Volume-7,Issue-4, (Apr-17)
ISSN (O) :- 2349-3585

PRODUCTION OF BIOFUEL FROM VARIOUS FEEDSTOCKS

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Abstract - Biofuel is produced by alcoholysis of edible, non-edible and waste cooking oil is seen as a promising renewable source of fuel. Decreasing petroleum reserves and increasing environmental regulations have made us to search for renewable fuel. This paper focuses on review of a work carried out by researchers in the field of production of Biofuel from different types of oil. The raw oil used by researchers for production of Biofuel first briefly summarized followed by a description of Biofuel production method applied and yield percentage, FFA content, molar ratio and the reaction time of the Biofuel produced from the raw oil. The review is divided into three categories that is production of Biofuel from edible oil, non-edible oil and waste cooking oil. This review paper contains the work of past researchers published between 2005 and 2016.

Key Words: Biofuel , Transesterification , FFA Content , Reaction time , diesel .

1.INTRODUCTION

With the increasing use of diesel fuel, many initiatives have come up and has becomes more attractive to search for other fuels to supply or replace fossil fuels. Biofuel is synthesized from edible, non-edible and waste cooking oil or animal oil can be reused as an alternative diesel fuel. The various alternative fuel options tried in place of hydrocarbon oils are mainly biogas, producer gas, ethanol, methanol and vegetable oils. Out of all these, Biofuel offers an advantage because of their equivalent fuel properties with that of diesel. The emissions produced from Biofuel are more cleaner as compared to petroleum-based diesel fuel. Particulate emissions, soot, and carbon monoxide are lower because Biofuel is an oxygenated fuel. The Biofuel could be used as pure fuel or as blend with petro diesel, which is stable in all ratio. Alternative new and renewable fuels have the potential to solve many of the current social problems and concerns, from air pollution and global warming to other environmental improvements and sustainability issues.

1.1 BRIEF DESCRIPTION OF BIOFUEL

Biofuel is an alternative fuel made from renewable biological sources such as vegetable oils both (edible and non-edible oil) and animal fats According to the US standard specification for Biofuel (American Society for Testing and materials (ASTM) 6751), Biofuel is defined as a fuel comprised of mono alkyl esters of long chain fatty acids from vegetable oils or animal fats[1]. The prevailing bio-diesel production process, namely transesterification, typically involves the reaction of an alkyl-alcohol with a long chain ester linkage in the presence of a catalyst to yield mono-alkyl esters (bio-diesel) and glycerol[2, 3].1.2 Production of Biofuel by Transesterification Generally, Biofuel is produced by means of transesterification. Transesterification is the reaction of a lipid with an alcohol to form esters and a by-product, glycerol. in this principle, the action of one alcohol displacing another from an ester, referred to as alcoholysis (cleavage by an alcohol). In Transesterification mechanism, the carbonyl carbon of the starting ester (RCOOR1) undergoes nucleophilic attack by the incoming alkoxide (R2O−) to give a tetrahedral intermediate, which either reverts to the starting material, or proceeds to the transesterified product (RCOOR2). Transesterification consists of a sequence of three consecutive reversible reactions. The first step is the conversion of triglycerides to diglycerides, followed by the conversion of diglycerides to monoglycerides, and finally monoglycerides into glycerol, yielding one ester molecule from each glyceride at each step. The reaction is represented in equation 1. The reactions are reversible, although the equilibrium lies towards the production of fatty acid esters and glycerol. This reaction proceeds well in the presence of some homogeneous catalysts such as potassium hydroxide (KOH)/sodium hydroxide

(NaOH). Depending on the undesirable compounds (especially FFA and water), each catalyst has its advantages and disadvantages. Sodium hydroxide is very well accepted and widely used because of its low cost and high product yield. The most common alcohols widely used are methyl alcohol and ethyl alcohol. Among these two, methanol found frequent application in the commercial uses because of its low cost.

EQUATIONS -1

Triglycerides + ROH ⇄ Diglycerides + R1COOR

Diglycerides + ROH ⇄ Monoglycerides + R2COOR

Monoglycerides + ROH ⇄ glycerol + R3COOR

2. PREVIOUS RESEARCHES

2.1 Previous work done on production of Biofuel from edible oil.

Over the last few years, there has been increasing amounts of research and interest in the different edible feedstocks that can be used to make Biofuel and the effects of the different feedstocks on the quality of the Biofuel. Currently, Biofuel is produced from different crops such as, Jojoba oil, palm oil, soybean oil, canola, rice bran, sunflower, coconut, rapeseed, soybean and sunflower oil[4, 5, 6]. The major difference between various edible oils is the type of fatty acids attached in the triglyceride molecule. Fatty acid composition effects the yield percentage, reaction temperature, FFA content and molar ratio of the Biofuel oil[7].Leung D.Y.C and Guo Y.[8], compared the transesterification reaction conditions for fresh canola oil and used frying oil. Higher molar ratio (7:1, methanol/used frying oil), higher temperature (60° C) and higher amount of catalyst (1.1 wt% NaOH) was maintained in used frying oil when compared to fresh canola oil where optimal conditions maintained were 315-318 K, 1.0 wt% NaOH and 6:1 methanol/oil molar ratio. However, less reaction time (20 min) was observed for used frying oil when compared to fresh canola oil reaction time (60 min). The Fig. 1 shows the effect of temperature on the transesterification of (a) neat Canola oil; and (b) UFO. In the further work Lingfeng Cui et al.[9] developed Biofuel from cottonseed oil by using KF/γ-Al2O3 as heterogeneous catalysts for the transesterification of cottonseed oil with methanol. The operation variables used were methanol/oil molar ratio (6:1–18:1), catalyst concentration (1–5 wt %), temperature (50–68 °C), and catalyst type. The Biofuel with the best properties was obtained using a methanol/oil molar ratio of 12:1, catalyst (4%), and 65°C temperature with the catalyst KF/γ- Al2O3.

Later Sinha Shailendra et al.[4] determined the optimum condition for transesterification of rice bran oil with methanol and NaOH as catalyst by mechanical stirring method. The condition was found at 55° C reaction temperature, 1 h reaction time, 9:1 molar ratio of rice bran oil to methanol and 0.75% catalyst (w/w). Further, the physical properties of rice bran methyl ester were tested and compared with other Biofuels and diesel. The result showed that characteristics of rice bran methyl ester were comparable to diesel.

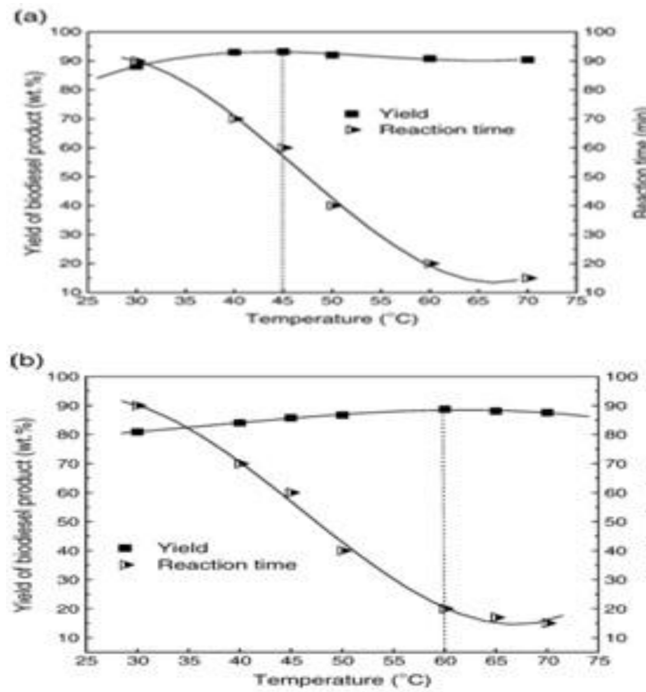

Fig 1: Effect of temperature on the transesterification of (a) neat Canola oil; and (b) UFO.

In an important research Georgogianni K.G. et al.[2] studied transesterification reaction of rapeseed oil with methanol, in the presence of homogeneous (NaOH) and heterogeneous (Mg MCM-41, Mg–Al Hydrotalcite, and K+ impregnated zirconia) using low frequency ultrasonication (24 kHz) and mechanical stirring (600 rpm) for the production of Biofuel fuel. The study concluded that that the homogeneous catalyst accelerated significantly the transesterification reaction, as compared to all heterogeneous catalysts, using both mechanical stirring (15 min vs. 24 h) and ultrasonication (10 min vs. 5 h). The table 1 shown below gives the conversion speed of rapeseed oil in the presence of different catalysts

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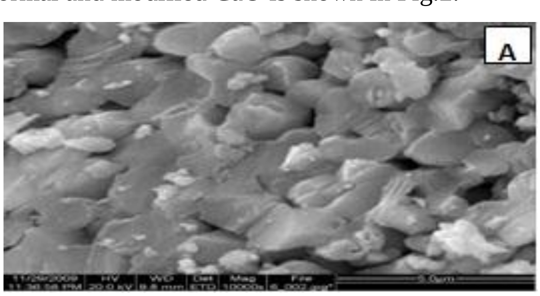
using both mechanical string and ultrasonication.Further, Issariyakul Titipong and Dalai K. Ajay[5] carried out work on transesterification of canola oil and greenseed canola oil via KOH-catalyzed along with methanol, ethanol and a mixture of methanol and ethanol. The reaction was conducted at 60°C and a stirring speed of 600 rpm for 90 min. Prior to transesterification, greenseed canola oil was bleached to remove pigments using various adsorbents at different conditions. The result of the research work disclosed that Biofuel derived from the treated greenseed canola oil showed an improvement in oxidative stability (induction time of 0.7 h) as compared to that derived from crude greenseed canola oil (induction time of 0.5 h).

Table -1: Conversion of rapeseed oil in the presence of different catalysts using both mechanical stirring and ultrasonication.

	Time(h)	Yield(%)			
		Type of	catalyst		
		Mg/MCM-41	MgAl hydrotalcite	10K/ZrO_2	20K/ ZrO_2
Mechanical Stirring	5	21	28	30	38
	10	43	54	37	42
	15	56	73	49	56
	20	73	89	61	69
	24	85	97	67	89
Ultrasonication	1	25	32	29	35
	2	48	58	39	48
	3	59	76	52	59
	4	75	89	63	73
	5	89	96	70	83

Afterwards Alamu J Oguntola et al.[10], produced the Biofuel from through transesterification 100g coconut oil, 20.0% ethanol (wt% coconut oil) and 0.8% potassium hydroxide catalyst at 65°C reaction temperature with 120 min. reaction time. Low yield of the Biofuel (10.4%) was obtained.While Tang Ying et al.[7], developed a new method catalyst, benzyl bromide-modified CaO for production of Biofuel from rapeseed. The improved catalytic activity was obtained by better fat diffusion to the surface of the benzyl bromide-modified CaO. Further, a 99.2% yield of fatty acid methyl esters in 3h was obtained in comparison to by better fat diffusion to the surface of the benzyl bromide-modified CaO. The normal and modified CaO is shown in Fig.2.



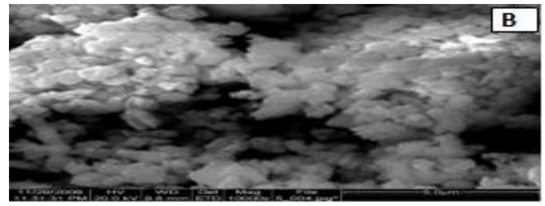


Fig -2: SEM Photo of (a) CaO and (b) Modified CaO

Further, Silva F. Giovanilton et al.[6], produced Biofuel from soybean oil by transesterification with ethanol. Optimum conditions for the production of ethyl esters were the following: mild temperature at 56.7 °C, reaction time in 80 min, molar ratio at 9:1 and catalyst concentration of 1.3 M. For esterification reaction, HR2RSOR4R was added as a catalyst and for transesterification KOH was added as the catalyst with methanol.In the investigation of Wakil Abdul Md. et al.[11], chosen Cottonseed oil, Mosna oil and Sesame oil for producing Biofuel. Biofuel is produced by transesterifying the oil with an alcohol such as methanol under mild conditions in the presence of a base catalyst. Satisfactory amount of Biofuel is produced from Cottonseed oil at 3:1 molar ratio of methanol and oil. Three types of oil (cottonsed oil, mosna oil, sesame oil) are extracted from the seeds and chemically converted via an alkaline transesterification reaction to fatty acid methyl ester. The optimum conditions established for the methanolysis of crude cotton seed oil in the investigation were recorded to be: 3:1 molar ratio of methanol to oil and 1.00% (w/w) catalyst. For Mosna oil the optimum conditions were recorded to be 3. 5:1 M ratio of methanol to oil and 1.00% (w/w) catalyst. But small amount of Biofuel was found from this oil and production cost is higher than cottonseed oil. And for Sesame oil the optimum conditions were recorded to be 3.5:1 M ratio of methanol to oil and 1.00% (w/w) catalyst. Ali N. Eman and Tay Isis Cadence[12], investigated characteristics of Biofuel produced from palm oil via base catalyst transesterification process. To find the optimum yield value of Biofuel, three important parameters were selected such as reaction temperature 40, 50, and 60°C, reaction time 40, 60 and 80 min. and methoxide ratio 4:1, 6:1 and 8:1. By conducting the experiments the optimum yield value 88% was achieved by the parameters such as reaction temperature 60°C, reaction time 40 minutes and methoxide ratio 6:1. From the optimum yield value, the physical properties were calculated like, density is 876.0 kg/m3, kinematic viscosity of 4.76 mm2/s, cetane number of 62.8, flash point of 170°C, cloud point of 13°C. The produced Biofuel had similar properties of ASTM D 6751, and EN 14214.In the important study Banerjee Madhuchanda et al.[13], determined the catalytic activity of bimetallic Gold–silver core–shell nanoparticles toward Biofuel production from Sunflower oil through transesterification. The structure of nanoparticles was examined by UV–vis spectroscopy, transmission electron microscopy (TEM) and energy dispersive X-ray (EDX) analysis. The result of studied showed that at certain catalyst concentration, temperature and reaction time, highest yield of Biofuel (86.9%) is attained. Further, the catalyst showed sustained activity for 3 cycles of transesterification. The effect of variable on the yield of Biofuel is shown in Fig. 3.

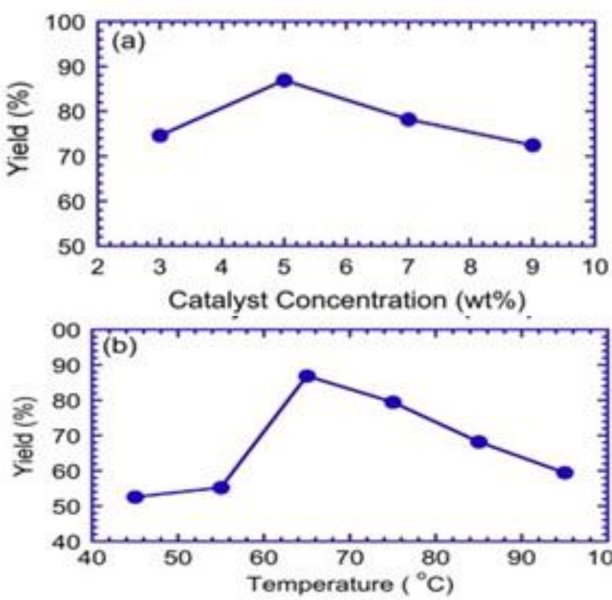


Figure 3: The fatty acid composition of palm oil raw material and Ethyl Ester product

In the most recent work Nikhom Ruamporn and Tongurai Chakrit[14], examined the continuous deglycerolisation (CD) for the production of ethyl ester Biofuel from palm oil. In this work, KOCH3 was selected as the catalyst in transesterification and the reaction temperature was maintained at 60°C. The result showed that ethyl ester production using CD process could obtain good purity and yield in a single step transesterification. The ester content and yield were 98.0 wt.% and 93.1 wt.%, respectively at molar ratio of oil to ethanol of 1:5.5, KOCH3 concentration of 1.2 wt.% and retention time of 30 min. The FFA content of palm oil and ethyl ester is shown in table 2 below.

Table -2: The fatty acid composition of palm oil raw material and Ethyl Ester product

FATTY ACID COMPOSITION	Wt.%	
	PALM OIL	ETHYL ESTER
LAURIC ACID(C12:0)	1.11	0.24
MYRISTIC ACID(C14:0)	1.23	0.97
PALMITIC ACID(C16:0)	36.58	37.95
PALMITOLEIC ACID(C16:1)	1.39	0.16
STEARIC ACID (C18:0)	4.5	3.62
OLEIC ACID (C18:2)	43.38	45.95
LINOLEIC ACID (C18:8)	11.81	11.10
OTHERS	----	2.01

2.2 Previous work done on production of Biofuel from non-edible oil.

Azam Mohibbe M. et al.[15], found that FAME of Jatropha curcas were most suitable for use as bio- diesel and met the major specification of bio-diesel standards of the European, Germany and USA Standards Organization.Afterwards Sarin Rakesh et al.[16], made appropriate blends of Jatropha and palm bio-diesel to improve oxidation stability and low temperature properties because Jatropha bio-diesel has good low temperature property and palm bio-diesel has good oxidative stability. It was found that antioxidant dosage could be reduced by 80-90% when palm oil bio-diesel is blended with Jatropha bio-diesel at about 20-40%.Moreover, Tiwari Kumar Alok et al.[17], used response surface methodology to optimize three important reaction variables, including methanol quantity, acid concentration, and reaction time. The optimum the FFA of Jatropha oil from 14% to less than 1% was found to be 1.43% v/v sulphuric acid catalyst, 0.28 v/v methanol-to-oil ration and 88 min reaction time at 60 ºC. The properties of Jatropha oil bio- diesel conform to European and

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American standards.

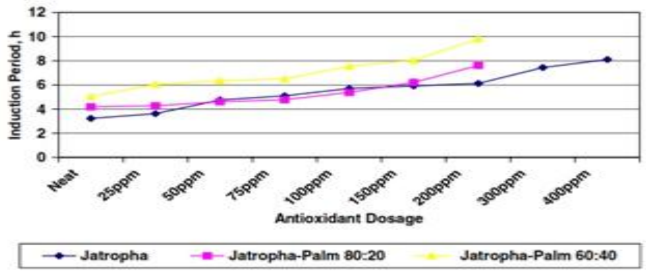

Fig -4: Antioxidant dose optimisation for Jatropha and Palm Biofuel

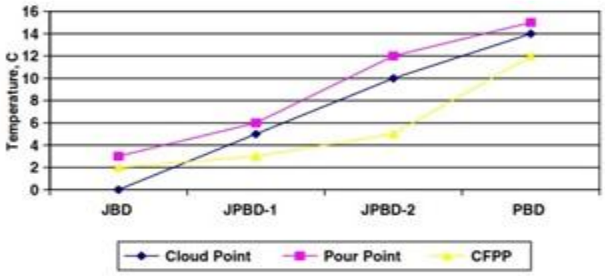

Fig -5: Low temperature property of Jatropha–Palm methyl ester blend

A year later Berchmans Johanes Hanny and Hirata Shizuko[18], developed a two-step pre-treatment process in which the high FFA hydroxide (15%) of Jatropha curcas seed oil was reduced to less than 1%. In the first step, the reaction was carried out with 0.60 w/w methanol-to-oil ratio in the presence of 1 wt.% sulphuric acid as an acid catalyst in 1 h at 50ºC. In the second step, the transesterification reaction was performed using 0.24 w/w methanol-to-oil ratio and 1.4 wt% sodium hydroxide.While Chakrabarti H. Mohammed and Ahmad Rafiq [1], presented work on extraction of oil from castor bean and converting it into Biofuel from transesterification. It was found that reaction mixture containing 65ml of methanol along with 2.4 g of catalyst (KOH) took a good start in half an hour at 30°C. In this reaction, amount of glycerine removed as well as ester content produced was considerably increased with rise in temperature of mixture upto 70°C by extending time period (180-360 minutes). The removal of glycerine increased by two and half times and ester content by four times, respectively. When castor oil was subjected to acid esterification, prior to transesterification (a separate investigation), it was found that ester contents up to 95% could be obtained. The comparison of physical- chemical properties of castor oil and diesel done by them is shown in table 3.

Table -3: Physical-chemical properties of mineral diesel, castor oil

Parameter	ASTM Test Method	ASTM Limits	Castor Oil	Diesel
Viscosity (mm2/s)	ASTM D445	1.9 - 6.0	13.75	3.2
Sulfur (%)	ASTM D5453	0.0015, Max	0.0001	0.20
Density 15*C (g/cm3)	ASTM D1298	0.875-0.9	0.9279	0.850 3
Density 20*C (g/cm3)	ASTM D1298	0.86	0.9245	0.846 5
Flash Point (*C)	ASTM D93	93*C , Min	120	37
Copper Corrosion	ASTM D130	No.3, Max	1	1
Cetane Index	ASTM D613	47, min	50	45
Water & Sediment (Vol.%)	ASTM D2709	0.050,Max	0.05	Nil

In the further research work Kapilan N and Reddy R.P.[19], produced Biofuel from Mahua oil methyl esters (MOME) by transesterification using potassium hydroxide (KOH) as catalyst and tested the conversion of vegetable oil to Biofuel by nuclear magnetic resonance (NMR) testing method. Further, studied the performance characteristics fuelling with Mahua Biofuel in a diesel engine. They concluded that B20 gave higher thermal efficiency and lower specific fuel consumption then diesel fuel. The physical properties of Mahua oil prepared by them is shown in table 4.

Table -4: Properties of MOME and its blends with diesel

Property	MO	MOME	Diesel	B20
Flash point (*C)	212	129	65	103
Kinematic Viscosity at 40*C (cst)	28.58	5.10	2.4	4.04
Copper strip corrosion	1.5	1	1	1
Cloud Point (*C)	17	4	-6	-3
Density at 15*c (kg/m^3)	897	876	821	838
Calorific value (Mj/kg)	35.614	36.914	42.960	41.750

In another research work Kansedo Jibrail et al.[20], extracted oil from the seeds of C. odollam fruits. The transesterification

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of the extracted oil was done to form fatty acid methyl esters (FAME). The transesterification reactions were carried out using three different catalysts; sodium hydroxide (NaOH) as a homogenous catalyst, sulfated zirconia alumina and montmorillonite KSF as heterogeneous catalysts. The seeds were found to contain high percentage of oil up to 54% while the yield of FAME can reach up to 83.8% using sulfated zirconia catalyst.Further, Kafuku Gerald et al.[3], examined the feasibility of converting a non-edible oil source croton megalocarpus oil to methyl esters (Biofuel) using sulfated tin oxide with enchansed SiO2 as super acid solid catalyst. At the following reaction condition 180°C, 2 h and 15:1 methanol to oil molar ratio, while keeping constant catalyst concentration and stirring speed at 3 wt.% and 350–360 rpm the yield up to 95% was obtained without any pre-treatment was obtained. The researcher Padhi S.K. and Singh R.K. [21] produced Biofuel from Mahua oil through the Esterification by varying different parameters. The conditions for produce Biofuel were 8% Sodium Methoxide, 0.33% v/v alcohol/oil ratio, 1 hr reaction time, 65°C temperature and 150% v/v excess alcohol. They concluded this was the best condition for Biofuel production. The results show that 4% H2SO4, 0.33% v/v alcohol/oil ratio, 1 hr reaction time and 65°C temperature are the optimum conditions for esterification. Optimum conditions for the production of Biofuel from Mahua oil are 8% Sodium Methoxide, 0.33% v/v alcohol/oil ratio, 1 hr reaction time, 65°C temperature and 150% v/v excess alcohol.E.I Bello and A Makanju[22] analyzed castor oil methyl ester as possible alternative fuel for diesel engines. To overcome the high kinematic viscosity of the neat oil, a high molar ratio of 6:1 was used to produce the methyl ester. The viscosity of the ester was high and further reduced by blending with diesel fuel to reduce it to within the American Society for Testing and Materials (ASTM) D6751 limits for Biofuel. The Biofuel was characterized and tested in a single cylinder diesel engine. The results obtained gave properties, torque outputs and specific fuel consumption that are close to those of diesel fuel thus confirming that it can be used as alternative fuel for diesel engines.Deshpande D.P. et al.[23], studied transesterification reaction on castor oil in a batch reactor using potassium hydroxide as a catalyst. The variables chosen for the study were reaction time, Oil to methanol ratio, catalyst concentration; and reaction temperature. The effects of these variables on the viscosity of Biofuel were studied, since this is one of the important specifications in ASTM standard. Apart from viscosity other properties like specific grravity, acid value, and sap value were also determined for the Biofuel product. From the study it was concluded that the optimum operating condition are oil to methanol mole ratio 1:9, temperature 30oC, catalyst concentration 1 wt % and run time 45 min. The variation of viscosity, specific gravity, acid value with time is shown in table 5.

Table -5: Variation of viscosity, specific gravity, acid value with time

Time of Run (min)	30	45	60	90
Kinematic viscosity, (cSt) for Sulfuric Acid as Catalyst	16.56	11.28	12.44	13.93
Kinematic viscosity, (cSt) for Sodium Hydroxide as Catalyst	21.57	13.10	15.33	18.11
Specific gravity for Sulfuric Acid as Catalyst	0.9018	0.9006	0.9012	0.9019
Specific gravity for Sodium Hydroxide as Catalyst	0.9106	0.889	0.9016	0.9039
Acid value for Sulphuric Acid as Catalyst	0.90	0.58	0.562	0.541
Acid value for Sodium Hydroxide as Catalyst	0.92	0.37	0.40	0.52

Afterwards Widayat et al.[24], presented work on Biofuel from the rubber seed by situ method. The researcher focused on influence of reaction time, concentration of acid catalyst and ratio of raw material to methanol. This process took 120 minutes at 60°C with maximum yield of FAME 91.05% at HR2RSOR4R 0.25% (v/v) and ratio of raw material to methanol (1:3). Based on the results, ratio of raw material to methanol was quite important to increase yield of FAME significantly. The experimental setup used by the researcher is shown in Fig. 6. Further, the team of researchers Ali Hasan Md. et al.[25] produced Biofuel from neem seeds, its properties were close to diesel. The methodology of esterification process was selected and carried out by 1000 ml raw neem oil, 300ml methanol and sodium hydroxide on mass basis as a catalyst usually kept in oven to form methyl ester, and initially to reach equilibrium condition at temperature 55-66°C. The ester and glycerine were separated by stimulating continuously and allow settling under gravity for 24 h. Thus the separated ester contains 3% to 6% methanol and soap agents. The methanol was removed by vaporization. The Biofuel had some catalyst; it was removed by warm water mix with ester. Kinematic viscosity lay between 1.9 to 6.0 according to the ASTM D6751 specification. Hence, 0.95 ltr. Biofuel was production from 1 ltr neem oil.

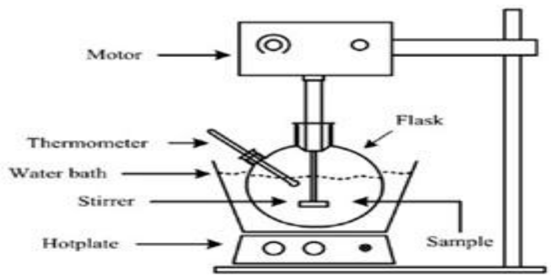

Fig-6: Experimental Setup

In an advance production method of Biofuel Riadi Lieke et al.[26], produced Biofuel from karanja oil by two step process. The first step process which was designed for 3 hours reaction time at 30°C and 5.8% of ozone using either 1 or 1.5 weight % KOH at various percent weight of supporting catalyst had proved simultaneous reaction for both ozonolysis and transesterification. The short chain methyl esters (methyl hexanoate, methyl octanoate and methyl nonanoate) were effectively produced for the first step process using 5.8% mole ozone at 30°C for 3 hours either for 1 or 1.5 weight % KOH at various percent weight of extracted supporting catalyst. From this reaction, the esters predicted by ozone reaction were sufficiently produced. The highest short chain methyl esters and long chain methyl esters produced in the first step process was 85.722 mg/litre and 655.286 mg/ltr respectively, which used 17.3 weight % ash and 1.5 weight % KOH. The presence of extracted ash in methanol as supporting catalyst enhanced the production of total methyl esters compared to that without the presence of ash in the first step process. Higher temperature (60°C) in the second step process without the presence of ozone gave enough vibration of energy, to increase rate of transesterification and decrease the viscosity. In the recent work Hotti R Siddalingappa and Hebbal D Omprakash[27], presented work on non-edible champaca seed oil Biofuel (CBD). The Biofuel was produced by two step process i.e. acid pretreatment process followed by base-catalyzed transesterification process as the free fatty acid (FFA) content found to be 5.30% (corresponding to acid value of 10.55, mg KOH/g). The first step of process was carried out with methanol and sulphuric acid as catalyst, followed by second step, base-catalyzed transesterification process with methanol and sodium hydroxide as catalyst the Biofuel yield was found to be 83.50 %. Previous work done on production of Biofuel from waste cooking oil. Zheng S. et al.[28] analyzed the reaction kinetics of acid-catalyzed transesterification of waste frying oil. They found that at the methanol/oil molar ratio of 250:1 at 70 ºC or in the range 74:1-250:1 at 80ºC, the reaction was a pseudo-first-order reaction. High yield of 99±1% could be achieved at both 70 ºC and 80 ºC temperatures while stirring at rate of 400 rpm, using a feed molar ratio oil:methanol:acid of 1:245:3.8. A year later Wang Yong et al.[29] investigated a two- step catalyzed processes for synthesis of bio-diesel by using WCO from Chinese restaurants. In the first step, ferric sulphate-catalyzed methanolysis was carried out, while potassium hydroxide catalysis was performed in the second step. The authors concluded that compared with one-step sulphur acid catalysis the two-step catalyzed process provided a simpler and more economic method to produce bio-diesel from WCO. The conversion rate is shown in fig. 7. In the further research work Issariyakul Titipong et al.[30] also used the two-step process to transesterify waste cooking oil, except that sulphuric acid was selected as acid catalyst and mixtures of methanol and ethanol were used for transesterification in order to use the better solvent properties of ethanol and a more rapid equilibrium using methanol. More than 90% ester was obtained by using the two-stage method compared with yield of ~50% ester by using the single stage alkaline catalyst.

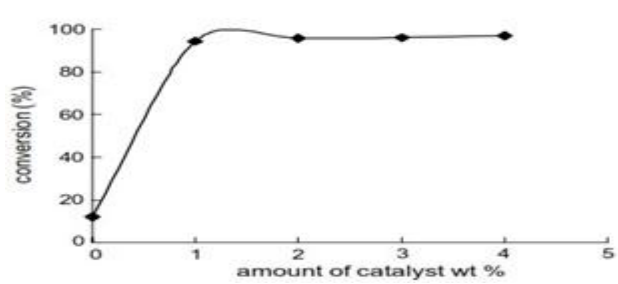

Fig 7: Conversion of FFA VS. Amount of Catalyst

Lin Fen-Ya et al.[31]also used WCO to prepare bio-diesel and then conducted a study in which the exhaust tail gas of bio-diesels was compared when the engine was operated using different fuel types, including neat bio-diesel, bio-diesel/diesel blends, and normal diesel fuels. Among the collected data, the authors found that B20 and B50 were the optimum fuel blends. The properties of diesel and Biofuel used by the researcher is shown in table 6.

Table -6: Major properties of premium diesel and Biofuel used

	Premium Diesel	B100	Test Method
Density at 20*C(g/mL)	0.826	0.86	ASTM D 1298
Kinemetic viscosty at 40*C	2.73	4.49	ASTM D 445
Cetane Index	46.2	44.28 48.05	ASTM D 976 EN IOS 4264
Flash Point (*C)	89	122	ASTM D 93
Water and Sediment (vol.%)	<1	0.22	ASTM D 2709
Gross Heating Value (cal/g)	11411.4	9850.6	ASTM D 240

Later Hossain A.B.M.S. and Boyce A.N.[32]in their work compared optimum conditions of alkaline- catalyzed transesterification process for Biofuel production from pure sunflower cooking oil (PSCO) and waste sunflower cooking oil (WSCO) through transesterification process. The highest approximately 99.5% Biofuel yield acquired under optimum conditions of 1:6 volumetric oil-to-methanol ratio, 1% KOH catalyst at 40ºC reaction temperature and 320 rpm stirring speed. Result of the test showed that the Biofuel production from PSCO and WSCO exhibited no considerable differences.

Afterwards Bakir T. Emaad and Fadhil B. Abdelrahman[33] presented work on single step transesterification and two step ransesterification, namely acid-base and base–base catalyzed transesterification process for production of Biofuel from Chicken fried oil. For this purpose, hydrochloric acid and potassium hydroxide with methanol were used. The results disclosed that two step base catalyzed transesterification was better compared to other methods. It resulted in higher yield and better fuel properties.Prafulla D. Patil et al.[34]carried out comparative study on Biofuel production from waste cooking oil using sulfuric acid (Two-step) and microwave-assisted transesterification (One-step). The two-step transesterification process was used to produce bio-diesel (alkyl ester) from high free fatty acid (FFA) waste cooking oil. While Microwave-assisted transesterification was done by using catalytic BaO and KOH in Biofuel production from waste cooking oil. The study shown that that the microwave-heating method consumes less than 10% of the energy to achieve the same yield as the conventional heating method. Further, fuel properties of Biofuel produced were compared with ASTM Standards for Biofuel and regular diesel. In important study Suvendu Mohanty etal[35]. observed that from Waste cooking oil CO emissions are increased with increase in engine load. Further it was found that volume of CO initially decreases but increase at full load indicating better burning conditions at higher temperature assisted by improved spraying qualities with uniform charge preparations of Biofuel. The emissions of unburnt hydrocarbon for Biofuel exhaust due to lower than that of diesel fuel the increased gas temperature and higher cetane number of Biofuel could be responsible for this decrease. Higher temperature of burnt gases in Biofuel fuel helps in preventing condensation of higher hydrocarbon reducing.While Canesin Antonio Edmilson et al.[36] produced Biofuel from Residual oils and also check the viability and degradation level of production process. Residual bovine, chicken and soybean oils were used for Biofuel production process. They used four transesterification methods, using acidic and basic catalysis and, gas chromatography with flame ionization detector (GC–FID). They concluded use of acidic catalysis at a lower temperature were the most efficient in the Biofuel production process.In the recent study Farooq Muhammad and Ramli Anita[37] prepared catalysts from raw chicken bones for transesterification reaction of waste cooking oil for Biofuel production. The study revealed that heterogeneous catalyst calcined at 900°C exhibited good catalytic activity in the transesterification of WCO, providing maximum Biofuel yield of 89.33% at 5.0 g of catalyst loading, 15:1 methanol to oil molar ratio at temperature of 65°C in reaction time of 4 h. The effect of molar ratio, catalyst amount and temperature observed by the researcher on the yield of Biofuel is shown in fig. 8

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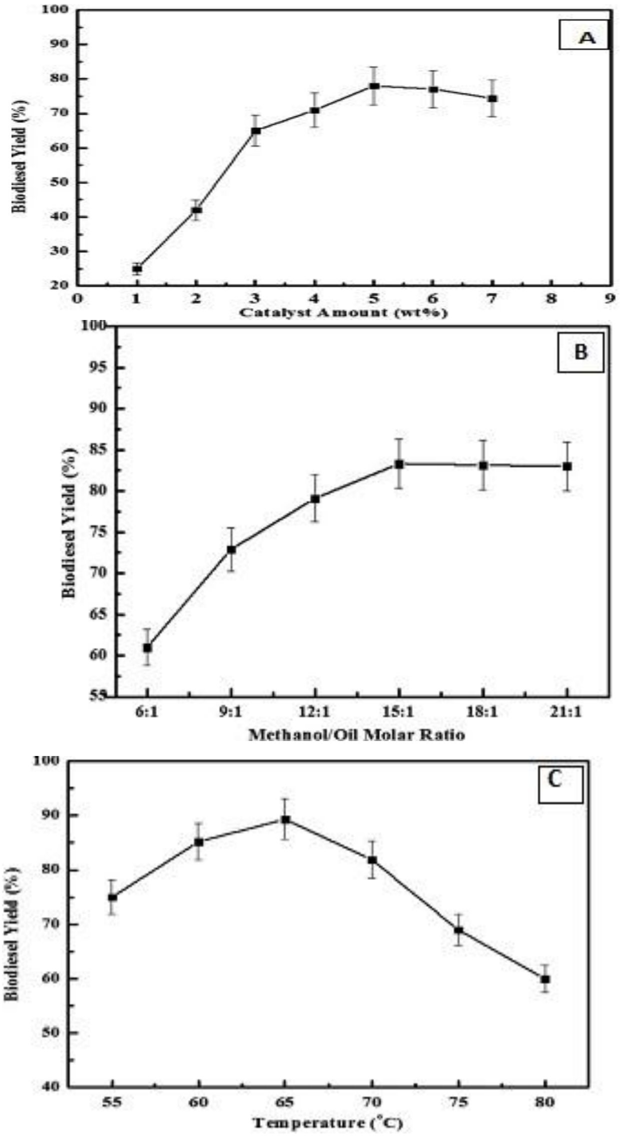

Fig 8: Effect of (a) Molar Ratio (b) Catalyst Amount and (c) Temperature on Biofuel Yield

3. CONCLUSIONS

This work has provided a extensive literature review of the previous research work carried out in past years on production and generation of Biofuel from edible, non-edible and waste cooking oil. An effort has been made to comprise all the important contributions and highlighting the most appropriate literature available for investigating the feedstock's of Biofuel. The conclusion from the current literature survey are as follows: -

a) Biofuel is an important alternative transportation fuel and it possess properties like renewability, biodegradability, non-toxicity and environmentally friendly benefits.

b)Biofuel can be produced from different feedstock containing fatty acids such as animal fats, edible oils, non-edible oils, and waste cooking oils and by products of the refining vegetables oils.

c)Transesterification is a commonly used method for its production. The purpose of this method is to decrease the viscosity of oil or fat using acid or base catalyst in the presence of methanol or ethanol.

d) Transesterification with alkali catalyst (KOH and NaOH) is more economical than acid catalyst and enzyme catalyst.

e) The Biofuel production is strongly affected by parameters such as molar ratio of alcohol, reaction temperature, reaction time and catalyst concentration.

ACKNOWLEDGEMENT

The review presented by author in this work is by no means completed but it gives a wide review of production of Biofuel from various feedstock's. The author wishes to apologize for the unintentional exclusions of missing references and would appreciate receiving comments and suggestion to other relevant literature for a future update.

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