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Biodiesel production using Soybeans: A green approach

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Abstract
The foremostexplanations behind the expansion of renewable energy sources
are the constantly rising need for energy on a worldwide scale and the drawbacks of using fossil fuels, mostly connected to the gas emissions that occur during their burning. In this light, biodiesel remains an intriguing option that may assist in reducing the amount of greenhouse gases released into the sky. This study looked at the soybean-based biodiesel synthesis method. Gas chromatography was used to examine the physical characteristics of the biodiesel, containing density, viscidness, and content of acids, as well as the ester concentration. The outcomes were then utilized to track the reaction's development and the catalyst's gradual deactivation over time, allowing researchers to confirm that the biodiesel's quality is maintained throughout.For this reason, we may draw the conclusion that the recycling reactor utilized in this study contributes positively to innovation in the manufacture of biodiesel.

Keywords: Biodiesel; Soyabean; gas chromatography.

1. Introduction

Unconventionalsources of energy must replace fuels that are produced using petroleum as bases due to environmental concerns, global climate change, and the exhaustion of the petroleum reserves of the world. The best substitute for diesel fuel, according to some, is biodiesel, a sustainable and clean energy (Singh & Singh, 2010). One of the major sources of feedstock is soybean oil used to produce biodiesel. As per United States Department of Agriculture, the United States produced more soybean oil than any other nation in the world in 2006–2007. (USDA). In connection with production of soybean oil, the United States remains next to other countries such as Argentina, China, Brazil, and India. The United States generated 34.5% of the world's soybean oil (United States Department of Agriculture, 2008). This quantity of extract is a viable supply for the ecologically responsible and natural generation of biodiesel (Patil & Deng, 2009).

Studies of Life Cycle Assessment (LCA) revealed that cultivating soybean has fewer adverse effects on the ecology on comparison with otherseeds that produce oil such as rapeseed and sunflower. However, theUnited Nations Food and Agriculture Organization (FAO) stating numerousproblems related to environmentwhich might be associated with production of maize and soyabeans in large-scales(FAO, 2009) (Sanz Requena et al., 2010).

Soybeans may be used to make ethanol in addition to biodiesel. Because of their high protein content, farmers choose to utilise soybean hulls for animal feed. Soybean hulls provide a substantial quantity of carbohydrates for ethanol synthesis (Mielenz et al., 2009). Even though biodiesel is typically employed in various blends with petro-diesel, compression ignition engines may run entirely on the fuel. According to the findings of engine emission testing, using biodiesel by itself resulted in lower emissions of harmful gases than using crude oils (Qi et al., 2009).

The extraction of oils and biodiesel conversion steps are carried out separately in conventional biodiesel manufacturing from soybeans. Mechanized pressing, extraction using solvents, extraction using supercritical fluids, and solvent extractions aided by microwave and ultrasound are all methods used to extract oil from soybeans. Transesterification is used to degum the extracted oil and produce biodiesel from it. Oil and alcohol, often methanol or ethanol, are blendedalong with catalyst during the chemical reaction process known as transesterification to create fatty esters and glycerol.Making biodiesel viable in the diesel fuel market requires lowering the cost of production from $ 3.11 to less than $3.00per gallon for petroleum-based diesel (Kargbo, 2010).

This chapter's goals are to evaluate the literature on soybean oil extraction, biodiesel synthesis, and processing of soybeans usingultrasound with high-intensityfor the creation of biodiesel. We'll talk about three uses for ultrasound in the processing of soybeans for biodiesel.In the first case, the yield of soybean oil will be examined in relation to solvent quantity, oil extraction time, and ultrasonication. The nextinstance we will look at the trans-esterification of soybean oil with ultrasonic assistance to make biodiesel. The third application will look at the viability of combining in-situ transesterification with ultrasound to produce biodiesel while also extracting soybean oil.

2. Literature review

The grains must be pretreated in order to extract the oil from soybeans. Operations related to pretreatment include cleaning, dehydration, husk dehulling, and crushing (Fig. 1). The main methods used to extract oil from soybeans include the use of power driven pressing, extraction using solvents, extraction using supercritical fluids, and extraction aided by microwave and ultrasound.

Mechanical Extraction

One of the most popular ways to extract oil across the world is by mechanical pressing of the oil seeds. But mechanized presses having single screw are capable of extracting oil only upto 8% to 14% that is present in the seeds (Singh &Bargale, 2000). Heat is used for mechanized extraction to counteract the effects of enzymes (Gerpen et al., 2002). Using an extruder is a productive approach to supply heat for enzyme neutralization.

Extruders apply sufficient pressure and heat to kernels to render enzyme inactive (Gerpen et al., 2002). For extracting proteins and oils, employing a high temperature dry extruder was reported by Jung and Mahfuz (2009). They discovered that the solubility of proteins in soybean oil increased with increased extruder pressure.

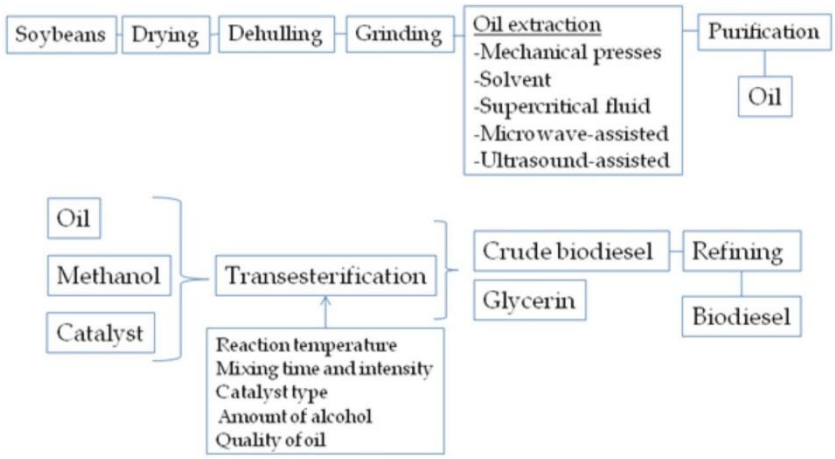

Fig.1.Processing of Soybeans for extracting oil and producingbiodiesel

Solvent Extraction

Hexane has low vaporization temperature, can resist corrosion, is stable, and has minimal residue in terms of grease make it a popular choice for extraction of oils from oilseeds like soybeans and other seeds that produces oils (Seth et al., 2007). The use non-petroleum fuels were suggested byJohnson and Lucas (1983).They listed a number of issues with hexane, including its price dependence on the market for fossil fuels and its detrimental consequences on the environment (Gandhi et al., 2003). According to Russin et al. (2010), soybean oil may be extracted using more than 70 different solvents. However, using various types'of alcohols in oil extraction was the major focus of several recent researches (Russin et al., 2010). According to Seth et al. (2007), using isopropyl alcohol resulted in greater rates of extraction and recovery than using hexane

(Seth et al., 2007). Isopropanol, hexane, and a 3:2 combination of the two was used for extraction of chickpea oils. On comparison of the results it was seen thathigher extraction was seen when isopropanol and hexane were combined and used for extraction (Lou et al. 2010)

Supercritical Fluid Extraction

A number of issues were listed for use of hexane, including its price dependence on the market for fossil fuels and its detrimental consequences on the environment (Gandhi et al., 2003). According to Russin et al. (2010), soybean oil may be extracted using more than 70 different solvents. However, using different types of alcohols in oil extraction was majorly focused in several recent researches (Russin et al., 2010). According to Seth et al. (2007), using isopropyl alcohol resulted in greater rates of extraction and recovery on comparison to using hexane (Seth et al., 2007). When oils from chickpea were extracted using isopropanol,hexane, and a 3:2 combination of the two, Lou et al. (2010) compared the results. Higher extraction was seen when hexane and isopropanol were combined.

Ultrasound-assisted Extraction

In their 2007 study, Luthria et al. examined different methods for extraction of oils from soybeans. With the ultrasonication approach, they were able to generate the most oil around 93.3% when matched to other techniques (Luthria et al., 2007). The approaches of microwave and ultrasound that Cravotto et al. (2008) employed independently and in combination to extract oil from microalgae and soybeans. In comparison to traditional (Soxhlet) extraction, extraction using ultrasound/microwave lowered the time required for extraction and volumes of solvents while producing higher efficiency of extraction (Cravotto et al., 2008). Use of ultrasonic waves is effective in comparison with the usual techniques for extraction of oil from flaxseed, according to Zhang et al. (2008), who used both ultrasonic and conventional methods (Zhang et al., 2008). Lou et al. employed ultrasonication technique for extraction of oil from chickpea (2010). They claimed that the use ofultrasonic waves accelerated extraction and improved the amount of the finished product (Lou et al., 2010).

Microwave-assisted Extraction

Extraction of oils from Hazelnut (Chilean) and analyzing the quality of oil were investigated(Uquiche et al. 2008). In the first step which is pretreatment, use microwave followed by mechanized pressing was done. The reported findings suggest application of microwave enhanced the oil's amount and quality (Uquiche et al., 2008). Kashyap et al. (2009) suggested enzymatic hydrolysis as a different technique to improve extraction of oils from soybeans. This routine was followed by the pretreatment step and it was observed that the hydrolysis of enzymes caused a considerable improvement in the extraction of oils from soyabeans (Kashyap et al., 2007). Terigar et al. (2010) evaluated

the extraction of isomers of flavones from soybeans by employing traditional solvent extraction vs microwave-assisted solvent extraction. They claimed that there was increase in yields of isomers of flavones and oilsby use of microwaveoncomparing it withextraction using solvents(Terigaretal.,2010).

Refining Oil

The initialstage in the refining of oils is referredas de-gumming, the objective of de-gumming is to segregate phospholipids from the mixtures of oils by addition ofchemical that are capable of hydrating. The two primary degumming techniques used by the oil industry are water and acid (Ribeiro et al., 2008). Pagliero et al. (2007) reported employing membrane separation as an alternate method of oil degumming. In comparison to traditional degumming methods, they indicated that membrane separation is a viable procedure (Pagliero et al., 2007).

Biodiesel production

Transesterificationmethod

Transesterification, instead of esterification that is done directly, is a typical technique for production of biodiesel from oils and fats of vegetable and animal respectively (Abreu et al., 2003). Alky esters and glycerol are produced when fats or oils and alcohol interact during transesterification or alcoholysis in the along with the catalyst (Meher et al., 2006). Oils with a higher viscosity than petro-diesel are made less viscous using the transesterification process (Stavarache et al., 2005). Choosing the specificcatalysts or alcohols is crucial for the process of transesterification. Transesterification may be done with a variety of alcohols, including ethanol,methanol, butanol, propanol, amyl alcohols and the like. Because it is significantly less expensive than other alcohols and has benefits over other alcohols in terms of chemistry and physical properties, methanol is utilised frequently (Ma & Hanna, 1999).
Theoretically, in order to make fatty acid methyl ester (3 moles) (FAME) and of glycerin (1 mole), 1 mole of triglyceride must be neutralized by 3 moles of alcohols (Leung et al., 2010). For the transesterification, triglycerides at a decent rate and convert them to biodiesel, a good catalyst is also required (Lotero et al., 2005). During the process of transesterification, catalyst having acid and alkaline nature can be utilized as homogeneous or inhomogeneous catalysts (Pereira et al., 2007). Since alkali catalysts, including NaOH and KOH, react more quickly and are less corrosive than acidic chemicals, research and industry favorthose(Pinto et al., 2005). Excessive levels of free fatty acids and H_2O in oils make soap and lower the efficiency of catalysts while requiring a lot of catalysts. Before using the base catalysis procedure, it is necessary to distinct the free acids of fats (FFAs) and water from the oil. By using an acid catalyst, Marchetti et al. (2008) were able to solve the aforementioned issues. They claimed that since catalysts with acidic nature are capable of converting a larger % of free acids of fats (FFAs) to triglyceride, they perform better than base catalysts. Sulfuric acid is the top option for acid catalysts, and many researchers have

employed it (Marchetti &Errazu, 2008). Enzyme catalysts are a potential alternative to acid and base catalysts for the generation of biodiesel. Due to the fact that they don't include soap, enzyme catalysts have recently attracted increased attention(Leungetal.,2010).

Ultrasound-aidedtransesterification

Many steps of the synthesis of biodiesel involved the use of ultrasound technology. Ultrasonic energies with low frequenciesfor synthesis of biodiesel were reported (Stavarache et al. 2005). The produced biodiesel was compared to those of traditional biodiesel production methods. They combined NaOH as a catalyst with three distinct kinds of alcohols. They demonstrated how ultrasonication improved the transesterification process, shortened the duration for completion, and conserved energy/power during the biodiesel synthesis process (Stavarache et al., 2005). Santos et al. (2009) investigated how ultrasonication affected the process of turning soybean oil into biodiesel. As a catalyst, they utilized KOH and methanol. They demonstrated how ultrasonic may increase biodiesel output (Santos et al., 2009). Forproduction of biodiesel from soybeans, high intensity ultrasound was employed in continuous system (Cintas et al. 2010). They heated the oil then mixed it using a stirrer mechanicallybefore using ultrasound. The findings demonstrated a significant improvement in saving of time as well as energy savings (Cintas et al., 2010). Investigated on how ultra-sonication affected the separation of glycerol during the transesterification of soybean oil and used response surfaces approach to improve the process was reported (Koc& McKenzie, 2010). Moreover, Yu et al. (2010) noted that ultrasonication enhanced the generation of biodiesel. They converted soybean oil into biodiesel using ultrasonic waves (Yu et al., 2010). Investigations onimpacts of ultrasonic time on extraction of soybean oil and contrasted the outcomes with the traditional techniques of extraction was conducted. The outcomes revealed a significant enhancement in the end product's quantity and quality. Their findings demonstrated that ultrasound has the ability to lower the level of free acids of fats (Li et al., 2004). Chand et al. (2010) examined mechanical stirring and ultra-sonication whichaimed at the generation of biodiesel from soybeans. They demonstrated that the use of ultrasonication decreased the amount of time needed to produce biodiesel (Chand et al., 2010).

In-situmethod for Transesterification

One approach that has certain leads over the process of direct transesterification is transesterification by in-situ. This method is quicker than conventional transesterification, and it only requires one step to extract the oil and convert it to biodiesel. This technique involves direct interaction of materials containing oils with acidic or alkaline alcohols (Fukuda et al., 2001). In the In-situ method of transesterification the lengthy method of production relatedwith pre-extraction of oil is minimized, removes the pricey hexane extraction procedure, and ultimately increases ester output (Verziu et al., 2009). By raising the alcohol amount and process temperature, in-situ transesterification might be enhanced (Ehimen et al., 2010). In-situ method of transesterification by employing a catalyst with

alkali nature and methanol was matchedwithconventional transesterification (Georgogianni et al. 2008). Their findings showed the process was quicker and completed in period of around 20 min (Georgogianni et al., 2008). Siatis et al. obtained similar outcomes using the same procedure and materials (2006). Acid catalysts and methanol wereemployed for process of in-situ transesterification trials (Harrington and D'Arcy-Evans 1985) (Kildiran et al. 1996). Their findings indicated a rise in overall oil output. Quian et al. (2008) looked at the efficacy of in-situ method of transesterification using catalyst for production of biodiesel from cotton seeds. It was demonstrated that the ratios of alcohol to the ratio of cottonseed oil is crucial for the generation of biodiesel (Qian et al., 2008). Santos et al. stated similar outcomes (2009). The alcohol to oil ratio of 9:1 produced the best output of biodiesel (Santos et al., 2004).Production of biodiesel from rice bran was carried out by transesterification in situ in two stepsby employing acid and base catalyst treatment (Shiu et al. 2010).As compared to one step in-situ transesterification, they were successful in producing a large volume of biodiesel (Shiu et al., 2010).

3. Materials and methods

Materials

Soybeans were procured from BradfordResearch and Extension Center, UniversityofMissouri,(Columbia, MO). Hexane was employed as solvent and procured from Chemstore. An electric grinder was used for crushing and grinding soybeans. For determining sizes of particlesafter grinding sieve analyzer was used. Electric oven was used for removing moisture from the sample. Probe type ultrasonicator with frequency of 20kHz and power capacity of 1000 W was used(UIP1000,Hielscher,Germany).

Methods

Soybeans (3.6 kg) wereimmersedinwarmwaterfor soften them and then manually dehulled. Following this the soybeans' were dried in oven for a time period of 24 hrs for removing the moisture and the remaining moisture was determined.On ensuring the soybeans are completely dried the particles were grinded to reduce its size and the sizes of particles were determined using sieve analyzer. The content of oil in the soybeans was estimated by Soxhlet extraction.For this 10 g of seeds which were grounded charged into the extraction column and in this 150 ml of hexane was refluxed. The process was carried out at 70 ˚C for time period of 10h. Subsequently the content of oil was determined by estimated by comparing the weight of seeds prior to and after extraction.

Design of experiments and statisticalanalysis

A group consisting of empirical techniques that can evaluate the relations among different parameters of experiments and their responses specific to particular parameter are known as response surfacesmethodology (Fereidouni et al., 2009).The software used to design the number of experiments and analyze the results of extraction of oil was

ECHIP(Wilmington,DE).In order to design the set of experiments the factors which were considered were size of particles, amount of solvent and power of ultrasound. Based on these parameter 19 experiments were suggested with 5 trials for replication. These five runs for replication were executed in order to estimate the errors. The experiments were performed randomly to reduce any apparent variations in the responses due to some factors which are not relevant (Sinetal.,2006).

Environmental Scanning Electron Microscope(ESEM)Microplots

The images of soybean surfaces after reducing of size by grinding, prior to extracting oil from seeds and after extracting oils from soybeans by solvent extraction and using ultrasound are examined by ESEM (FEIQuanta600FESEM,USA).

Yield measurement

After ultra-sonication the yield was estimated by collecting the mixture of hexane-oil.The sample was subjected to centrifugation at 1000 rpm for time period of 20 min to segregate any residual particles from sample. Subsequently 1 ml of supernatant was weighed and noted.The solvent was evaporated from the samples by keeping the samples in oven for time period of 2h at 105°C. Initial and final weights were checked and noted.Theyield of oil (Y)was estimated using the equation as shown below.

$$\int_{l}^{w} Y = \frac{we}{100}$$

Here, $w_e$is the weight of oil that is extracted (g)

w_t is the weight of oil in each sample

The weight of oil in each sample was estimated by Soxhletextraction.

Conventional biodiesel production

Soybean oil was obtained from a local shop.Firstly, by the method of titration the quantity of KOH was estimated. As per thetitration, the quantity of KOH was estimated to be 5.18 g per litre of oil. 0.259 g of KOH (purity >92%) was added to 50 ml of methanol (purity > 95%) and the resulting mixture was heated to a temperature of 50 ºC prior to adding it to oil.The solution of methanol-KOH having ratios of volumes as 1:5 were transferred to soybean oil at temperature of 50 ºC.This solution was then subjected to ultrasound for time period of 5 min at 700 rpm and 70% power level.Themixture was allowed to stand still at room temperature for time period of 24h for the components to settle down for separating glycerin from the biodiesel before it is refined. This was followed by washing of crude biodiesel by addition of 30 % (v/v) of water at temperature of 50 ºC and stirred for time period of 5 min. This mixture was allowed to settle again for time period of 24h for formation of separate layers of soap and biodiesel. Washing was carried out for 3 times to ensure complete removal of soap from biodiesel. The so-obtained biodiesel was moved to an oven which was maintained at 70 ºC and kept for 6

h to ensure complete evaporation of any moisture which may have resulted during washing.

Biodieselproductionwithultrasound-assistedin-situtransesterification

Theprocess of *in-situ*transesterificationwas performed by weighing 30 g of dried soybeans for trial. These soybeans were grindingto particles sizes of 0.25 mm. Methanol to oil ratio was maintained at 6:1 for carrying out the reaction.Titration was used for determination of quantity of KOH. The determined quantity of KOH was added into methanol solution. Three different ratios of methanol to oil i.e., 15:1, 20:1 and 25:1 were used for design of experiments. To the soybeans that were groundthe mixture of KOH-methanol was transferred and subjected to ultrasound at two dofferent levels i.e., 70% and 90%. Subsequently, the mixture was allowed to settle for a period of 2 h. The supernatant was collected and centrifuged for time period of 10 min and 1000 rpm. The soybean particles were washed with methanol having a ratio of 2:1 (v/w).This mixture was allowed to settle for time period of 2 h.

For separation of liquids and solids, the mixture was centrifuged for time period of 10 min at 1000 rpm. Separation of methyl esters from methanol that is present in excess was done using hexane. 1:1 ratio of hexane was used for washing. To this mixture water with volumetric ratio of 3:1 was used. This resulting mixture was heated to a temperature of 50ºCalong with stirring for a time period of20min.Subsequently, this mixture was allowed to settle for time period of 24 h at room temperature.Theupper layerwhich consisted of hexaneandbiodieselwasseparated from methanol.This mixture was water washed with ratio of 1:1 in an attempt to neutralize biodiesel. The water present in phase of FAME was dried using sodium sulfate.Lastly, evaporation of hexane wascarried out at a temperature of 70ºC for a time period of 6 h.The content of FAME was estimated by gas chromatography. Spent soybeanflecks were dried at temperature of 104 ºC for 24 h.For determining the content of oil that is remaining in the soybean flecks at 104 ºC for time period of 8 h using process of Soxhletextraction.

Propertiesofsoybeanoilbiodiesel

Analyzing the properties of biodieselwas carried out at MFA Oil Laboratory(Columbia,Missouri).The properties that were measure were viscosity, acid number, density, flash point, cloud point, sulfur content and the like.For determination of composition of fatty acids in crude biodiesel Varian 3400 equipped with Varian 8200auto sampler and a FID detector was used.DB-WAXeter fused silica column having dimensions of 30 m x 0.25 mm was employed for measuring. The weights of the samples were determined using a volumetricflask and a solution was preparedusing 5-6 mg of hexane. An aliquot which holds around 4-5 mg of sample was used as reaction vial. 1 ml (C17:0 methyl ester) of this sample was transferred to hexane and stirred.Nitrogen was used to evaporate any water present in hexane. To the reaction vial 2mlofBF3/Methanolreagentwas added, mixed well and capped firmly. This

mixturewasheatedtoa temperature of 100˚Cand allowed to stay at this temperature for a time period of 30 min with shaking at regular intervals. 1 ml of deionized water was added to cool this mixture.

2 ml of hexane was used for extraction of methyl esters offatty acids. The extractedesters were dried using anhydroussodium sulfate. 3 ml of this extract was used as sample for Gas Chromatograph. For quantitativeanalysisfattyacidmethylesters were used asstandardsandmethylesterwere used asinternalstandard.Theanalysis was presentedas percentageoffatty acid in sample of oil.Helium was used as carrier gas and a flowrate of 1 ml/min. The temperature ofinjector was maintained at a temperature of 250 ˚C and the temperature of column was scheduled toincreaseat a rate of 1˚C/min from temperaturestarting of170˚C.

4. Results and discussions

Analysis of biodiesel produced form soybean assisted by ultrasound

The analysis of production of biodiesel form soybean by transesterification process assisted by ultrasound-assisted is presented in Table 1. It can be seen that the properties of the produced biodiesel from soybeans on using of mechanical stirring and transesterification assisted by ultrasound are in accordance with the standards of ASTM. The flash point was observed to be 170 °C on use of ultrasound which was high in comparison to the flash point on use of mechanical stirring which was 150°C.The sulfurcontentfor biodiesel produced by both the methods was significantly lower than the standard values. Also, the content of waterin samples produced by both the levels was higher than the standards.

The yield of biodiesel was high on use of ultrasound in comparison to the yield of biodiesel produced by mechanical stirring. The values of standarddeviation for biodiesel produced by ultrasound and mechanical stirring were considerably different in terms of water content, viscosity,flash point, cloudpoint,andyieldat$p>0.05$.

Table1.Propertiesofbiodieselproducedusingultrasoundandmechanicalmixing.

Properties	Mechanical stirring	Ultrasound	ASTM	SD	Method ASTMD
Density(g/ml)	0.86	0.88	0.86-0.90	0.01	445
Viscosity(°C)	4.66	6.06	1.9-6.00	1.00	445
Cloudpoint(°C)	-5.56	-1.67		2.75	2500
Flashpoint(°C)	150	172	130	15.55	93
Pourpoint(°C)	-5.56	-6.67		0.55	5853
Sulfurcontent(ppm)	0.9	1.6	15	0.04	5433
Watercontent(ppm)	913.4	1650	500	520	2709
Acidvalue(mgKOH	0.23	0.23	0.80	0.57	664

/g)
Biodieselyield(%) 94.5 95.5

Analysis of in-situtransesterificationassisted by ultrasound

The effects of ultrasound power on production of eaters of methyl fatty acidspresented in Table 2. The methanol to oil ratio was maintained as 25:1. At this ratio, increasing the power of ultrasound from 70-90% the yield of FAME was increased from 83.9-98.50 %. This indicates that the entire oil accessible in soybean was completely renewed to biodiesel.Increase in the power of ultrasound increased the rates of conversion. When the power of ultrasound was maintained at 70 % and 90%, the quantity of linoleate acid (C18:2) the total fatty acid composition was observed to be 49.88 % and 56.83 respectively.As per the reports by Georgogiannietal.(2008),increase in the power of ultrasound led to reduction in the reaction time and improvement in the yield of biodiesel in transesterification of vegetableoil.

Table2:Composition of Fattyacids in biodiesel produced from in-situ transesterificationassisted by ultrasound.

SI. No	Esters of Methyl	Power of ultrasound (90 %)	Power of ultrasound (70 %)	Vegetable oil (GV)
1	Palmitate (C16:0)	10.12	9.84	10.0
2	Stearate(C18:0)	3.36	2.89	4.68
3	Oleate (C18:1)	17.46	10.55	21.8
4	Linoleate (C18:2)	56.83	49.88	58.3
5	Linolenate(C18:3)	10.26	9.91	7.49
6	Arachinate(C20:0)	0.45	ND	ND
Total	*SD*=10.32	98.50	83.09	102

The effects of ultrasound power on the yield of FAMEwhen different ratios ofmethanoltooilare used.Ultimately increase in the volumetric ratio of methanol to oil caused increase in the yield of biodiesel (Haas et al., 2004). Additionally increase in the power of ultrasound at different methanol levels from 70 % to 90 % significantly improved the yield. When the power of ultrasound was low, with increase in the ratio of methanol to oil from 15:1to25:1 there was increase in yield of biodiesel from 80.96% to 83.09 %. Also, on use of high power of ultrasound with the same ratio of methanol to oil the yield was seen to increase from85.92%to98.50%.The concentration of catalystwas maintained at a constant value foralltrials.Thestatisticalcoefficientvaluewere recorded to be R^2=0.96 and R^2=0.64when the power of ultrasound was high andlowrespectively.On

increase in the ratio of methanol to oil, the graph shows a significant effect on production of biodiesel by *in-situ*transesterification assisted ultrasound. Comparableresultswereobserved and publishedbyQianetal.(2008).

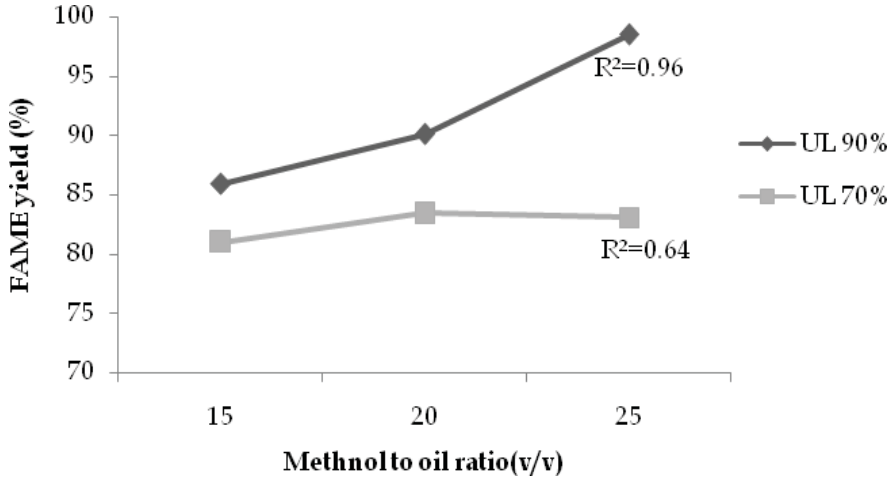

Fig. 2. Effects of ultrasoundonyieldsat variousratios ofmethanoltooil.

Fig. 3 shows the effect of ultrasound on the conversion of biodiesel with different ratios of methanol to oil. It can be seen from the graph that there was increase in the yield of biodiesel. The statistical coefficient had a value of R^2=0.89 and R^2=0.25 when the power of ultrasound was high and low respectively. The results demonstrated that methanol had low performance on extraction of oil on comparing with other solvents and alcoholic mixtures and in the absence of ultrasound. Comparableresults were published on the effect of methanol on production of biodiesel (Kim et al., 2010;Qianetal.,2008).

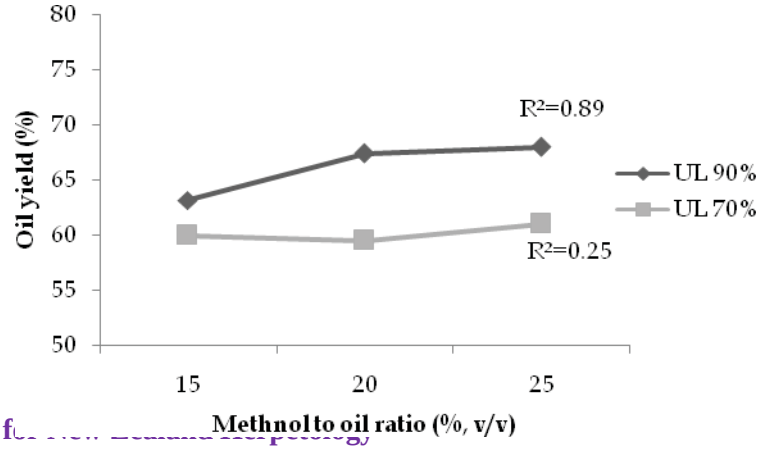

Fig.3.Effects of ultrasoundon yields of oilat various ratios of methanol to oil

5. Conclusions

This study reports extraction of oil from soybean and production of biodiesel using conventional as well as ultrasound. The effects of ultrasound, ratio of solvent to particles size, on extraction of oils were scrutinized using methods of responsesurfaces. The results revealedultrasound did not affect the extraction significantly on extraction of oil from soybean flecks.However, the particles sizes and the ratio of hexane to solids considerably affected yield of oil.Production of biodiesel was carried out by transesterificationand*in-situ*transesterification assisted by ultrasound.In the processes of *in-situ* transesterification use of ultrasound significantly increase the yield of biodiesel.The biodiesel that was produced was analyzed and it was observed that the physical property of the biodiesel that was produced using mechanical stirring and ultrasound was in accordance with the standards of ASTM. Ultrasound stands to be promisingfor *in-situ* transesterification for production of biodiesel from soybeans. The forthcominginvestigations will report use on continuous *in-situ* transesterification systems that will employultrasound with highintensityfor *in-situ* transesterification of soybean oil.

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