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Biofuel Production and Characterization from Waste Chicken Skin and Pig Fat

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Abstract: ***The biofuels are the most important alternative energy sources in future to fulfil the energy demands. The team of our students carried out an innovative process to convert waste to value-added products. The students have been visited many meat stalls and gathered the required amount of resources with and without cost. The collected waste chicken skin and pig tallow is heated and extracted fat, which is the primary sources to produce the biofuel. The fat extraction process was carried by shredding down the waste chicken skin and pig tallow. The obtained fat was filtered and heated up to 110ºC to remove all the impurities, water suspensions, blood cells and pieces of bones. The process called transesterification process was carried out to convert obtained fat into biofuel with methyl alcohol and KOH as a catalyst. Transesterification process carted with fat before acid wash and after acid wash to examine the effect of FFA on biofuel yield. The quantity of biofuel yield has been observed to be 62 to 68% for fat from waste chicken skin and 82 to 83 % for fat from pig tallow. The derived fuel from fat from both resources is combined with conventional diesel fuel to check the different properties on a volume basis varied by 10% up to 40%. The essential properties such as viscosity, density, flashpoint, fire point and calorific values were determined, and results show that the fuel combination CB20 and PB20 meets the all requirements of ASTM standards to fix as an additive fuel to CI engines. The clear biofuel from both the fat expressed higher viscosity, density, flash and fire point with a lesser value of energy density.***

Keywords: Biofuel, Chicken skin, Pig fat, Transesterification,

I. INTRODUCTION

Biofuel is the non-conventional liquid fuel compound derived from biological raw materials, which is a promising substitute for conventional energy sources. It is universally accepted as an eco-friendly solution for energy shortage issues [1]. Simultaneously well-deserved waste processing or management technology needs to invent for the sustainable development of a country like India [2]. As per the baseline survey was done by an SRS research institute, 71% of the population in India is non-vegetarian. A daily basis lakhs of animals and birds (Chicken) are killed for food and leads to create massive wastage from meat stalls [3]. The improper disposal of these generated waste will be a reason for spreading diseases and lousy smell around [4]. The development and establishment of new waste converting technology will give a permanent solution for waste treatment. On the other hand, turning this kind of waste materials into a value-added product like fuel compounds can be a single solution for two different problems such as waste treatment as well as an energy problem [5]. A man Rudolf Diesel proposed a concept of biofuel exactly over 130 years ago, and he has tested the self-developed engine by using peanut oil [6]. Biofuel extraction in a developing country like India has performed a decisive level. India using nearly more than 205 million tons of conventional fuels and stands at fifth rank after Russia, US, China, Japan in terms of fuel consumption [7]. Many research scholars investigated that, biofuel can be derived from various natural resources such as pongamia seeds, jatropha, peanuts, cotton seeds, neem seeds, castrol seeds, and vegetable seeds, etc. which can degrade with the activities of bacterias [8, 9]. The direct utilisation of vegetable oils to generate biofuels will leads to a problem of food chain breakage and influencing in higher cost of food products [10,11]. The non-biodegradable waste materials like municipal plastic wastes, rubber tyres, thermocoal also can be converted into liquid fuel compounds with a well suitable eco-friendly technical method [16, 17]. Simultaneously accumulation of waste material density will increases day by day due to the higher rate of usage and non-biodegradable nature. The government of India initiates biofuel promoting the program to publicise the use of biofuel as an additive fuel in automobiles at the rate of 5% blend [12, 13].

The eco-friendly chemical method named pyrolysis process can be the most promising technique to process waste plastics, waste used tyres and thermocoals into liquid fuel compounds [17, 18]. The waste plastics and used tyre are available in abundant quantity with or without the cost involvement [14]. The pyrolysis process incurred capital investment to convert waste materials into fuel, and the process of collecting waste resources from different location may be required small capital investment, which further stands on labour and transportation charges. The current paper describes the effective utilisation of waste resources from different meat stall at our location to the extraction of fatty oils from waste chicken skin and pig fat, processing obtained fatty oils into biofuel and characterisation of derived fuels and its blends with conventional diesel [15].

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A. Current work

The work carried out by the team of students and collected the required quantity of waste chicken skin and pig fat from various meat stall. The waste generated from meat stall are biodegradable in nature and get processed in shorter duration. The collected waste chicken skin and pig fat are cleaned with water to remove feathers, blood cells, tissues, pieces of bones etc. The cleaned feedstock materials are shredded down into small pieces which help in extracting entire fat from the waste skin and pig fat. The separation of fat from the resources carted in different trails and the obtained quantity of fat was summarised. The gathered fat was converted into biofuels with the efficient chemical process, namely transesterification.

Transesterification process was carted with the utilisation of methyl alcohol and reactive agents such as NaOH. The conversion process carried out with different batches to optimise the transesterification process. An investigation carried out in out fuel testing laboratory to investigate the characteristics of derived fuels and their blends with conventional diesel fuel. The physio properties such as calorific value, heating value, flash point, fire point and percentage of carbon content were determined.

II. SOURCES AND METHODOLOGY

An exhaustive baseline survey was carted by the team of students by visiting to various meat stalls at our local area and collected resources needed for the extraction of biofuels. The survey results reveal that, at an average of 300 to 328 kg of waste generated from ten medium-sized meat stalls. The survey shows that the created waste chicken skin was usually disposed to open area in a non-technical manner by venders. The activities of bacterias and enzymes, disposed waste get decomposed and become a leading source of spreading diseases and pungent smell nearby the surrounding. The second type of resource called pig fat gathers from pig stall with the cost, because of the pig fat is in the group of edible food products. The collected resources such as waste chicken skin and pig fat, are showcased in fig.1.

Figure 1: Waste chicken skin and pig fat

B. Fat extraction

In this work, waste chicken skin and pig fat are used as resources to derive the biofuels. The fat extraction process was carried out with open utensil and electrical heater. The gathered waste chicken was washed with water to remove the blood cells, bone pieces, tissues and dirty contaminants. The cleansed skin shredded into small pieces, which further helps in extracting more fat due to the more exposed area to the temperature. Extraction of fat was carted in trails by taking 0.5 and 1 kg of samples to investigate the yield of fat from waste chicken skin and pig tallow. The resources are getting heated up to the temperature range between 80ºC to 120ºC. The heated products are allowed to cool down, and the fat liberates during the process from the skin was separated with the help of a fine filter. After the extraction, the measured quantity of fat was heated about to 100ºC to remove the excess water content with the obtained fat. The heated fat was allowed to get cool. The higher level of FFA content of oil will cause to the transesterification process and heading towards the formation of glycerine as a byproduct. The free fatty acids of obtained fat should be less than 1% to achieve the maximum yield of biofuel. The fat underwent through using isopropyl alcohol method. Fat obtained from pig tallow shows 3.46% of FFA were chicken fat consists maximum of up to 12-13%. The acid-catalysed esterification process was trailed to bring down the value of FFA. Fat derived from waste chicken skin, pig tallow and byproducts remains after the heating process are shown in fig.2 and 3.

Figure 2: Waste chicken skin and pig fat

Figure 3: Chicken skin and pig tallow after the heating

C. Fat converting into biofuel

Filtered and heated fat received from the extraction process is converted into liquid fuel compounds by adopting base catalysed transesterification process. The transesterification process was carried out with the presence of methyl alcohol and a base catalyst such as KOH. After the reduction of the free fatty acid level to less than 1%, a known quantity of fat took in a round bottom flask and heated to 80ºC about 90 minutes to remove water suspensions, dirt particles and impurities mixed up with it. There are several trails carried to check the feasibility, yield of product and byproduct by varying reaction time, alcohol and KOH concentration to optimise the transesterification process. On the other hand, a mixture of methyl alcohol and KOH with required quantity is prepared as shown in fig.4. Many investigations showcased that the formation of glycerine and biofuel yield will get affected by the concentration of methanol and catalyst. The quantity of reactive catalyst and methyl alcohol varied at the rate of 3 to 5gm and 250 to ml.

The methanol and KOH solution is mix with hot fatty oil and maintaining the same temperature for around 120 minutes. After adding the methoxide solution, the mixture was stirred well with the help of magnetic stirrer during the process to accelerate the reaction. The transesterification process is shown in fig.4.

Figure 4: Methoxide, Transesterification process and Biofuel

III. RESULT AND DISCUSSION

The method of converting washed fat from waste chicken skin and pig tallow into biofuel has been carried with methyl alcohol and KOH solution at variable quantity. Before that transesterification process, the fat was extracted from waste chicken skin and pig tallow separately. The results reveal that pig tallow provides a higher yield of fat than the waste chicken skin for the unit quantity of samples. The fat yield for waste chicken skin and pig tallow are tabulated in table I.

Table I: Fat yield from waste chicken skin and pig tallow

Types of feedstock	**Sample in kg**	**Fat yield in ml**
Waste chicken skin	1	180-230
Pig tallow	1	630-780

Obtained fats from different sources are secured with a higher value of FFA such as 3.46% for pig fat and 12-13% for waste chicken skin. The preprocess such as titration was conducted to bring down the FFA value to less than 1%. A trial was carried for the chicken fat before an acid wash to examine the effect of FFA on the transesterification process, and results showcased that the yield of biofuels are dramatically affected and quantity of biofuel was very less with increasing the amount of byproduct namely glycerine. The fat processing into biofuel after the acid wash gives better biofuel yield by reducing the amount of byproduct such as glycerine. The amount of biofuel yield with the concentration of methanol and KOH are tabulated in table II.

Table II: Biofuel yield with catalyst concentration

Waste chicken fat				
NaOH (gm)	Methanol (ml)	Biofuel yield (ml)	Glycerine (ml)	Methano l
3	250	580-610	280-300	-
3.5	260	590-610	250-270	-
4	270	620-680	180-220	-
4.5	280	540-570	320-340	-
5	290	510-530	320-305	-
Pig fat				
3	250	710-730	180-210	-
3.5	260	780-800	160-180	-
4	270	820-830	130-150	-
4.5	280	590-610	240-250	-
5	290	570-580	240-270	-

Exhaustive investigations were carried out to calculate the various physical properties of derived fuels and its mixtures. Table III showcased the different characteristics of biofuel from waste chicken skin and pig fat and their combinations with conventional diesel fuel. The blends ware prepared on volume bases like CB10, CB20, CB30 and CB40 with biofuel from waste chicken skin and PB10, PB20, PB30 and PB40 with biofuel from pig fat; all the blends were undertaken to determine the flashpoint, fire point, viscosity, calorific value, density and carbon content. The investigation results reveal that higher the value of flashpoint, fire point, viscosity for both the types of pure biofuel and lesser in the energy density of both pure biofuel. The blends of both biofuels with diesel fuel show that marginal changes in different properties with an increasing quantity of biofuel within it. The obtained properties for various combinations and pure biofuel from waste chicken skin and pig fats are shown in table IV.

Table IV: Properties of biofuels and their blends

Properties	**Chichen fat**	**CB100**	**CB10**	**CB20**	**CB30**	**CB40**	**CB0**
Density kg/m3	889.57	871.3	845.7	849.1	851.3	855.4	832.6
Kinematic Viscosity(c.St)	32.36	5.32	4.01	4.21	4.32	4.59	3.97
Calorific Value(MJ/Kg)	---	37.41	40.43	39.27	38.98	38.47	44.7
Flash Point (^{0}C)	247	143	97	101	110	118	53
Fire point (^{0}C)	263	157	103	111	119	137	59
FFA, NaOH(g/ltr)	12-13	---	---	---	---	---	---
Properties	**Pig fat**	**PB100**	**PB10**	**PB20**	**PB30**	**PB40**	**PB0**
Density kg/m3	873.73	857.9	842.7	849.3	853.3	859.1	832.6
Kinematic Viscosity(c.St)	29.98	5.09	3.98	4.12	4.29	4.43	3.97
Calorific Value(MJ/Kg)	---	37.32	40.29	39.19	38.26	37.98	44.7
Flash Point (^{0}C)	237	139	92	97	104	113	53

Fire point (^{0}C)	249	146	105	109	117	121	59
FFA, NaOH(g/ltr)	3.46	---	---	---	---	---	---

The tabulated properties of biofuel and their combinations indicates that the pure biofuel from both the feedstocks shows lesser in energy density when compared that of diesel fuel, higher the value of density, viscosity, flashpoint and fire point were observed for the pure biofuel. The concentration of biofuel with the high-speed diesel in combinations shows marginal difference in all the respective properties and by increasing the percentage of biofuel present in different combinations shows in to reduce the calorific value. The fig 5 to 12 illustrates the variation of different propertied with an increasing proportion of biofuel with combinations.

To utilise high viscous biofuel and their blends, fuel supply should modify accordingly to avoid the fuel line clogging. The combined fuel samples reduce the chance of clogging or blockage in the fuel line can achieve better fuel atomization within the combustion chamber. All the particular fuel combinations are in the route of accepting as promising alternative fuel for compression ignition engine even without altering any fuel supply system.

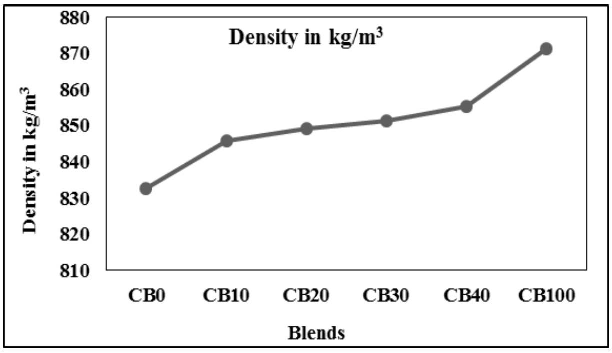

Figure 5: Density v/s Blends

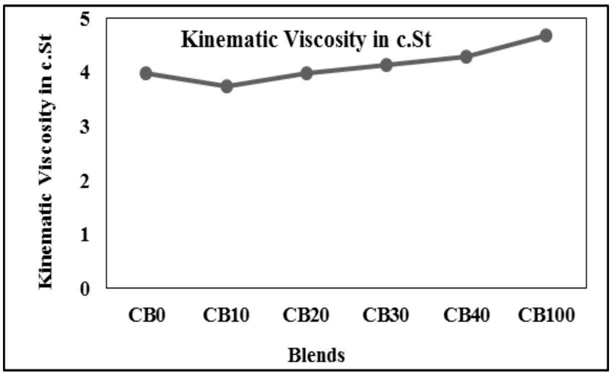

Figure 6: Kinematic Viscosity v/s Blends

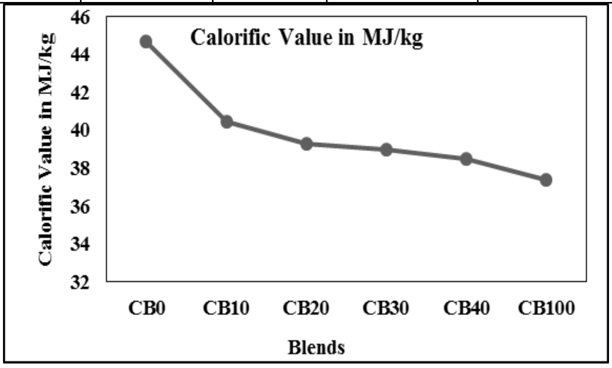

Figure 7: Calorific Value v/s Blends

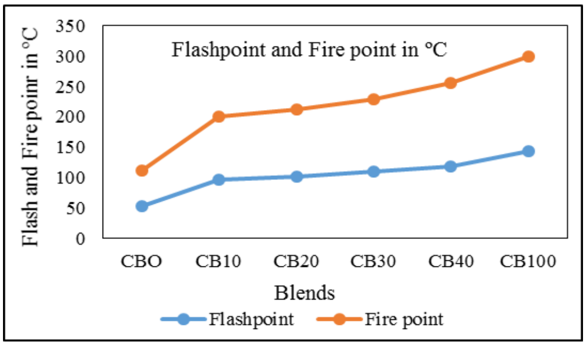

Figure 8: Flash and Fire point v/s Blends

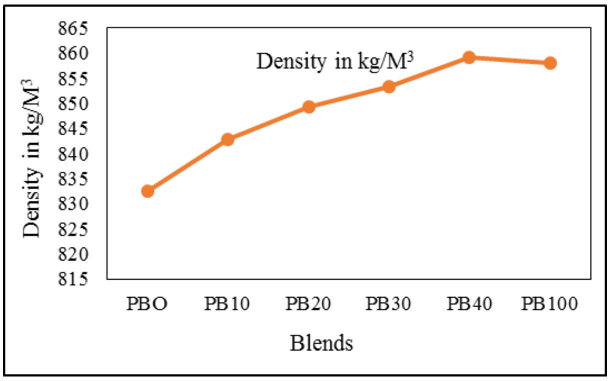

Figure 9: Density v/s Blends

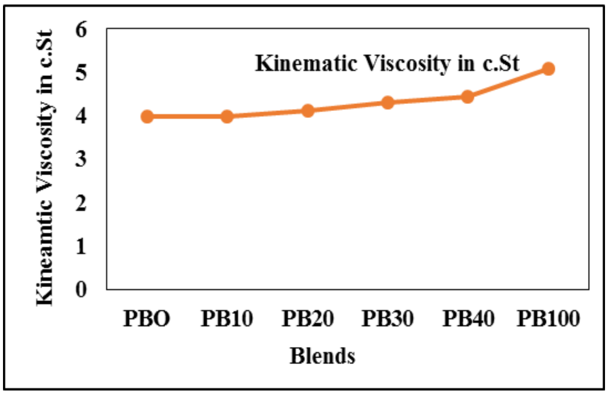

Figure 10: Kinematic Viscosity v/s Blends

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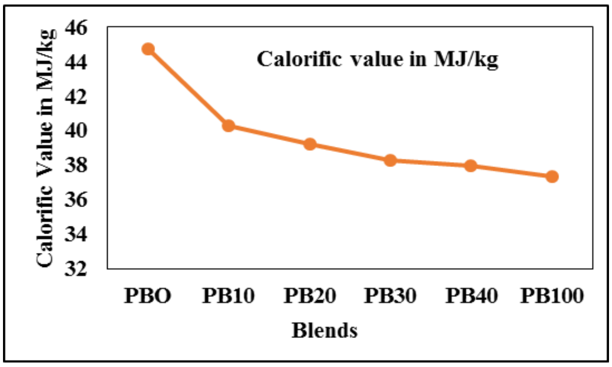

Figure 11: Calorific Value v/s Blends

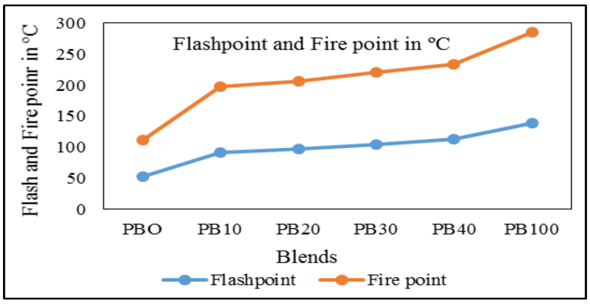

Figure 12: Flash and fire v/s Blends

IV. CONCLUSION

Currently, alternative fuels gaining more popularity due to its feasibility and suitability with a compression ignition engine. Worldwide all the respective counties initiated many biofuel programmes to progress and to create awareness towards utilising the biofuel in the IC engine. Similarly best efficient waste management technology is also needed for sustainable development of country. In our country 80% of fuels are importing of foreign countries means to say we are dependent on others to fulfil our energy requirements. The generated revenue in India is spending towards importing fuel to meet the fuel demands. If the Indian government initiates, the program like converting waste to value-added products will become the best promising method to solve two different problems with a single solution. The current work and investigations results reveal that the utilisation of waste generated from meat stalls can be better feedstocks to derive biofuel. The technical waste processing will be the most promising and zero polluting method to add values to waste resources. The pig fat stands first in giving more yield of lipid and biofuel compared to waste chicken skin. The fat extraction and biofuel production from waste generated from various meat stalls can be considered as the best alternative method to minimise the problem of waste treatment and shortage of energy sources. The derived biofuel from waste resources is meeting all the requirements to use it in existing IC engines without any significant modifications. The initiation of small industries to process this kind of waste can create employability in local areas.

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AUTHORS PROFILE

RAVIKUMAR R, BE, M. Tech, (PhD), He has published nine international peer-reviewed research articles, perusing research work on alternative fuels and internal combustion engines, a lifetime member of ISME, Fund received from Govt and non Govt agencies worth of 3 lacks. His ambition is to bring out better efficient alternative biofuel for IC engines in terms of better performance and lower emissions. Currently, He and his team working on engine combustion by utilizing biofuels derived from various waste sources such as waste plastics, used tyres, chicken waste skin, pig waste etc. by simulation as well as experimental methods. The engine will be operated by varying compression ratio, speed, load with different blends of derived fuels and conventional diesel.

Mosharib Ahmad Hashmi, He is pursuing B.Tech in Automobile Engineering from faculty of Engineering, CHRIST (Deemed to be University) Bangalore. He has done an internship in companies like Tata motors limited. RIPO (Republic of Belarus)- Industrial Automation 4.0 and Modular Production system, Service Training in Jamshedpur- Mithila motors. He is also a member in building in-house projects such as REEV (Range Extended Electric vehicle), Prototype Model of Centrifugal pump, U.G.V. (Unmanned Ground Vehicle). He received academic scholarships (AISSE-2013) for excellence in his academic performance. Currently, he is studying in 7th-semester and actively engaging himself in many research projects such as Biofuel, Autonomous Vehicle, Electric Vehicle etc.

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SARVESH V BIKKANNAVAR, He has done Diploma in Tool and dies making at NTTF, Currently studying 7th semester in Mechanical engineering at Faculty of Engineering, CHRIST (Deemed to be University), Bangalore. He has done a certificate course in Peer education, attended workshop on 3D printing, carrying service-learning project on weed remover. He has completed internship at accurate tool tech on injection mould manufacturing and TATA Marco polo on bodybuilding at Dharwad, Karnataka. He has contributed his innovative idea in vehicle building project named by Rang extension electric vehicle which is in-house project carried out by the team of students. He's interested in Alternative fuels, vehicle building, Manufacturing process etc.

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