ISSN 0973 - 6379

JOURNAL OF LIPID SCIENCE AND TECHNOLOGY

Volume 52 No. 01 Jan - Mar 2020

Published by
Oil Technologists' Association of India

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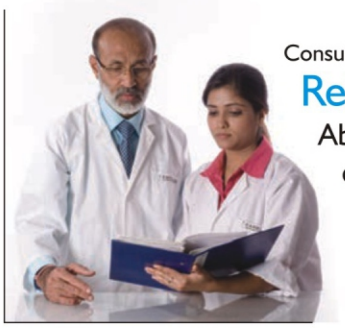

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Journal of Lipid Science and Technology

Volume 52 **No. 1** **Jan - Mar 2020**

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From Editors Desk

Hello Friends,

Inevitable use of fuels other than petroleum based diesel fuel was predicted some time ago in 1890's . However, more than a century has passed in course of time, still vegetable oils or their derived products have not emerged as major fuel substitute due to a single, but highly important reason that is the availability of raw material.

The boundary line between food and fuel is blurred since both the fields are competing for the same resources. Debating over food versus fuel is still a dilemma. There are large surplus of food crops in developed countries. However, millions of people in developing countries still face the scarcity of food. Conversion of food crops such as coconut oil, corn, soybean and sugarcane to fuel could lead to serious food shortage.

Different seed oils have been used in several countries as feed- stocks for production of biodiesel according to their availability. Soybean oil is often used in United States, Brazil and Argentina, while rapeseed oil is common to a good number of European countries, while palm and coconut oils are used in Malaysia and Indonesia for biodiesel production. But countries having lesser availability of edible oil than demand like India can not use these oils for biofuel production because it would increase the price of fuel as well as edible oil and can cause a food crisis.

India's total oilseed production in Marketing Year (MY) 2020/21 (October-September) is expected to rise two percent to 38.4 million metric tons (MMT), averaging one metric ton per hectare. An improved oilseed supply situation will help oil meal production rebound 5.2 percent to 17 MMT. Total oil meal exports will recover from 2.1 MMT to 2.5 MMT, but strong consumption demand, which is projected to rise 4.6 percent to 15.2 MMT, will limit the trade surplus. Concurrently, vegetable oil imports will rise six percent to 15 MMT to fill the supply-demand gap.

In the present scenario exploiting non-edible oil/ minor oilseeds for the production of biofuel is one of the solutions for fuel security without interfering with the food supply. There are several oilseeds available in India which are not suitable for human consumption, which have to be identified and exploited and utilised for biodiesel production.

R. P. Singh

(R.P. SINGH)

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The views and opinions expressed in this journal are those of the contributors; Oil Technologists' Association of India does not necessarily concur with the same. All correspondence should be addressed to the Honorary Editor in Chief, Journal of Lipid Science and Technology, 7/105-E, Ratan Kunj, Villa-3, Swaroop Nagar, Kanpur - 208 002, e-mail : rpshbti@rediffmail.com, journalotai@gmail.com, editorinchief@otai.org

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Putranjiva roxburghii Seed Oil-based (α- Hydroxy Amino Ethyl Thio Undecanoate) Triglycerides: Synthesis and Characterization

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ABSTRACT

Vegetable oils represent promising alternatives to mineral oil- based lubricants because of their high biodegradability, good lubricity and low volatility. However, their poor thermo-oxidative stability and the small range of viscosity represent a clear disadvantage to be used as suitable biolubricants. Epoxidation of *Putranjiva roxburghii* oil was effected by reaction with in situ generated peroxy performic acid in H_2O_2. The oxirane rings of the derivatized oil were then opened using methyl 11-((2-aminoethyl) thioundecanoate catalyzed by anhydrous $ZnCl_2$ to afford the poly(α- hydroxy aminoethyl thio undecanoate) triglyceride. The purpose of this work was to derivatize and thereby stabilize this unsaturated oil for its eventual use in lubrication applications. Synthesized compounds were characterized by ^{1}H NMR, ^{13}C NMR, ESI-MS and FT-IR.

INTRODUCTION

Ever increasing petroleum products prices and uncertainties concerning their availability, have increased the importance of vegetable oil based oleochemicals tremendously. In USA, soybean oil is mainly used for industrial applications as it is produced in surplus over the edible consumption, on the other hand, in Europe rapeseed oil or sunflower oil or used frying oils are utilized. In Asian countries like Malaysia and Indonesia, palm oil based oleochemicals are prepared as they have huge surplus of palm oil. India, being one of the major importer of vegetable oils every year, cannot afford to use any edible oil for the preparation of industrial applications as almost half of its edible oil consumption depends on imports. However, India, due to its tropical climatic conditions and vast terrain region has more than 100 types of trees yielding oil which are yet to be explored. The tree borne oils can be exploited for the preparation of oleochemicals.

Oils from the seeds of minor forest trees can serve some of the need for renewable non-food industrial products. Examples of such plants include the castor, karanja, jatropha and many other seed-producing deciduous trees. Putranjiva is an evergreen tree of *Euphorbiaceae* family found in tropical parts of India. This tree grows all over India and is well known for its medicinal qualities,. Leaves are normally procreant, bitter, refrigerant and astringent. The leaves are handy in treating of illness, phlegm, skin ailment, aridity and are also helpful in curing rheumatism [Supriya et al., 2017]. The leaf extracts and bio-oil extracted from seeds are mostly utilized in Ayurveda, herbal and Unani medications. Pharmacognostical analysis of its leaves, fruits, stem and roots revealed the presence of many active polyphenolic compounds which could be associated with its many therapeutic properties. These include saponins, glycosides, triterpenes, ellagic acid, gallic acid and flavonoids. Putranjiva roxburghii leaf extract has also been studied as a biological reducing agent for synthesis of gold nano particles [Gupta, 2016].

A recent study of methyl esters of the seed oil suggests the potential of this biobased material in biodiesel fuel [Ghosha et al 2005]. It is reported that biodiesel from putranjiva oil, blended or pure, has demonstrated very acceptable results as an alternate fuel for diesel engines. It has been concluded that the diesel engine can run very satisfactorily using 100% of biodiesel at the timing

of 45 bTDC timing and compression ratio of 20. All diesel engines can be operated with 100% biodiesel obtained from putranijiva as a primary force without any alteration of the engine (Acharya et al. 2018). Putranjiva oil can also be used in diesel engine for its fuel properties which are comparable with diesel. Blends (10%, 20%, 30%, and 40% v/v) of pure putranjiva oil and diesel are used in Ricardo Variable Compression Diesel Engine to study the performance and emission characteristics at various brake power. Maximum 30% blend of putranjiva oil with diesel can be used as an alternative fuel in diesel engine as it differs very little from diesel in performance and is better than diesel with regard to emissions (Haldar et al 2009). In the current study, we have investigated conversion of the unsaturated putranjiva seed triglyceride into new product starting from developing the oxirane from its olefinic moieties as a platform material for synthesis of new products. Thus, from the epoxy derivative ring-opening, α-hydroxyamines of putranjiva oil have been synthesized and characterized spectrometrically using ^{1}H and ^{13}C NMR. This study may help in the effort to find alternatives to petroleum-based products.

EXPERIMENTAL

Materials

Putranjiva oil (JO, iodine value of 92.7 mg I_2/g) was procured from VRS & YRN College, Chirala, Andhra Pradesh. Formic acid (85%), sulfuric acid, aqueous hydrogen peroxide (30%), sodium sulphate and sodium methoxide were purchased from s.d.Fine-Chem Ltd., (Mumbai, India). Hexane, methanol and ethyl acetate (LR) were purchased from Industrial Solvents and Chemicals Pvt. Ltd. (Mumbai, India).

Synthesis of epoxy putranjiva oil (EPO)

Putranjiva oil (10 g, 11.4 mmol), formic acid (0.9 mL, 2.29 mmol) and sulfuric acid (0.11 mL, 2% weight of HCOOH and hydrogen peroxide) were stirred under mechanical stirring at 10 C. Hydrogen peroxide solution (30% concentration, 9.4 mL, 92 mmol), which was pre-equilibrated at the same temperature was added slowly to the contents through addition funnel during a period of 10 min. This precaution was taken to prevent over heating of the system due to the exothermic nature of epoxidation. After addition of hydrogen peroxide the reaction contents were stirred at 60 C temperature. Sample was taken periodically and analyzed for oxirane value to monitor the reaction. After complete conversion, the reaction mixture was cooled to room temperature and washed with water until it was acid free. Ethyl acetate was used for the separation of product from water phase and the final product was passed through anhydrous sodium sulphate, dried under reduced pressure. The weight of the product was 9.7 g (95 wt% yield) with an oxirane value of 4.8, iodine value of 6.1 and without hydroxyl value. The product was analyzed by ^{1}H and ^{13}C NMR spectra.

^{1}H NMR ($CDCl_3$, ppm): δ 0.87 (t, -CH_2-C$\underline{H}_3$), 1.24-1.39 (m, -C$\underline{H}_2$-CH_3), 1.52 (d, C$\underline{H}_2$-CHOCH-), 1.66 (m, -C$\underline{H}_2$-CH_2-C=O) 2.29-2.34 (t, -CH_2-C=O), 2.8-3.1(m, -C$\underline{H}$OC$\underline{H}$-), 4.12-4.32 (dd, -OC$\underline{H}_2$-CH-); 5.37 (m, -OC$\underline{H}$-$(CH_2)_2$). ^{13}C NMR ($CDCl_3$, ppm): δ 14.1 (-CH_3), 22.5-32.5 (-CH_2-), 34.5 (-CH_2-C=O), 57.6 (-CHOCH-), 62.5 (-CH_2O-C=O), 68.4 (-CHO-C=O), 174.2 (-COO-).

Synthesis of methyl undecenoate

10-Undecenoic acid (2 g, 10 mmol), was added to methanol (3.52 mL) and sulfuric acid (0.02 mL, 2 wt % 10-undecenoic acid) and stirred at refluxing temperature of methanol for 6 h. After completion of the reaction as shown by TLC (hexane/ethyl acetate 80:20, v/v), excess methanol was removed under reduced pressure and the product was diluted with ethyl acetate (15 mL), washed with 5% aqueous $NaHCO_3$ solution (3 × 15 mL), and dried over anhydrous Na_2SO_4. The organic solvent was removed under reduced pressure to afford crude methyl undecenoate. The product was purified by column chromatography with basic alumina and hexane as the eluent. The product was analyzed by ^{1}H NMR, ^{13}C NMR and ESIMS.

^{1}H NMR (300 MHz, $CDCl_3$): δ 5.75-5.85 (m, -CH=CH_2-, 1H), 4.91-5.01 (m, -CH=CH_2-, 2H), 3.66 (s, -OCH_3, 2H), 2.28-2.31(t, -CH_2-, J = 7.4 Hz, 2H), 2.01-2.06 (m, -CH_2-, 2H), 1.59-1.65 (m, -CH_2-, 2H), 1.26-1.39 (m, -$(CH_2)_5$-, 10H). ^{13}C NMR ($CDCl_3$, ppm): δ 173.1 (-C(O)-OCH_3), 139.1 (-C$\underline{H}$=CH_2-), 115.7 (-CH=C$\underline{H}_2$-), 51.9 (CH_3O-C(O)), 33.6 (-C$\underline{H}_2$-CH=CH_2-), 25.0-29.7 (-CH_2-). ESI-

mass: $[M+H]^+$ $m/z = 199$.

Synthesis of methyl 11-(2-aminoethylthio) undecanoate (MAU)

Methyl undecenoate (2 g, 0.01 mol) and ABCN (0.06 g, 3 wt % of methyl undecenoate) were dissolved in 40 mL chloroform. Then, 2-mercaptoethylamine hydrochloride (2.27 g, 0.02 mol) and 20 mL of 1,4- dioxane/ethanol (70:30; v/v) were added and the mixture was stirred at 85 C for 48 h. The progress of the reaction was monitored by TLC (hexane/ethyl acetate 80:20, v/v). After maximum conversion, the reaction mixture was extracted with dichloromethane (40 mL) and the combined organic phases were washed with saturated sodium carbonate, brine and finally with water and dried over anhydrous sodium sulphate. This crude product mixture was concentrated and purified by column chromatography with hexane/ethyl acetate (92:8, v/v) to obtain pure methyl 11-(2- aminoethylthio)undecanoate in 87% yield (2.38 g). The purified product was characterized by ^{1}H and ^{13}C NMR, IR and ESI-MS spectral studies.

^{1}H NMR ($CDCl_3$, ppm) : δ 3.67 (s, 3H, CH_3-O-C(O)-), 2.87 (t, J = 6.4 Hz, 2H, -S-CH_2-CH_2 NH_2), 2.62 (t, J = 6.4 Hz, 2H, -CH-S-CH_2-CH_2), 2.5 (t, J = 7.2 Hz, 2H, -CH_2-S-CH_2-), 2.3 (t, J = 7.5 Hz, 2H, -CH_2-C=O), 1.54-1.71 (m, 4H, -CH_2-CH_2-S-), 1.24-1.42 (m, 12H, CH_2). ^{13}C NMR ($CDCl_3$, ppm): δ 174.35 (-C(O)-OCH_3), 51.46 (CH_3O-C(O)), 41.10 (-CH_2-CH_2-NH_2), 38.20 (-S-CH_2-CH_2-), 36.79 (-CH_2-S-), 29.80-24.95 (-CH_2-). FT-IR ($CHCl_3$, cm^{-1}): 3291, 2918, 2849, 1734, 1466, 1109. MS-ESI (m/z): 276 $[M+H]^+$.

Preparation of *roxburghii* Seed Oil -based Poly (α- Hydroxyaminoethyl Thio-Undecanoate) Triglycerides (TAHAEPTJO) based on EPO and MAU

EPTO (1 g, 1 mmol), MAU (1.7 g, 6.2 mmol) and anhydrous $ZnCl_2$ (0.35 g, 2.6 mmol) were added in a flask and stirred with a magnetic stirrer by maintaining the reaction temperature at 140-150 C under dry nitrogen atmosphere for 8h, a light reddish, viscous liquid was obtained. The product was extracted in to ethyl acetate and washed with water, dried over sodium sulphate and removed the solvent under vacuum. The product was confirmed by ^{1}H and ^{13}C NMR spectra.

^{1}H NMR ($CDCl_3$, ppm): δ 0.88 (t, -CH_2-C$\underline{H}_3$), 1.26-1.40 (m, -C$\underline{H}_2$-CH_3), 1.53 (d, C$\underline{H}_2$-CHOCH-), 1.66 (m, -C$\underline{H}_2$-CH_2-C=O) 2.29-2.34 (t, -CH_2-C=O), 2.53 (t, S-CH_2- C$\underline{H}_2$), 2.84 (t, S-CH_2), 2.92 (t, NH_2-CH_2), 3.35 (-CH_2-C$\underline{H}$OH-CH_2), 3.6 (s, -OCH_3), 4.12-4.32 (dd, -OC$\underline{H}_2$-CH), 5.25 (m, -OC$\underline{H}$-$(CH_2)_2$). ^{13}C NMR ($CDCl_3$, ppm): δ 14.1 (-CH_3), 22.5-32.5 (-CH_2-), 35.4 (-CH_2-C=O), 49.6, (-S-CH_2-C$\underline{H}_2$-NH-), 51.6 (CH_3-COO-), 56.8 (-CH_2-NH-), 57.5-58.7 (-CHOCH-), 61.5 (-CH_2O-C=O), 63.6 (-NH-C$\underline{H}_2$-CH_2-OH), 69.4 (-CHO-C=O), 72.3 (OH-C$\underline{H}_2$-CH_2-NH-), 77.8 (-CH_2-C$\underline{H}$OH-CH_2), 173.4 (-COO-).

RESULTS AND DISCUSSION

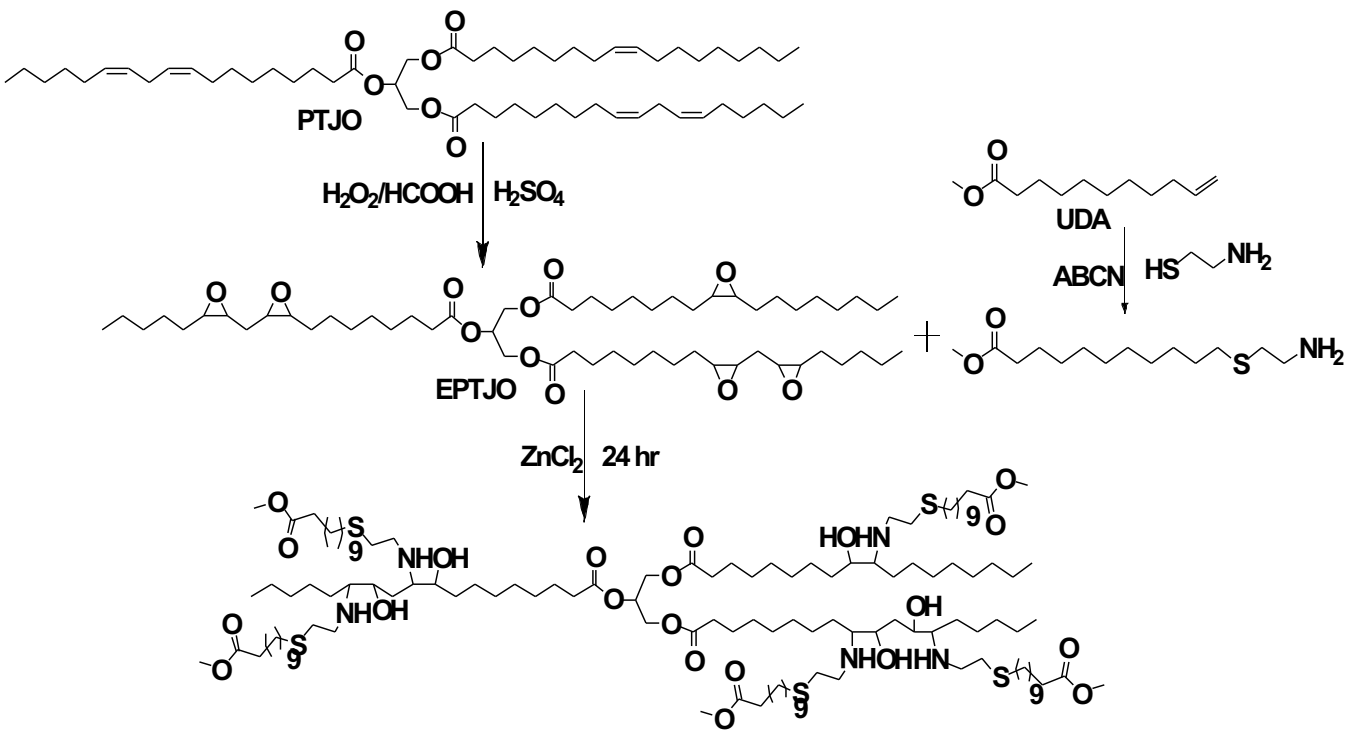
Epoxidation of the putranjiva oil was smooth with high conversion. Scheme 1 depicts the epoxidation reaction converting the unsaturated bonds to oxirane units forming a polyoxirane derivative. The ^{1}H NMR spectrum indicateds almost complete conversion of unsaturation by the absence of peaks of olefinic and allylic hydrogen atoms at 5.3-5.4 ppm and 1.95-2.05 ppm respectively .Signals in the region 2.8 -3.1 ppm indicate the presence of epoxy group protons. The peak at 1.5 ppm indicates the presence of methylene protons next to epoxy group and the signal at 1.7 ppm shows the presence of methylene protons between two epoxy groups indicating the presence of diepoxy groups. Absence of peaks in the range 3.3-4.0 ppm indicates that diol formation did not occur during epoxidation.

^{13} NMR spectrum also indicated almost complete conversion of olefinic carbon atoms by their absence at 120-140 ppm. The presence of signals at 54-58 ppm indicate the presence of epoxy carbon atoms. Peaks at 172-173 ppm due to carbonyl carbons of triacyl glycerol , 69 and 62 ppm for CH and CH2 carbons of glycerol backbone confirms that glycerol fatty acid linjkage is intact during epoxidation.

The epoxy group of EPTJO was opened with methyl 11-(2-aminoethylthio) undecanoate in stoichiometric ratio to prepare putranjiva oil based Poly (α- Hydroxyaminoethyl Thio- Undecanoate) Triglycerides at reflux temperature using anhydrous

$ZnCl_2$ as catalyst. The reaction was monitored by TLC analysis for the disappearance of epoxide. Aminolysis of the oxirane was more sluggish compared to the oxirane formation even as catalyzed by anhydrous ZnCl2 under gentle reflux and irrespective of the lower scale of reactants used. FTIR spectrum confirmed the ring opening reaction with methyl 11-(2-aminoethylthio) undecanoate. Disappearance of epoxy band (835 cm^{-1}) a new broad band at 3403 $cm^{-1}$is attributed to the addition of hydroxyl and amine groups in the product. These changes are due to opening and elimination of oxirane ring by amine group. A new band at 1603 cm^{-1} which is due to N–H bending confirmed the introduction of amine group into the molecule. In ^{1}H NMR spectrum, signals at 6.48–7.2,.15–3.22, and 3.7–3.8 ppm confirmed oxirane ring opening introduction of amine and hydroxy groups into the molecule, respectively.

DSC measured the oxidation stability of amine-functionalized oil sample. Data illustrate the improvement in oxidation stability of amine derivative compared to EPO. DSC is widely used in the lubricant industry and is considered to be a reliable method for evaluating base oils as well as finished lubricants. The amine-functionalized derivative show higher oxidation stability than EPTJO. Although, epoxidized oils are fairly stable to oxidation, at higher temperatures (>250 C), rapid degradation sets in when the oxirane ring is broken under oxidizing environment. Such degradation often follows a radical pathway to give polymeric oxidation products (Sammaiah et al, 2014). However, due to the presence of amine groups, the antioxidant characteristic of the molecule is significantly improved. Sterically hindered amine compounds are often used as radical trapping agents to arrest oxidation process. Furthermore, greater affinity of amines for metal surfaces will improve the tribochemical behavior through lubricity improvement, otherwise unattainable with EPO (Harry-O'kuru et al., 2015) Thermo Gravimetric (TGA) studies also indicate the improvement in the thermal stability of synthesized amine derivative over EPO and their degradation temperatures T_d 324 C for EPTJO and 363 C for amine derivative



Scheme1: Synthesis of *Putranjiva roxburghii* Seed Oil -based Poly (α- Hydroxyaminoethyl Thio-Undecanoate) Triglycerides (TAHAEPTJO)

CONCLUSIONS

The epoxidation of putranjiva oil was performed resulting in high reaction conversion of >96%. The spectroscopic and gas chromatographic data indicate that nearly entire C-C unsaturation in putranjiva oil was converted to epoxy group. The epoxy group of EPTJO was opened with methyl 11-(2-aminoethylthio) undecanoate in stoichiometric ratio to prepare putranjiva oil based Poly (α-Hydroxyaminoethyl Thio- Undecanoate) Triglycerides at reflux temperature using anhydrous $ZnCl_2$ as catalyst. Modified putranjiva oil (TAHAEPTJO) showed superior oxidation stability compared to EPO due to incorporation of hetero atoms. Both the EPTJO and TAHAEPTJO exhibited high thermal stability indicating that they are appropriate to be used as high temperature lubricating oil additives.

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UPCOMING EVENTS

1. **8th International Symposium on Surfactants in Tribology**
   Place: Lublin, Poland
   Date: 30th June - 1st July 2020

2. **17th Global Oleochem Summit 2020**
   Place: Xiamen, China
   Date: 15th July - 17th July 2020

3. **Palmex Thailand 2020**
   Place: Songkhla, Thailand ICC Hatyai
   Date: 14th August - 15th August 2020

4. **Biofuels Environmental, Health & Safety Forum**
   Place: Minneapolis, Minnesota, USA Minneapolis Convention Center
   Date: 24th August 2020

5. **Biodiesel Production Technology Summit**
   Place: Minneapolis, Minnesota, USA Minneapolis Convention Center
   Date: 24th August - 26th August 2020

6. **ICIS World Surfactants Conference**
   Place: Jersey City, New Jersey, USA Hyatt Regency Jersey City
   Date: 16th September - 18th September 2020

7. **Oils and Fats Industry Exhibition**
   Place: Kiev, Ukraine Expocenter of Ukraine
   Date: 22nd September - 24th September 2020

8. **Future of Biofuels**
   Place: Copenhagen, Denmark
   Date: 22nd September - 23rd September 2020

9. **5th Future of Surfactants Summit North America**
   Place: Boston, USA
   Date: 23rd September - 24th September 2020

10. **7th High Oleic Oils (HOC) 2020**
    Place: Toulouse, France
    Date: 22nd October - 23rd October 2020

11. **4th ICIS Pan American Oleochemicals Conference**
    Place: Miami, USA Ritz Carlton South Beach
    Date: 29th October - 30th October 2020

12. **10th ICIS Asian Surfactants Conference**
    Place: Singapore
    Date: 10th November - 11th November 2020

13. **Nordic Lipid Forum**
    Place: Gothenburg, Sweden Chalmers University of Technology
    Date: 11th November - 12th November 2020

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A Comparative Study on Some Lesser Known Treeborne Oilseed-based Biodiesel Feedstocks of Indian Origin

Ram Chandra Reddy Jala*, M. Ram Mohan, Shiva Shanker Kaki, A. Thirupathi, Amit Kumar Rajak, K. Saravanan, B.L.A. Prabhavathi Devi, P. P. Chakrabarti, R.B.N. Prasad, B.V.S.K Rao
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Abstract

In the present study, feasibility of biodiesel production from *Melia dubia* seed kernel oil, *Butea parviflora*, *Knema attenuata* seed oils were investigated and compared with *Swietenia mahagoni* biodiesel. The oil contents of three species were found to be 41.5 (kernel), 33.0 and 33.8% respectively; and it was 58.1% incase of *Swetenia*. All the fatty acid methyl esters were within the range of European Specification (≥96.5%). In cases of *melia* linoleic (57.7%), *butea* oleic (27.0%) and linoleic (27.2%), *knema* myristic (66.6%) and in *swetenia* linoleic (32.4%) and oleic (25.5%) were found to be the major fatty acids. The oxidative stabilities of biodiesels were found to be within the range of ASTM specification (3 h minimum). Even though, *butea* (5.05) exhibits slightly higher viscosity compared to *knema* (4.6 cSt) their viscosity profiles are comparable to that of sunflower (4.52), soybean (4.2), rapeseed (4.4) biodiesels, fall within the range of ASTM (1.9 to 6.0 cSt) specifications. Cloud points of all the biodiesels were within the range of ASTM specification (−3 to12 C). Pour points of *melia* (0 C), *butea* (4 C), *knema* (1 C) were within the range of ASTM specifications (−15 to 10 C). The flash points of *melia* (168.4 C), *butea* (122 C) & *knema* (123 C) were within the range of EN specifications (≥ 120 C) and are lower compared to that of soybean (171 C), sunflower (177 C) and rapeseed (170 C) biodiesels. The density of *melia* (0.884), *butea* (0.880) and *knema* (0.870) biodiesels were found to be within the range of EN specifications (0.86-0.90 g/cm^3).

1. Introduction

Biodiesel is an ecofriendly, non-toxic, alternative and renewable diesel fuel being generally produced from a broad range of feed stocks such as vegetable oils, animal fats or used cooking oils [Encinar et al., 2007; Gernard Knothe, 2005]. Biodiesel is miscible with petrodiesel in all ratios and it can be used in existing diesel engines without major modifications to the engines and can be obtained by transesterification [Ma and Hanna, 1999; Foidl et al., 1996; De and Bhattacharyya, 1999; Fernandes and Ferreira, 2001; Zullaikah et al., 2005; Gernard Knothe, 2005]. Each biodiesel property depends on the structural features of fatty acid and alcohol that comprise a fatty ester (Cvengros et al., 2006).

Throughout the world typical lipid feedstocks being used for production of biodiesel are refined vegetable oils. Nevertheless, the choice of oil varies with location as per the availability. Therefore, rapeseed and sunflower oils are being used in the European Union (Harold, 1997), palm oil predominately being used in tropical countries (Sii et al 1995, Masjuki and Sapuan 1995) and soybean oil (Jewett, 2003) and animal fats are the major feed stocks utilized for the production of biodiesel in the United States. Biodiesel production was well established with a variety of vegetable oil-based feedstocks such as coconut (Solly 1980), rice bran (Kamini and Iefuji, 2001; Özgül-Yücel and Türkay, 2003), safflower (Isigigür, 1994), palm kernel (Choo et al., 1991), *Jatropha curcus* (Foidl et al., 1996), Ethiopian mustard or *Brassica carinata*

(Cardone et al., 2003) and the animal fats, tallow (Geise, 2002; Nautusch et al., 1984; Richardson et al., 1985) and lard (Lee et al., 2002). However, the influencing factors such as supply cost, storage properties, and engine performance are generally driving forces behind the selection of potential feed stock for commercial production of biofuel.

In addition, there is an increase in the interest to search for suitable alternative feedstock oils for the production of biodiesel (Sukumar et al., 2005; Usta, 2005) as recently the edible oil exploitation for non-edible application is being discouraged throughout the world.

Therefore, researchers are still investigating for newer resources having high oil content through screening of lesser known/unknown tree-borne oil seeds that make biodiesel commercial production economically feasible. As part of our screening programme of unknown/lesser known oilseeds for the raw material to be used for biodiesel production a comparative study on *Melia dubia*, *Butea parviflora*, *Knema attenuata*, and *Swetenia mahagoni* (Ram et al., 2016) oil-based biodiesels were carried out.

Melia dubia belongs to plant family Meliaceae, locally known as Malabar Neem wood, is an indigenous plant possessing several therapeutic properties and different parts of the plant are known for a variety of applications (Amarasekara, 1995; Vijayan et al., 2004; Nagalakshmi et al., 2003; Koul et al., 2000; Valentina 2013). *Melia dubia* seed oil consists of linoleic, oleic, stearic, palmitic fatty acids predominantly (Robert and Kathleen, 1984). The present study describes about the preparation and evaluation of biodiesel from *Melia dubia* seed kernel oil for the first time.

The genus *Butea* of the Fabaceae family namely *Butea monosperma*, *Butea parviflora*, *Butea minor* and *Butea superba* and is widely distributed throughout India (Wealth of India, 1998). In our previous report complete physico-chemical characterization of the seed oil from *Butea parviflora* was given (Shiva et al., 2016).

Knema attenuata is a species of plant in the Myristicaceae family and is endemic to India. Wild Nutmeg is a tree up to 20 metres tall and its bark is brownish, usually smooth, irregularly flaky and branches are arranged in whorls, horizontal (Krishnamoorthi et al., 2015; Wan and Farediah 2017).

Swietenia mahagoni (Linn) Jacq belongs to plant family Meliaceae, locally known as mahagoni mainly cultivated at the tropical countries such as India, Bangladesh, Malaysia, Southern China, and in America (Mulholland et al., 2000; Anon, 1989). All the physico-chemical properties of oil and biodiesel are reported in our exclusive previous study on *Swietenia mahagoni* (Ram et al., 2016).

However, in the present study a comparative discussion is made on physico-chemical properties of biodiesels prepared from *Melia dubia, Butea parviflora, Knema attenuata, and Swetenia mahagoni* oils.

2. Materials and methods

2.1 Materials

The seeds of *Melia dubia*, *Butea parviflora*, *Knema attenuata*, *S. mahagoni* were supplied by the Andhra Pradesh Forest Department. The authentications of the specimens were done at Andhra Pradesh Forest Department, Hyderabad, India. All reagents and solvents used were purchased from M/s. Sd. Fine Chemical Co., Ltd. (Mumbai, India).

2.2. Extraction of *Melia dubia*, *Butea parviflora*, *Knema attenuata* seed oil.

The ripe seeds were chosen for extraction of oil. The extraction procedure was adopted from our previous report (Ram et al., 2016). The seeds were thoroughly cleaned and

dried in an oven at 100 C for 1 h to make them free from moisture. The dried kernels of the seed were finely powdered and extracted thoroughly using n-hexane at 60–80 C temperature in a Soxhlet extractor for 8 h. After this the solvent was removed in vacuum at 40 C by using rotary evaporator and further dried under the reduced pressure to recover the oils, percentages of 41.5, 33.0, 33.8 respectively are the yields obtained during extraction.

2.3. Physico-chemical characteristics

Physico-chemical characteristics of *Melia dubia*, *Butea parviflora*, *and Knema attenuata* biodiesels were determined using Standard International methods. American Oil Chemists' Society (AOCS) methods were used to determine the free fatty acid (FFA) content, unsap matter, iodine value, saponification value (Firestone, 2003 a, b, c, d). International Union of Pure and Applied Chemistry (IUPAC) method was used to determine the phosphorous content (Paquot and Hautfenne, 1987). The viscosity, flash point, cloud point, pour point were determined according to the American Society for Testing and Materials (ASTM) methods (ASTM, 2010 a, b, c, d). The remaining physico-chemical characteristics, namely, methyl ester content, oxidation stability and the presence of Group I metals namely Na, K, (EN, 2011a, b, c; Methods 14103, 14112, 14538, respectively) were determined using EN methods.

2.4. Typical procedure for acid catalyzed esterification

Acid-catalyzed esterifications of *Melia dubia*, *Butea parviflora*, *and Knema attenuata* oils were carried out as mentioned in our previous study (Ram et al., 2016).

2.5. Typical procedure for base-catalyzed methanolysis of oil

Biodiesels were prepared by adopting the procedure reported earlier (Nakpong and Wootthikanokkhan, 2010). The FFA free oil (280 g, 0.327 mol) prepared using acid-catalyzed esterification (procedure given in Section 2.4) from crude oil was taken and transesterified employing sodium hydroxide-methanol solution as reported in our previous study (Ram et al., 2016). At the end, the products of different oils were dried under high vacuum to obtain biodiesels (*Melia* yield 256.2 g; *Butea* yield 261.3 g; *Knema* 252.7 g).

2.6. Fatty acid composition

All the GC analysis conditions were like our previous report (Ram et al., 2016). The fatty acid compositions of biodiesels were analyzed by an Agilent 6890 Gas chromatograph (GC) equipped with a Flame ionization detector (FID) detector, split/split less injector, and a non-bonded cyano silicone column (DB-225, 30 m × 0.25 mm × 0.2 μm). The oven temperature was maintained at 160°C for 2 min and this was increased from 160 to 180°C at 6°C/min with a holding time of 2 min and finally raised to 230°C at 4°C/min with a holding time of 15 min at 230°C. The injector and detector were at 250°C. Chemstation software was used for the data analysis.

3. Results and discussion

The oil content in *Melia dubia kernel*, *Butea parviflora* and *Knema attenuata* seeds were found to be 41.5, 33.0, and 33.8%, respectively. However, except in *butea* oil (0.49%) other two studied oils namely, *melia* (3.5%) and *knema* (22.32%) were having higher FFA content in comparison with *Swetenia* (1.35%, Ram et al., 2016, **Table 1**).

Table 1 : Physico-chemical properties of Melia dubia seed kernel oil, Butea parviflora oil, Knema attenuata oil and Swietenia mahogani oil

Characteristic	M. dubia	B. parviflora	K. attenuata	S. mahogoni
Oil content (% w/w)	41.5 (kernel)	33.0	33.8	58.1
Free fatty acids (% w/w)	3.5	0.49	22.32	1.39
Unsaponifiable matter (% w/w)	1.0	1.7	1.07	0.87
Phosphorus content (ppm)	11.8	140.0	89.7	175.0
Specific gravity at 30°C	0.9132	0.9085	0.92133	0.9213
Iodine value (g/100 g)	118.8	76.43	23.4	106.0
Viscosity at 40°C (cSt)	32.8	41.99	111.96	35.6
Density (g/cm^3)	0.9123	0.9045	0.9718	0.9173
Saponification value (mg KOH/g)	181.0	190.42	194.36	192.9

Keeping the above facts in view, the biodiesel preparation was planned in two-steps. Initially the extracted oil was subjected to acid-catalyzed esterification to bring down the FFA present in different oils to minimal levels. Because of this pretreatment process in *melia*, *butea*, *knema* and *swetenia* the FFA contents after transesterification reaction were found to be 0.12, 0.25, 0.17, 0.05%, respectively. To bring down the FFA content in oil, the FFA was converted to fatty acid methyl ester (FAME) using methanol/sulfuric acid methylating agent. Thereafter, the FFA free oil was converted to biodiesel (FAME) using an alkali-catalyzed transesterification where sodium hydroxide-methanol solution was used as methylating agent. As furnished in Table 3, the FFA content of all the four prepared biodiesels were within the range i.e., 0.12, 0.25, 0.17 and 0.05, respectively. The FAME contents in biodiesels within the range of European Specification (≥96.5%). On the other hand, fatty acid compositions of biodiesels were studied. In *melia* biodiesel linoleic (57.7%) was the first major fatty acid followed by oleic (25.5%), palmitic (8.8%) and stearic acids. Whereas incase of *butea* oleic (27.0%) and linoleic (27.2%) were found to be the two major fatty acids and palmitic (19.1%) and behenic (11.5%) were present in substantial amounts. Further, in case of *knema* biodiesel myristic (66.6%) was found to be the major fatty acid followed by oleic (19.2%) and palmitic (9.4%) acids. As already described in our previous report (Ram et al., 2016) in the *swetenia* linoleic (32.4%) and oleic (25.5%) were the major fatty acids and stearic (14.1%) and linoleic (12.2%) were present in substantial amounts (**Table 2**).

Table 2 : Fatty acid composition (wt%) of biodiesel prepared from Melia dubia seed kernel oil, Butea parviflora oil, Knema attenuata oil and Swietenia mahagoni oils

Fatty Acid	M. dubia	B. parviflora	K. attenuata	S. mahogoni
12:0	-	-	0.20	-
14:0	0.10	0.60	66.60	-
16:0	8.80	19.10	9.40	13.0
16:1	-	0.10	-	0.40
18:0	6.80	7.20	2.20	14.10
18:1	25.50	27.00	19.20	25.50
18:2	57.70	27.20	0.80	32.40
18:3	0.20	0.20	0.20	12.20
20:0	0.40	2.00	0.20	1.20
20:1	0.40	1.70	1.20	0.10
22:0	0.10	11.50	-	0.20
22:1	-	0.50	-	-
24:0	-	2.90	-	0.90

The physico-chemical properties of all the three biodiesels are compared with the *swetenia* biodiesel (Ram et al., 2016) and ASTM (D 6751) and European (EN 14214) biodiesel specifications (**Table 3**). Except in *melia* (0.97ppm) none of the other studied biodiesels even contained traces of phosphorous meeting ASTM and EN specifications (≤ 10 ppm). The iodine values of the *melia, butea, knema* and *swetenia* biodiesels are indicative of degree of unsaturation and are found to be 105.8, 67.24, 21.4 and 104.6, respectively. It is noteworthy that these iodine values of new biodiesels were found to be less compare to the sunflower, rapeseed, soybean biodiesels i.e., 108.2, 109.0, 128.0 g I_2/100g, respectively (Ramos et al., 2009). This is an indication of having less degree of unsaturation and more oxidative stability compare to sunflower, rapeseed and soybean biodiesels. *Melia* (105.8 I_2/100g) and *swetenia* (104.6 I_2/100g) are approximately having same iodine value. However, since *knema* was having higher amount of myristic acid (66.6%) the iodine value was found in accordance with that. Similarly, incase of *butea* due to the presence of substantial amounts of saturated fatty acids i.e palmitic, (19.1%), stearic (7.2%), behenic (11.5%), eicosanoic (2%) and lignoceric (2.9%) the iodine value was found to be much lower compare to *melia* and *swetenia* but higher than *knema* biodiesel. Nevertheless, Iodine values of all the studied biodiesels are within the range of EN specification (≤ 120).

Table 3 : Comparison of Physico-chemical properties of Biodiesel prepared from Melia dubia seed kernel oil, Butea parviflora oil, Knema attenuata oil, S. Mahagoni Oils with ASTM & EN Specifications

Characteristic	M. dubia	B. parviflora	K. attenuata	S. mahagoni	ASTM specifications	EN specifications
Methyl ester content (Wt %)	97.30	96.90	96.80	97.20	-	≥ 96.50
Free fatty acid (wt%)	0.12	0.25	0.17	0.05	≤0.250	≤ 0.25
Phosphorus content (ppm)	0.97	Nil	Nil	Nil	≤10.00	≤ 10.00
Iodine value (g/100g)	105.80	67.24	21.40	104.60	-	≤ 120
Oxidative stability (h)	3.00	4.75	4.25	3.7±0.10	≥ 3 hours	≥ 6 hours
Viscosity at 40^{0}C (cSt)	4.24	5.05	4.60	4.13	1.90 to 6.00	3.5 to 5.0
Cloud point (^{0}C)	1.00	6.90	2.40	7.00	-3 to 12	-
Pour point (^{0}C)	0.00	4.00	1.00	9.00	-15 to 10	-
Flash point (^{0}C)	168.40	122.00	123.00	165.00	‖130	≥ 120^{0}C
Density (g/cm^3)	0.884	0.880	0.870	0.880	-	0.86 to 0.90
Group I metals (Na & K) ppm	0.90	0.89	0.95	0.50	‖5	‖ 5

The oxidative stabilities of all the studied biodiesels were found to be within the range of ASTM specification (3 h minimum). *Butea* and *knema* showed higher than 4 hrs stability due to substantial amounts of saturated fatty acids where as *melia* (3 hrs) showed lower oxidative stability compare to *swetenia* (3.7 hrs). This phenomenon in *melia* attributed to the presence of high linoleic (57.7%) compared to *swetenia* biodiesel (32.4%). On the other hand, the viscosity profiles of *melia* (4.24 cSt) and *swetenia* (4.13 cSt) are comparable. Eventhough, *butea* (5.05 cSt) exhibits slightly higher viscosity compared to *knema* (4.6 cSt) their viscosity profiles are comparable to that of sunflower (4.52 cSt), soybean (4.2 cSt), rapeseed (4.4 cSt) biodiesels (Ramos et al 2009) and are within the range of ASTM (1.9 to 6.0 cSt) specifications. The cloud point of *melia* (1 C) is comparable to that of sunflower biodiesel (1 C) similarly *butea* (6.9 C) and *swetenia* (7 C) biodiesels were exhibiting approximately same clouds points. Further, *knema* (2.4 C) was exhibiting lower cloud point compared to *swetenia* (7 C) and *butea* (6.9 C) biodiesels. Except for *melia* (1 C) biodiesel the cloud points of other biodiesels (*butea*, *knema* and *swetenia*) are slightly higher compared to soybean (−2 C), rapeseed (−4 C) and sunflower (1 C) (Ramadas et al 2005; Bindu et

al 2012). Cloud points of all the studied biodiesels were within the range of ASTM specification (−3 to 12).

Pour points of *melia* (0 C), *butea* (4 C), *knema* (1 C) were within the range of ASTM specifications (−15 to 10 C). The flash points of *melia* (168.4 C), *butea* (122 C) and *knema* (123 C) are within the range of EN specifications (≥ 120 C) and are lower compared to that of soybean (171 C), sunflower (177 C) and rapeseed (170 C) biodiesels (Ramos et al 2009; Bindu et al 2012). In general, exhibiting higher cloud and pour points can be attributed to the presence of large amounts of saturated fatty acids. The density of *melia* (0.884), *butea* (0.880) and *knema* (0.870) were found to be within the range of EN specifications (0.86-0.90 g/cm^3). Alkali metal analysis revealed that Group 1 metals were present within the ASTM and EN specifications (<5 ppm).

4. Conclusion

Physico-chemical properties of *Melia dubia*, *Butea parviflora*, *Knema attenuata* biodiesels were investigated and compared with *Swietenia mahagoni* biodiesel and ASTM and EN specifications. Physico-chemical properties of all above said methyl esters fall within the range of ASTM and approximately falling in the range of EN specifications. Presence of higher amount of myristic (66.6%), linolenic (12.2%), linoleic (57.7%) acids in *knema*, *swetenia*, *melia*, respectively, has no drastic effect on physico-chemical properties due to the rest of the fatty acid profile of corresponding biodiesels. Considering these facts, above four oils could be potential sources for biodiesel production.

Acknowledgements

This work was carried out with the financial grant provided by Council of Scientific and Industrial Research, Ministry of Science &Technology, Govt. of India under the project PEOPLE HOPE (CSC-0112). The authors thank Dr. B. V. Prasada Reddy, Addl. PCCF, A. P. Forest Department for his valuable support during the study. The authors would like to thank the Director, CSIR-IICT for granting permission to publish this work (Manuscript Communication No.: IICT/ Pubs./ 2020/ 036).

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Introduction of improved cultivar of menthol mint (*Mentha arvensis* L.*)* in district Chhatarpur of Madhya Pradesh for better yield and quality of essential oils

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Abstracts

A study was conducted in district Chhatarpur of Madhya Pradesh on existing cultivation practices of menthol mint and introduction of improved cultivars of CSIR-CIMAP in 2017-18 and 2018-19 under DBT sponsored project. In the studied area, the cultivation of mint was depends on rains because there was no facility of any alternative types of irrigation. This method of cultivation of menthol mint was most popular in Chhatarpur since last twenty year and they are using local varieties. A need was felt during project period for introduction of improved varieties and better agro-practices of menthol mint in this region for better yieldin per unit area. Now, farmers are growing menthol mint in rainy session due to scarcity of water in this region. The farmers are adopting cultivation of following crops in *Rabi* (wheat, gram, linseed, pea, etc.) and in *Kharif* (soybean, sesame, urad bean and menthol mint) throughout the year in which *Rabi* is the main crop in rainfed areas of Madhya Pradesh. The data was collected through survey and personal interview with the farmers in Chhatarpur and calculated net return of *kharif* season and annual crop rotations. In this study, the net return of menthol mint was Rs. 38,883 acre^{-1} from different *kharif* crops and net return of mint-gram was highest with Rs.54, 538 acre $^{-1}$ in comparison with different crop rotations in district Chhatarpur. After introduction of new cultivars developed by CSIR-CIMAP, the net return was enhanced from Rs. 38,883 acre $^{-1}$ to Rs. 54, 633 acre $^{-1}$ with an average yield of essential oil was increased up to 10 kg per acre over existing oil yield from common adopted varieties.

Keywords: Menthol mint, essential oil, improved cultivar, rainfed cultivation, Chhatarpur.

Introduction

India is a global leader in production and exporter of menthol mint oil and its value-added products since last 30 years. This position is being maintained due to extensive research of CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow on improved variety development, proper support to the farmers and then adoption of new varieties by the farmers of UP, MP, Bihar and Punjab. Now, menthol mint (*Mentha arvensis*) or mentha or corn mint is the most popular and bonus crop among the small and marginal farmersin Indo-Gangetic plains Singh *et al*., 1999 & 2007. Owing to its excellent return during a short time period between March to June, farmers are adopting this aromatic plant as a bonus crop in *zaid* period. Usually, the menthol mintplantation in these areas is being carried out after harvest of *Rabi* season main crops viz. potato, mustard, lentil, pea, wheat, etc. Srivastava *et al.*2000. An unusual cultivation practice of menthol mint in blocks Raj Nagar, Lav-kush Nagar, Naogaon and Chhatarpur were encountered by us while executing our DBT project work in the district of Chhatarpur and Panna falling in Bundelkhand region of Madhya Pradesh. This unusual cultivation practice of mint which is currently extended in 5000 to 8000 acres evolved our curiosity to understand the cause and return per unit area from this practice and compare the economics with improved varieties developed by CSIR-CIMAP. In DBT project, 30 acres area was plated by improved varieties and also compared with existing varieties cultivated by the farmers since years. Thus, the present studies were exploratory in nature and also present comparative performance and economics with yield and quality of improved varieties and existing adopted varieties

in *Kharif* mint cultivation, its roleon economic enhancement and crop-rotation.

Materials and Methods

Lav Kush Nagar and Ram Nagar blocks are situated in between of Chhatarpur district chosen for this study.As we were working in these blocks to popularize the cultivation of Lemongrass, and Palmarosa to enhance the agriculture return per unit area of land in adverse climate conditions draught which is the usual features in Bundelkhand region. However, some farmers were cultivating mint since long time as a *kharif* crop due to scarcity of water. As demanded by farmers, we have provided 20 kg suckers of mint var. *Kosi* to 30 farmers for planting of nursery in the month of January. This variety was performed well and found better crop growth, oil yield and oil quality in this area. Thus, the preliminary survey and collection of data in our project site was the basis of this study. The other important basic information regarding crops grown, cropping pattern followed in this region and net return obtained were also collected through individual farmers' interactions and analyzed to find the actual gains. The detail comparison between existing and improved cultivation practices is presented in table-1.

Results and Discussion

In this study, sesame, soybean, urad bean/mung bean and pearl millet share the major *kharif* season crops of this region as the paddy cultivation is restricted to few small patches owing to various limiting factor viz. lack of irrigation being a rocky area, limited number of lakes and ponds seasonal rivers, etc. are available as a source of water. The sesame, soybean, and uradbean are moisture sensitive crop and excessive moisture condition during rainy season may very often way to cause poor returns or sometimes complete failure of crop and leading to zero or negative return (https://bundelkhand.in/info/agriculture-in-bundelkhand). Perusal of the table-2 indicates that returns from menthol mint crops were significantly higher than other prevailing crops in this area.

Traditionally, in Bundelkhand region i.e., *Rabi* is the major cropping season followed by the farmers. This was evident from the net sown area of *Ravi* season crop was about 3.15 lakh hectares (https://bundelkhand.in/info/agriculture-in-bundelkhand).The cropping intensity of the blocks of Chhatarpur districts indicates that the farmers of these areas are at least growing 108% crops in a year (https://chhatarpur.nic.in/en). The wheat, lentil, gram, and linseed are the major *Rabi* crops being cultivated in this region. Therefore, the net returns obtained from different popular crops rotations were compared with menthol mint base rotations and the results presented in table-3 which indicates that the rotations of mint - gram had the highest net return and was followed by mint-wheat, mint-barley, mint–linseed, Kumar et al, 2001, Singh *et al,*2003, Srivastava *etal.,*2002.

The important intervention in this area was introduction of new variety of *Kosi* and slightly change in cultivation practices. As interviewed to the farmers, they are unable to identify the variety and their source of menthol mint. The variety Kosi was distributed and performed well in existing crop cycle. As shown in table-4, the highest yield was recorded in mint-gram crop-rotation followed by mint and linseed rotation Srivastava *et al.,* 2019. The quality parameter especially menthol was detected using GC and found upto the mark i.e. highest in mint-wheat/mint-linseed crop rotations followed by mint-gram and mint-barley rotations in newly introduced variety in this area.

Conclusion

The findings of this study was indicated that farmers were adopted crop-rotation with menthol mint for better economic returns,however, the introduction of new cultivar in the sponsored project was shown better performance (oil yield and menthol content)in comparison to the existing variety of mint. The oil production in existing variety was 38 to 45 kg acre^{-1} and percentage of menthol was 68 to

69 whereas oil yield of newly introduced variety (*Kosi*) was 47 to 55 kg acre^{-1} and menthol percent was 70 to 73. The highest percentage of menthol was found in two rotations, i.e. wheat-mint and linseed-Mint. The reason for diversification from traditional cultivation practices of menthol mint was February-June in U.P., Bihar and Uttarakhand but due scarcity of water availability in *Zaid* season in Bundelkhand areas, the monsoon season was shown better season for plantation of mint. This study was also reflected for the better returns by adoption of new cultivars over the existing variety of menthol mint cultivated by the farmers of Chhatarpur, Madhya Pradesh.

Acknowledgment

Authors are thankful to Director, CSIR-CIMAP, Lucknow for providing appropriate facilities to implementing the project in 7 districts of Bundelkhand region under DBT sponsored project.

Funding information

Authors are thankful to Department of Biotechnology, Govt. of India, New Delhi for granting a mega project for upliftment of the farmers of Bundelkhand region by adoption of drought tolerant aromatic crops. This project is being implemented by four organizations, i.e. CSIR-CIMAP, Lucknow, CSIR-IIIM, Jammu, FFDC, Kannauj, and Bundelkhand University, Jhansi.

Table 1: Net returns from different *kharif* crops of Chhatarpur district of MP.

S. No.	Crops	Cost of Cultivation (Rs/ Acre)	Net Return (Rs/ Acre)
01.	Soybean	12480	1116
02.	Urad bean	11315	5485
03.	Sesame	11418	7329
04.	Mentha	24117	38883

Table 2: Comparison between net income of different crops rotation followed by the farmers in District Chhatarpur

S. No.	Crops	Yield (Quintal/ acre)	Market Price (Rs/Q.)	Gross Income (Rs)		Total Cost (Rs)		Net Income (Rs.)
1.	Soybean Linseed	4 3	3399 4475	13596 13425	27021	12480 11794	24274	2747
2.	Sesame Gram	3 6	6249 4620	18747 27720	46467	11418 12185	23603	22864
3.	Wheat Soybean	12 4	1840 3399	22080 13596	35676	15526 12480	28006	7670
4.	Urad Been Wheat	3 12	5600 1840	16800 22080	38880	11315 15526	26841	12039
5.	Mentha Wheat	0.4 12	157500 1840	63000 22080	85080	24117 15526	39643	45437
6.	Mentha Gram	0.4 6	157500 4640	63000 27840	90840	24117 12185	36302	54538
7.	Mentha Barley	0.4 12	157500 1440	63000 17280	80280	24117 13430	37547	42733
8.	Mentha Linseed	0.4 2	157500 4475	63000 8950	71950	24117 11794	35911	36039

Table 3: Adopted cultivation practices by the farmers and demonstrated method of cultivation practices of menthol mint by CSIR-CIMAP in Chhatarpur

S. No.	Cultivation practices	Existing cultivation practices adopted by the farmers	Improved cultivation practices demonstrated by CSIR-CIMAP
1.	Source of Planting Material	Unverified varieties from the local market	CSIR-CIMAP under DBT Project
2.	Planting method	Direct and Plantation	Transplantation on the ridge
3.	Spacing	Not followed any pattern of particular spacing	45cm x 15cm spacing maintained during transplantation
4.	Fertilizer use	No applied particular dose of approximate 35:25:20 NPK per acre	70:30:20 NPK per acre on the basis of soil health report
5.	Method of Fertilizer use	Fertilizer applied after 2-3 days of planting	Fertilizer applied in basal dose before plantation and top dressing after one month of plantation

Table 4: Comparison between existing and improved varieties of menthol mint cultivated by the farmers of Chhatarpur, M.P.

S. No.	Crop - rotation	Oil yield (Kg/ Acre)		Menthol content (%)	
		Existing varieties of Mentha	Improved varieties of Mentha	Existing varieties of Mentha	Improved varieties of Mentha
1.	Wheat- Mentha	40	50	69	73
2.	Gram- Mentha	42	55	69	71
3.	Barley- Mentha	38	47	68	70
4.	Linseed- Mentha	45	53	68	73

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Research Roundup Jan - Mar 2020

[Contributed by Dr. K.V. PADMAJA]

Oxidative Stability and Characterization of Quinoa Oil Extracted from Wholemeal and Germ Flours

Quinoa seeds are a source of lipids of great quality, and they highlight the content and composition of fatty acids and the presence of antioxidants such as tocopherols. Solvent extraction of quinoa oils was carried out by Mufari et al. from two matrices (wholemeal and germ flours), and in both cases, the extraction performance, physical–chemical characteristics, and oxidative stability were determined. Oxidative stability of the oil was assessed using an accelerated aging experiment under storage conditions at 60 C for 12 days, in which the following parameters were measured: peroxide value, acid value, conjugated dienes and trienes, and scavenging radical capacity [J. Amer. Oil Chem. Soc. 97 (1), 57-66 (2020)]. Germ flour showed greater extraction yields (27.30±0.15g/100 g) compared to wholemeal (5.88±0.02g/100g). Both oils presented similar physicochemical parameters, although the tocopherol content was higher in the oil extracted from germ flour (1354 vs. 735 mg/kg oil). At the same time, wholemeal oil showed a superior oxidative stability; hence, the wet milled process produces a minor impact on the compounds responsible for protection against lipid oxidation.

Enzymatic Synthesis of Ether Lipids Rich in Docosahexaenoic Acid with Squalene as Reaction Medium

Squalene as reaction medium was tried by Sun et al. for the enzymatic synthesis of ether lipids rich in docosahexaenoic acid (DHA) *via* transesterification of alkylglycerols (AKG) obtained from shark liver oil and DHA-enriched ethyl esters (DHA-EE) from *Schizochytrium* sp. The effects of reaction time, temperature, molar ratio (AKG /DHA-EE), and enzyme dosage were investigated. DHA conversion of 74.47% was achieved for 48 hours of reaction at 60 C using a molar ratio of 1:2 and an enzyme dosage of 30% based on AKG in the presence of squalene with Lipozyme® 435 (Novozymes, Tianjin, China) as the catalyst. With a high boiling point, squalene could act as a solvent without being vaporized from the reaction system under vacuum and improve the operational stability of immobilized lipase, which may be useful for enzymatic reactions under vacuum for lipid modification with byproducts of low boiling points [J. Amer. Oil Chem. Soc. 97 (2), 135-140 (2020)].

Performance Evaluation and Biodegradation Study of Polyvinyl Chloride Films with Castor Oil-based Plasticizer

In the present study, a renewable resource-based plasticizer was synthesized by Mukherji and Ghosh using the lipase-catalyzed esterification reaction of furfuryl alcohol (FA) and castor oil fatty acid (COFA). The resultant ester (FA-COFA ester) was used as secondary plasticizers to the polyvinyl chloride (PVC) films. The PVC films were formulated using the combination of a conventional plasticizer di-butyl phthalate (DBP) and FA-COFA ester as a secondary plasticizer at different concentrations. Films were characterized by X-ray diffraction analysis, scanning electron microscopy, thermal analysis, mechanical performance, and migration stability. A biodegradability study of the PVC films showed increased degradability with increasing concentration of the FA-COFA ester in the PVC film [J. Amer. Oil Chem. Soc. 97 (2), 187–199 (2020)]. The study showed that ester of FA and COFA could be a substitute of DBP by as much as 80% of the total plasticizer with improved elongation and tensile properties, and such a kind of sustainable resource based PVC blend films could be used as a good packaging material with biodegradable property.

Application of Response Surface Methodology for the Optimization of β-Carotene-Loaded Nanostructured Lipid Carrier from Mixtures of Palm Stearin and Palm Olein

The main purpose of this study by Rohmah et al. was to optimize a β-carotene-loaded nanostructured lipid carrier (βC-NLC) using the lipid matrix of palm stearin and palm olein and Tween 80 as a surfactant. The NLC was prepared by using the high shear homogenization method. Box–Behnken Design (BBD) response surface methodology (RSM) was applied to optimize the process and formulation. A three-factor experimental model was used to optimize the combination of palm stearin ratio (A, %w/w), lipid:surfactant ratio (B, %w/w), and (lipid+surfactant):water ratio (C, %w/w). The formulations were evaluated for their responses on particle size (Y1), polydispersity index (Y2), zeta potential (Y3), and encapsulation efficiency (Y4). Subsequently, Fourier-transform infrared spectroscopy (FTIR), thermal (DT-TGA), X-ray diffraction (XRD), transmission electron microscopy (TEM), and in vitro release (Franz diffusion cell) analyses were utilized to observe the resulting optimum formulation. The optimum formulation was obtained at a combination of A (5.5:4.5), B (1:4.9), and C (24:76) %w/w. This resulted in βC-NLC having a particle size of 166 nm, polydispersity index of 0.35, zeta potential of −26.9 mV, and an encapsulation efficiency of 91.2%. No strong interaction between different NLC components was observed based on FTIR, DT-TGA, and XRD profiles. Round-shaped NLC particles were observed under TEM. Franz diffusion cell observation resulted in diffusion profile of β-carotene of 110.6 μg/cm^{-2} with a flux of 1.06 (μg/ cm^{-2} hour^{-1}). This indicates that palm stearin and palm olein can be prospectively developed as βC-NLC [J. Amer. Oil Chem. Soc. 97 (2), 213–223 (2020)]. .

Fatty Acid Estolides: A Review

Estolides are bio-based oils synthesized from fatty acids or from the reaction of fatty acids with vegetable oils. Estolides have many advantages as lubricant base oils, including excellent biodegradability and cold flow properties. Promising applications for estolides include bio-lubricant base oils and in cosmetics. In this review by Chen et al, the synthesis of estolides from fatty acids using four different types of catalysts, namely, mineral acids, solid acids, lipases, and ionic liquids, is summarized. The summary includes the yield of estolide obtained from varying synthetic conditions (time, temperature, catalyst). Also reviewed are studies comparing the physical properties of estolides synthesized from refined fatty acids against those synthesized from fatty acid mixtures obtained from vegetable oils such as coconut, castor, Physaria, etc. [J. Amer. Oil Chem. Soc. 97 (3), 231–241 (2020)]. By varying the structure of the fatty acids, estolides with a wide range of pour point, cloud point, and viscosity are synthesized to meet a wide range of application requirements. Currently, estolide products are being commercialized for personal care and lubricant base oils for automotive, industrial, and marine applications. The application areas and the demand for estolides is expected to grow as the drive for switching from petroleum to bio-based products keeps growing.

Robust and Reliable Quantification of Phospholipids in Edible Oils Using ^{31}P NMR Spectroscopy

Upon storage, crude plant oils will form a solid sediment called gum, which consists mainly of phospholipids (PL). In a detailed study on quantification of phospholipids by Rijn et al. PL are removed during the production of edible oils by a process called degumming. A higher yield is recognized as a major advantage of enzymatic degumming over traditional

processes. Robust and accurate PL quantification methods are needed to develop and monitor enzymatic degumming processes. Several techniques, such as atomic emission spectroscopy, liquid chromatography, and thin-layer chromatography, have been applied for the quantification of PL in edible oils. In the past decade, ^{31}P NMR spectroscopy has been shown to have advantages over these techniques because of the possibility of the simultaneous, fast, and accurate quantification of different PL directly in the oil [J. Amer. Oil Chem. Soc. 97 (3), 253–262 (2020)]. This article demonstrates the application of ^{31}P NMR spectroscopy as a method for the quantification of all relevant PL and phosphorous-containing degradation products in crude and refined oils. In addition, the validation results show that this method is robust because the limit of detection is as low as 5 µmol/100 g oil. Variations of less than 5% were obtained for all P-containing compounds present in the oils at concentrations above 100µmol/100g oil.

Production of Structured Triacylglycerol *via* Enzymatic Interesterification of Medium-Chain Triacylglycerol and Soybean Oil Using a Pilot-Scale Solvent-Free Packed Bed Reactor

Oils rich in medium- and long-chain triacylglycerols (MLCT) serve as functional oils to help reduce body fat accumulation and weight gain. However, most of the MLCT-rich products on the market are physical blends of medium- and long-chain triacylglycerols (MCT and LCT, respectively) that are not structured triacylglycerols (TAG). In this study by Zhang et al., an efficient pilot-scale packed bed reactor (PBR) of immobilized lipase from *Thermomyces lanuginosus* (Lipozyme® TL IM, Novozymes, Bagsvaerd, Denmark) was employed for producing structured MLCT *via* 1,3-specific interesterification of TAG enriched in caprylic and capric acyl groups and soybean oil (SBO). The PBR was operated under continuous recirculation mode in the absence of solvent. Optimal reaction conditions were determined to be: caprylic/capric TAG : SBO ratio (45:55 w/w), reaction temperature (75 C) and residence time (16.0 min) on MLCT production were studied [J. Amer. Oil Chem. Soc. 97 (3), 271-280 (2020)]. When employing a pilot-scale PBR (100kgday^{-1}) under optimal conditions, a product containing 76.61wt% MLCT was produced. Lipozyme TL IM was reused for 25 successive batch reactions (125 kg substrates) with no significant reduction in catalytic efficiency. The light yellow MLCT-enriched product had a high level of saturated fatty acids (SFA, 82.74 wt%) in its *sn-2* position as a result of the enzyme's 1,3-positional specificity. One-stage molecular distillation and methanol extraction were used to remove the free fatty acids, mono-, and diacylglycerols generated from hydrolysis. With distillation temperature of 150 C and oil-to-methanol ratio of 1:3% v/v, MLCT content was further increased to 80.07 wt%. The enzymatic PBR was therefore effective in producing structured MLCT at a pilot-scale under solvent-free conditions.

Isolation and Evaluation of Stearin and Olein Fractions from Rice Bran Oil Fatty Acid Distillate by Detergent Fractionation and Conversion into Neutral Glycerides by Autocatalytic Esterification Reaction

Detergent fractionation (Lanza process) offers a valuable separation process for edible oils that contain varying amounts of saturated and unsaturated fatty acids. The rice bran oil fatty acid distillate (RBOFAD), obtained as a major byproduct of rice bran oil deacidification refining process was used for this study by Sahu et al. RBOFAD was fractionated by detergent solution into a fatty acid mixture as follows: low□melting (19.00 C) fraction of fatty acids as olein fraction (44.50 g/100 g) and high melting (49.00 C) fatty acids as stearin fraction

(37.15 g/100g). A high amount of palmitic acid (42.75 wt%) is present in stearin fraction, while oleic acid is higher (48.21 wt%) in the olein fraction. The stearin and olein fractions of RBOFAD with very high content of free fatty acids are converted into neutral glycerides by autocatalytic esterification reaction with a theoretical amount of glycerol at high temperatures (130–230 C) and at a reduced pressure (30 mmHg). Acid value, peroxide value, saponification value, and unsaponifiable matters are important analytical parameters to identity for quality assurance [J. Amer. Oil Chem. Soc. 97 (3), 301-308 (2020)]. These neutral glyceride-rich stearin and olein fractions, along with unsaponifiable matters, can be used as nutritionally and functionally superior quality food ingredients in margarine and in baked goods as shortenings.

Synthesis of Alkyl Sulfur-Functionalized Oleic Acid-Based Polymethacrylates and Their Application as Viscosity Index Improvers in a Mineral Paraffinic Lube Oil

This work by Lomege et al. describes the synthesis of alkyl sulfur-functionalized polymethacrylate-based Viscosity Index Improvers (VII) derived from oleic acid (OLA) for mineral paraffinic lubricating oils. In this strategy, OLA was first quantitatively ramified by alkyl thiols containing long aliphatic chains through thiol-ene coupling as demonstrated by ^{1}H NMR spectroscopy with the complete consumption of OLA internal double bonds. The resulting alkyl sulfur-functionalized OLA-based derivatives were methacrylated through Steglich esterification in order to afford highly suitable hydrophobic OLA-based monomers which, as far as we know, have not been described yet in the current literature. High polymethacrylate molecular weights were reached through radical polymerization despite the long alkyl pendant chains contained in their backbones. Finally, the resulting alkyl sulfur□functionalized OLA-based polymethacrylates have been blended in a mineral paraffinic oil (MPO) of reference at 5 wt% and evaluated as VII. Rheological measurements revealed that polymer thickening powers were significantly improved in oil with temperature and promoted by increasing the pendant alkyl thiol contained in polymer backbones [J. Amer. Oil Chem. Soc. 97 (3), 309-318 (2020)]. Moreover, the viscosity index of MPO was significantly improved with the addition of both synthesized homopolymers which confirmed their efficiency as VII. In the meantime, these results have been compared with a previously reported polymer, the poly(2-[methacryloyloxy]ethyl oleate) (PMAEO), which demonstrated a lower VII efficiency compared with its analogous polymethacrylates containing an additional alkyl chain in their pendant chains.

The epoxidation of linseed oil with *in situ* formed peracetic acid: A model with included influence of the oil fatty acid composition

The epoxidation of vegetable oils with percarboxylic acids yields commercially applicable green products/precursors for the polymer industry. A reliable model of this reaction system could help to improve the quality of the produced epoxidized vegetable oils. A biphasic model, pseudohomogenous with respect to the catalyst, was proposed by Janković et al. for the vegetable oil epoxidation with peracetic acid formed in situ in the presence of an ion exchange resin. The model takes into consideration the influence of the oil fatty acid composition, as an important property of this renewable raw material, on the kinetics of the process. Non-edible linseed oil was chosen for the study since it contains significant amounts of different unsaturated fatty acids, i.e., linolenic (54.8%), linoleic (16.0%) and oleic (19.8%) acids, in its triglycerides. The effects of temperature (333–358K), molar ratio of linseed oil double bond:hydrogen peroxide (1:1.1–1:1.5),

catalyst amount (10–20 wt%) and reaction time (1–17 h) on the relative epoxy yield and the process selectivity were investigated. The proposed model explained the experimental data concerning changes in double bond and epoxy group amounts during the linseed oil epoxidation with a standard deviation of less than 0.024. The partition coefficient for acetic acid between the liquid phases of the reaction system, as the thermodynamic constant in the model, was separately determined for the linseed oil-epoxidized linseed oil-acetic acid-hydrogen peroxide-water system [Ind. Crops & Products 143, 111881 (2020)]. Its values ranged from 0.0705–0.3159. The kinetic study showed that one double bond per linolenic acid chain has significantly higher reactivity towards the epoxidation reaction compared to other double bonds in the linseed oil triglyceride. The reactivity difference between these double bonds increased from 6.5 to 41 times with the temperature rise from 333 to 358 K.

Synthesis of thermal insulating polyurethane foams from lignin and rapeseed based polyols: A comparative study

Nowadays, a large number of polyurethane (PU) system modifications relies on the use of different bio-polyols. In this context, two bio-based polyols were synthesized by Kuranska et al., one synthesized from lignin and one from rapeseed oil were evaluated in the replacement of a petrochemical polyol at an amount of 10–30 wt.% in rigid polyurethane foam formulations (RPU). The lignin-based polyol was produced by oxypropylation from an organosolv lignin (ALCELL) and the rapeseed oil-based one prepared by a two-step method of epoxidation followed by oxirane ring opening with diethylene glycol [Ind. Crops & Products 143, 111882 (2020)]. The replacement of the petrochemical polyol with the lignin bio-polyol increased the reactivity of the reactive mixtures, while the rapeseed oil bio-polyol gave the opposite effect. This was confirmed by the respective changes observed in the dielectric polarization of the reactive mixtures together with the maximum temperature achieved in the foam core during the foaming process. The foams modified with the tested bio-polyols had both lower apparent density (40–45 kg/m^3) and closed cell content (86–89%), comparatively with a reference foam. The replacement of petrochemical polyol with the bio-polyols up to 30 wt% caused, in the modified foams, a slight decrease of the compressive strength. Moreover, the introduction of the bio-polyols into PU formulations generally did not influence the thermal conductivity coefficient that was around 23 mW/m·K for the obtained materials.

Production of linseed diacylglycerol- rich oil by combined glycerolysis and esterification

The objective of this work by AbdAwadallak et al. is to propose a new route to produce diacylglycerol (DAG) by combining glycerolysis and esterification to convert the formed monoacylglycerol (MAG) into DAG instead of separating it from the product. Linseed oil was used as the source of triacylglycerol (TAG), oleic acid as free fatty acid (FFA), and phospholipase Novozyme 435® as catalyst. Two methodologies were evaluated: simultaneous reactions of glycerolysis and esterification and sequential reactions of glycerolysis followed by esterification. Both the sequential and simultaneous reactions presented an increase in DAG production compared with pure glycerolysis. The best results were obtained for the sequential reaction in the following conditions: (1) glycerolysis step - 57.7 C, GLY:TAG 1:1 M ratio, 4 % enzyme; (2) esterification step 57.7 C, FFA:TAG 1:1 M ratio, 4% enzyme. In these conditions, oil was obtained with 62.05 w% DAG, which represents an increase of 57 % over the concentration of DAG obtained in the pure glycerolysis step [Ind. Crops & Products 145, 111937 (2020)].

Biodiesel production from *Hiptage Benghalensis* seed oil

Increasing demand of fossil fuel and its depleting stock across the globe have necessitated a search for potential alternative sources of renewable energy. Recently focus has shifted to production of diesel from bio-oils derived from plant biomass as a potential source. However, it has been an endeavour to shift the exploration to non-edible oils produced by non-crop plants. *Hiptage benghalensis* is one such unexplored plant which stores ricinoleic acid in its seeds. In this report by Dubey et al., analyses of various biochemical and biophysical parameters of *H. benghalensis* seed oil have been undertaken in order to explore the potential of this oil for biodiesel production. The plant was sourced from three different geographic regions of India. The total lipid and ricinoleic acid contents of seeds obtained from three locations varied from 54 to 69% and 69–87 %, respectively. Properties of various parameters of the *H. benghalensis* seed oil (HbSO), besides being non-edible prove its potential as a biodiesel feedstock. In order to test this potential, the seed oil was converted into biodiesel through the process of transesterification with an efficiency of ~93 %. Analysis of various fuel properties like acid value, calorific value, viscosity, density, ash content, flash, pour and cloud point of the biodiesel in accordance with ASTM-D6751 standard and a comparison with the properties of other reported biodiesels showed its reasonable quality [Ind. Crops & Products 145, 111937 (2020)]. Thus, this non-edible oil from *H. benghalensis* seeds has a potential to be utilized as an alternate green energy source for biodiesel production.

Chemical modification of castor oil fatty acids (*Ricinus communis)* for biolubricant applications: An alternative for Brazil's green market

Plants oils have been increasingly gaining acceptance in world markets, due to their great potential as raw material to replace conventional mineral oils for formulation of lubricants. In this studyby Rios et al, samples of new potential bio-based lubricant molecules were synthesized from castor oil fatty acids. The synthesis occurred in three steps: esterification with 2-ethyl-1-hexanol, epoxidation and opening of oxirane rings with different nucleophilic agents: 1-butanol (BIOBUT) and water (BIOWAT). The main objective was to study the influence of hydroxyl groups and branching level on physicochemical properties and thermal degradation of samples. The products obtained in each step were characterized by ^{1}H NMR and their physicochemical properties. The results indicated that the less polar samples (BIOBUT) exhibited a better low-temperature performance (PP −48 C). Furthermore, BIOBUT has superior oxidation stability (IP 4.22 h) compared to BIOWAT (IP 3.27 h) [Ind. Crops & Products 145, 112000 (2020)]. However, the BIOWAT showed a higher viscosity values (> 470 mm^2/s at 40 C). Thermogravimetric analyses have indicated that BIOWAT shows better thermal stability. Finally, the activation energy determined for the first thermal event for BIOWAT (151 $kJ.mol^{-1}$) was higher than BIOBUT.

Selective Hydrogenation of Fatty Nitriles to Primary Fatty Amines: Catalyst Evaluation and Optimization Starting from Octanenitrile

In this contribution by Hinzmann et al, an evaluation of the potential of various homogeneous and heterogeneous catalysts for a selective hydrogenation of fatty nitriles toward primary amines is reported exemplified for the conversion of octanenitrile into octane-1-amine as a model reaction. When using heterogeneous catalysts such as the ruthenium catalyst Ru/C, the palladium catalyst Pd/C, and the platinum catalyst Pt/Al_2O_3, low selectivities in the hydrogenation are observed, thus leading to a large portion of

secondary and tertiary amine side-products. For example, when using Ru/C as a heterogeneous catalyst, high conversions of up to 99% are obtained but the selectivity remains low with a percentage of the primary amine being at 60% at the highest [Eur. J. Lipid Sci. Technol. 122 (1), 1900163 (2020)]. The study further reveals a high potential of homogeneous ruthenium and manganese catalysts. When also taking into account economical considerations with respect to the metal price, in particular, manganese catalysts turn out to be attractive for the desired transformation and their application in the model reaction leads to the desired primary amine product with excellent conversion, selectivity, and high yield.

Evaluation of the Antioxidant Properties of Micronutrients in Different Vegetable Oils

Micronutrients (tocols, sterols, and total phenolic) and antioxidant activities of 15 varieties of common vegetable oil samples obtained from different countries are investigated by Liu et al. All methanol extracts are assayed for total antioxidant ability and cellular antioxidant activity (CAA) using oxygen radical absorbance capacity (ORAC) method and CAA assay. CAA has been widely used in the evaluation of food antioxidants recently. It quantifies antioxidant capacity utilizing a HepG2 cell model, which is more biologically representative. Linseed and sesame oils show much higher CAA values than the others tested; however, levels of walnut, sunflower, and coconut oils are extremely low, which are hard to be quantified. A significant correlation between the ORAC and CAA values and total phenolic content ($p < 0.05$) is observed. High-phenolic olive oil has the highest level of phenolics and the highest ORAC, while linseed oil has the highest CAA value. Based on this, choosing proper edible oil consumption may reduce oxidative damage of human body and promote the precision processing of edible oil such as retaining beneficial ingredients moderately [Eur. J. Lipid Sci. Technol. 122 (2), 1900079 (2020)].

Formation of Phospholipid Association Colloids in Rapeseed Oil and Their Effect on Lipid Autoxidation in the Presence of Sinapic and Ferulic Acid

This study by Rokosik et al. describes the formation of 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC) association colloids (reverse micelles) in rapeseed oil and interactions of sinapic and ferulic acids with these structures. Furthermore, the process of oil autoxidation in the presence of DOPC is characterized and the antioxidant efficiency of phenolic acids in the oil containing reverse micelles is determined. Formation of DOPC reverse micelles above the phospholipid critical micelle concentration (51.13 μmol kg^{-1}) is observed. The fluorescence probe emission parameters confirm the interactions of sinapic and ferulic acids with reverse micelles and changes of their structure (reduced rigidity) as a result of phenolic acid incorporation[Eur. J. Lipid Sci. Technol. 122 (2), 1900243 (2020)]. In the analyzed rapeseed oil, an evident prooxidative effect of DOPC reverse micelles is found, as their presence accelerates decomposition of hydroperoxides to hexanal. The antioxidant effect of sinapic acid is strongly influenced by the presence of DOPC reverse micelles. Ferulic acid shows a concentration-dependent antioxidant effect in relation to the formation of hexanal.

Synthesis of Trimethylolpropane Esters by Base-Catalyzed Transesterification

Trimethylolpropane (TMP) esters are synthesized by Nie et al.from fatty acid methyl esters (FAMEs) and TMP to produce a fluid with properties suitable for use as a lubricant base oil, exhibiting good stability, and low-temperature performances. In this study, triacylglyceride (TAG) molecules are modified to produce FAME and then linked to TMP. Initially, vegetable oil is transesterified with

excess methanol, and potassium hydroxide to produce crude FAME. The FAMEs are then refined and further transesterified with TMP and heating, under vacuum, using potassium carbonate catalyst. The conversion of TMP is successfully achieved by adding an excess of FAME to a reaction mixture of base and polyol in the second step. All reactions are monitored and confirmed using ^{1}H-NMR [Eur. J. Lipid Sci. Technol. 122(3), 1900207 (2020)].The reactions proceed quickly as an efficient production of FAME and TMP to TMP triesters is successfully achieved by adding an excess of FAME slowly to a mixture of TMP and catalyst.

Recent Advancement in Plant Oil Derived Polyol-Based Polyurethane Foam for Future Perspective: A Review

Polyurethane foams (PUFs) are widely used materials because of their wide range of applications, particularly, thermal and sound insulation, mattresses, furniture, construction, cushioning, packaging, transportation of goods, etc. Recently, commercial PUF products fabricated from plant oil (PO)-based polyols have gained increasing popularity, because of their low cost and eco-friendly nature in comparison to petroleum-based PUF. To date, insufficient reviews have been reported in the area of modification of plant oils for synthesizing polyol for foam synthesis. Due to abundant availability, low-cost, and renewable nature of plant oils, they are being used as precursors for modern polyurethane industry use. There is a need for versatile and economical methods for conversion of plant oils such as castor oil (CO) and soybean oil (SO) into useful polyols for industry use. This review by Singh et al. is an overview of the most recent advanced methods for the conversion of plant oils into polyol and further utilization of it for commercial PUF products. Since the last decade, many researchers have shown that plant-polyol-derived PUF can compete with conventional PUF.

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2. **S. D. THIRUMALA RAO MEMORIAL AWARD**
3. **DR. J. G. KANE MEMORIAL AWARD**

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This award was instituted by J. G. Kane Memorial Trust, Mumbai for an eminent scientist for his outstanding contribution in the field. The scientist selected by the OTAI, at the occasion of Annual Convention of OTAI, delivers a lecture named professor J. G. Kane Memorial Lecture. The award carries a cash prize of Rs. 25000/= and a Citation which is jointly financed by J.G. Kane Memorial Trust & OTAI (WZ).

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This award was instituted by Zaheer Science Foundation of the CSIR in the year 1979, to perpetuate the memory of Dr. S. Husain Zaheer, for excellence in research contribution in Oil Chemistry and Technology, Surface Coatings and allied subjects through research papers which include applicant's name among the authors and which appeared during the previous three calendar years. The award consists of cash prize of Rs. 5,000/= and a Citation.

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Annual cash award of Rs. 5000/- was instituted with the support of OTAI (CZ) in memory of Prof. R.K. Khanna. This team award is for the best research paper published in all issues of the Journal of Lipid Science Technology, which appears during previous calendar year. No application is required for this award.

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Annual Cash Award of Rs.10,000/- and citation was instituted by OTAI (EZ) with corpus fund donated by Dr. Pubali Ghosh Dhar in memory of Dr. Santinath Ghosh for the Young Researcher (age below 35 years). The award is for excellence in the field of Oil Technology and Allied Sciences with best Social / Industrial Implication through patent / research paper, which include applicant's name among the authors which appeared during the previous calendar year. Applicant must be a member of OTAI.

LIFE TIME ACHIEVEMENT AWARDS:

Besides these awards, on recommendations of host zone, CEC awards committee announces to felicitate with Life Time Achievement Awards during the inaugural session of annual convention of OTAI.

Thanks and Regards
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Half Page (Black & White)	**Rs 8,000/- per insertion (Rs 25,000/- per four insertions)**

MECHANICAL DATA

Frequency of Publication	:	Quarterly
Overall size	:	28 cms x 21.5 cms
Print area	:	23 cms x 17.5 cms
No. of columns	:	Two
Paper	:	Art paper

Bank Account Details for Payment by NEFT/ RTGS/ IMPS	
Name of Account	: **OTAI - PUBLICATION COMMITTEE**
Name of Bank	: **YES BANK LIMITED**
Account No.	: **048794600000653**
IFSC Code	: **YESB0000487** & MICR CODE : **110532094**

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- Payment is to be made in advance by N.E.F.T./ R.T.G.S./ I.M.P.S. (Account details mentioned here-in-above) or crossed cheque/ demand draft in favour of **"Publication Committee, Oil Technologists' Association of India" Payable at Kanpur.** Outstation cheques are not accepted. Please send your payment along with the advertisement material to the Editor at the above mentioned address.

This Quarterly periodical is published by Mr C.S. Joshi on behalf of Oil Technologists' Association of India, C/o Lipid Science & Technology Division, CSIR- Indian Institute of Chemical Technology, Hyderabad - 500 007, Telephone No. 91-40-27193370 and Printed by him at Bhakti Prakashan (Designers & Printers), Shri Ram Krishna Pragya Bhawan, 8/87, Arya Nagar, Kanpur - 208 002. Ph. 9336270570.
Editor - in - Chief : Prof. R.P. Singh

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