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Investigation of Rice Bran Bio-fuels and Engine Performance

Sivashankaran[a], Ravi Kumar[b], Manuneethi Arasu[c]*, Karthick[d], logesh[e], Ramkumar[f], Sudharshan[g]

[a&c] *Professor, Jayalakshmi Institute of Technology, Dharmapuri, Tamilnadu.*
[b] *Professor, Bannari Amman Institute of Technology,Sathiyamangalam, Tamilnadu*
[d,ef&g] *Student , Jayalakshmi Institute of Technology, Dharmapuri, Tamilnadu.*

A B S T R A C T

Environmental awareness and depletion of resources are driving the industry to develop viable alternative fuels from renewable resources that are more environmentally acceptable. Vegetable oil is a potential alternative fuel. The most harmful properties of vegetable oils are its high viscosity and low volatility, and these cause many problems during their long-term use in compression ignition (CI) engines. A commonly used method for making vegetable oil suitable for use in CI engines is to convert it into biodiesel, i.e. vegetable oil esters using a transesterification process. Rice bran oil is an underutilized non-edible vegetable oil that is abundantly available in rice-growing countries, and very little research has been done on its use as a substitute for mineral diesel. In the present work, the transesterification process for the production of rice bran oil methyl ester was investigated. Various process variables such as temperature, catalyst concentration, methanol amount and reaction time were optimized with the aim of producing high quality rice bran oil biodiesel with maximum yield.

Keywords: Biodiesel, Rice bran oil, Fatty acid profile

1. Introduction

Increased demand for fossil fuels due to increasing population, industrialization and urbanization leads to increase in fossil reserves and price of crude oil. This urbanization leads to excessive use of fossil fuels in the transportation sector. The main greenhouse gas, CO2, is significantly emitted by cities. One such alternative is bio-fuel, as it has lower GHG emissions over the complete life cycle. This makes economic growth based on massive consumption of fossil fuels very unsustainable. Mankind's energy needs are increasing. Among all bio-fuels like bio alcohols (ethanol, methanol, butanol, propanol), biodiesel, biogas, bio-hydrogen, etc, ethanol has been widely supported by scientists all over the world as an alternative to petroleum-based fuels owing to the numerous advantages it offers over other bio-fuels. De-oiled rice bran is a by-product of industries producing rice bran oil, which is produced by hexane extraction of oils from rice bran and is commonly used as a nutritional supplement in animal feed [1].

The pretreated biomass contains a range of polysaccharides that require their respective hydrolyses to release simple sugars. Bio-fuels can be categorized into primary and secondary bio-fuels. Natural bio-fuels including plants, firewood, animal waste, crop residue, forest waste are primary bio-fuels. The secondary bio-fuels are generated from plants and microorganisms by processes and technologies. The third-generation bio-fuels are mainly produced from algal biomass. The fourth generation of bio-fuels is a relatively new type and it makes use of the synthetic biology tools to produce electro fuels and photo-biological solar fuels by direct conversion of solar energy into fuels [2].

Rice bran oil is a unique vegetable oil produced from the outer brown layer of rice, which is removed in the form of rice bran during the polishing process of the rice milling industry [3].

Besides having an almost ideally balanced fatty acid profile, it is rich in natural anti-oxidants. A number of scientific studies conducted in India & abroad have well documented the better cholesterol lowering properties of rice bran oil as compared to other conventional vegetable oils [4&5]. All these studies have attributed these properties of the oil to the presence of unique nutraceuticals in this oil known as oryzanol & tocotrienols.

Rice bran oil is the world's healthiest cooking oil, rich in vitamins, antioxidants and nutrients. Not only is it soft and delicious; But it helps reduce cholesterol, fight disease, boost immunity, and fight free radicals. It contains highest amount of all natural vitamin-E and contains unique component oryzanol which is linked with increase in good cholesterol and lowering down the bad cholesterol and triglycerides [6].

India is the second largest producer of rice in the world next to China, having potential to produce about 13.04 lakh MT of Rice Bran Oil per annum [7]. RBO has the ideal ratio of saturated, monounsaturated and poly-unsaturated fatty acids and is the closest to World Health Organization recommendation. The tocotrienol present in RBO has anti-thrombotic and anti-Cancer properties and good for skin. It contains squalene which improves skin tone and delays wrinkle formation [8].

The typical composition of crude rice bran oil is 81.3-84.3% triglycerides, 2-3% diglycerides, 5-6% monoglycerides, 2-3% free fatty acids, 0.3% waxes, 0.8% glyco-lipids, 1.6% phospholipids, 4% unsaponifiables Orysanol is a powerful antioxidant found only in rice bran oil [9]. It is more active than vitamin E in fighting free radicals. Oryzanol is effective in lowering blood cholesterol levels, reducing liver cholesterol synthesis, and treating menopausal disorders. Crude rice bran oil contains about 1.5% or more gamma-oryzanol, a group of ferulate esters of triterpene alcohols and phytosterols[10].

2. Experimental work

2.1 Degumming of crude rice bran oil

2.1.1 Materials

Crude rice bran oil was obtained from A. P. Solvex Ltd., Dhuri, Punjab. Commercially extracted crude rice bran oil was degummed under a range of experimental conditions of water concentration, temperature, time and speed of agitation.

2.1.2 Acid Degumming

Crude rice bran oil (500g) was weighed in a 1 lt beaker and heated to 60-70 ºC on hot plate with a magnetic stirrer, then was treated with 2% water and food grade phosphoric acid. A critical quantity of dilute caustic soda was added to neutralize the acid and stirred at 300 rpm for 30 min using magnetic stirrer at 60-70ºC to complete gum hydration.

Physically refined rice bran oil, sunflower oil and safflower oil were obtained from A. P. Organics Pvt. Ltd. Dhuri, Punjab. Packaging materials, used for storage of oil samples were PET, laminates consisted of typical three layer co-extruded film consisting of LD+LLD-HM HDPE- Primacor and glass bottles. The packaging materials used under study were also supplied by A. P. Organics Pvt. Ltd., Dhuri, Punjab. All the chemicals used in the study were of AR grade.

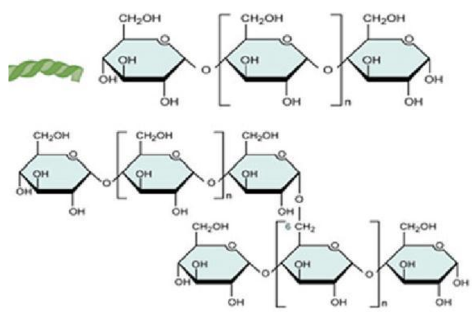

Fig. 1. Structure of starch

2.2 Preparation of samples and their storage

Safflower, PRBO: Sunflower, oil blends were prepared in the proportions of 20:80, 60:40 respectively (Sharma et al., 1996 b and Sharma et al., 2006) and were filled in PET bottles, glass bottles and laminated pouches (typical three layer co-extruded film consists of LD+LLD-HM HDPE- Primacor). The samples were stored for a period of 11 months at a temperature of 25±5ºC and relative humidity of 60-70% respectively. The samples were opened after every two months for the evaluation of various physico-chemical parameters.

Table1. Advantage and disadvantage of acid and enzymatic hydrolysis

Hydrolysis	Advantage	Disadvantage
Acid	High yield of sugar Less reaction time Pretreatment not required	Acid is highly corrosive to equipments, High acid consumption, Acid needs to be recovered, Unsafe and detrimental to the Environment, Formation of inhibitors
Enzymatic	Non-corrosive to equipment Environment friendly Inhibitors are not formed	Pretreatment needed, The high cost of commercial enzymes, Reaction is slow

3. Result and Discussion

The physicochemical characteristics of crude rice bran oil are shown in Table 1. Initially crude rice bran oil contained 350 ppm P (phosphorus)-content, 0.45% moisture insoluble volatiles, 56.0 unit color, and 29.0 unit colors after bleaching. Bleachability of crude rice bran oil was 48.21% and gums-oil percentage in crude rice bran oil was 98.24 % and 1.76 % respectively whereas free fatty acid of oil was 16.29 % and unsaponifiable matter was 5.10 %.

Table 2. Parameters and rude rice bran oil component

Parameters	**Crude Rice Bran Oil**
P content (ppm)	350±27
MIV (%)	0.45±0.01
Colour (1/4" cell)	56.0±0.28
Bleached oil colour (1/4"cell)	29.0±0.28
Bleachability (%)	48.21±0.18
Oil (%)	98.24±0.13
Gums (%)	1.76±0.03

The efficiency of degumming was evaluated on the basis of p content, FFA and color as shown in Table 2. Results observed after acid degumming by using different concentrations of phosphoric acid ranging from 1 - 3.5 kg/ ton is shown in Table 3. As the concentration of phosphoric acid increased from 1 to 3.5 kg/ton, there was a decrease in p-content, FFA and colour up to 86 ppm, 16.60% and 38.0 units respectively. The residual oil percentage after enzymatic degumming was increased to 69.19% from an initial value of 55.98% on increasing the enzyme concentration from 40 to 65 g/ ton. While after acidic degumming the residual oil were reduced to 51.72 % from an initial value of 66.32 % when the phosphoric acid concentration was increased from 1 to 3.5 kg/ ton. The highest level of free fatty acids formation was found in PRBO, 0.30% when stored in PET bottles whereas the lowest was 0.24% when packed in laminated film pouches after 11 months of storage. However, the blended oil, consisting of PRBO and SAF (safflower oil) showed least amount of free fatty acids formation after 11 months of storage as compared to the PRBO and blended oil (PRBO+SNF).

The PV of PRBO and blends stored for 11 months in PET, laminated pouches and glass bottles was increased with the storage period (Table 2). However, all the oil samples, packaged under PET, glass and laminates remained acceptable and within the limits, less than 10 meq/kg stipulated by PFA (1954). The initial PAV in PRBO and its blends with sunflower and safflower oil was 30.56, 29.02 & 20.79 respectively.

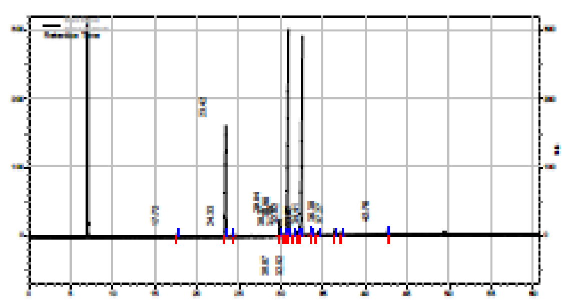

Figure 2. Fatty acid profile for Rice bran oil

The effect of storage on the different quality parameters of chemically refined rice bran oil (CRBO), physically refined rice bran oil (PRBO), sunflower oil and safflower oil is given. The initial PAV in CRBO, PRBO, SnFO and SaFO was 25.64, 30.56, 6.26 & 5.19 respectively (Table 2-4). PAV for all the samples increased with storage period. Gulla et al., (2010) reported increase in PAV during storage of sesame and sesame and soybean blends.

4. Conclusion

Efficiency of degumming was evaluated on the basis of p content, FFA, color of degummed oil and residual oil content in gums separated. It was found that the p content in oil, degummed enzymatically was lesser as compared to acid degummed oil. After enzymatic degumming, the residual oil percentage was increased to 69.19 from an initial value of 55.98 while the residual gums were reduced to 30.81 from an initial value of 49.02 when the concentration of enzyme was increased from 40 to 65g/ton.

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