the open market and the sample stored in a cool place.

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Other materials used include, weighing balance, electronic digital scale (model 333), beakers, conical flasks, funnels, sample bottles, measuring cylinder, wash bottle, burette, white tile, retort stand and clamp, measuring tape, volumetric flask (250ml), PH meter, thermometer, X-ray machine (GEC CD385), stop watch, cotton wool, methylated spirit etc.

The oil was analyzed for iodine value, pH value, Free Fatty Acids (FFA) and viscosity by following analytical methods and procedures outlined by Association of Official Analytical Chemists (AOAC), [10] which evaluates and validates the methods through collaborative studies and appropriate techniques to give accurate and reproducible analytical results on the matrix and analyte to which the method is stated.

The oil sample was then irradiated using a single phase diagnostic X-ray machine (GEC CD385) at the Federal Medical Center, Makurdi, Nigeria. The sample irradiation parameters were:

1. Tube current or exposure factor of 56mA at 0.1 seconds
2. Peak tube voltage of 100kVp
3. Source to sample distance (SSD) of 100cm

Results

Table 1. Physicochemical properties of grand oil before irradiation

Iodine value	2.38
Free Fatty Acid value	1.83
pH value	5.73
Viscosity (m^2/s)	4.80×10^{-5}

Table 2. Physicochemical properties of grand oil after irradiation

X-ray exposure	1st	2nd	3rd
Iodine value	2.28	2.23	2.17
Free Fatty Acid Value	2.86	3.25	3.70
pH value	5.25	5.14	5.06
Viscosity (m^2/s)	4.52×10^{-5}	4.36×10^{-5}	4.20×10^{-5}

Discussion

The result of the physicochemical characteristics of grand groundnut oil is presented in tables 1 and 2 above. The result for all the parameters studied show that the values obtained for the samples before X-ray irradiation are different from those after irradiation of the samples. This broke molecular bonds and produces free radicals. This effect is observed in the increase in the pH value of 5.73 before X-ray irradiation and decrease in the pH values range from 5.12, 5.14 and 5.06 respectively due to the number of these irradiations. This makes the oil more acidic thereby increasing the free fatty acid (FFA) value. The report of Anwar *et al* [11] that was looking at the assessment of oxidative deterioration of grand oil at ambient and sunlight storage showed increase in the free fatty acid (FFA) has become saturated as the iodine value showed a decrease from the value of 2.38 to 2.28, 2.23 and 2.17 respectively due to the number of times of X-irradiation. Low iodine value oils are more saturated with fewer double-bonds, therefore having high cetane values and are more efficient fuels than high iodine value oils. However, they have higher melting points and are usually solids at room temperature.

Biodiesel made from low iodine value oils also has a higher melting point and might only be suitable for use as summer fuel. The iodine value can be important because many biodiesel fuel stands specify an upper limit for fuel that meets the specification. The iodine value does not necessary make the best measurement for stability as it does not take into account the positions of the double bonds available for oxidation. In some cases, this could lead to iodine values that are misleading. Thus, the modification of the iodine value in this research has shown that the X-irradiation of the grand oil has actually lead to the decrease in the iodine value thereby making it suitable as a biofuel and as a lubricant by way of introducing a thickener to hold the unsaturated free fatty acid (FFA) together.

Conclusion

The use of X-rays to irradiate grand oil has decreased the iodine value, pH value and viscosity value and increased the Free Fatty Acid (FFA) value of the grand oil. The increase in the iodine value may lead to a rise in the plasma iodine which is however small and can be ignored especially in irradiated oils. Also, the formation of Free Fatty Acid (FFA) is generally responsible for the soapy taste of the oil after irradiation and may suggest that exposing it to irradiation renders it unsuitable for human consumption and domestic use. Furthermore, the use of X-rays to irradiate the grand oil has shown that there are significant changes in the physicochemical properties of the oil. It must however be pointed out that the use of X-rays on grand oil renders it not edible as it changes the free fatty acid (FFA) values.

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