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Investigation of the Usability of Essential Oils as Fuel in Diesel Engines

Uçucu Yağların Dizel Motorlarda Yakıt Olarak Kullanılabilirliğinin Araştırılması

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ABSTRACT

In this study, the usability of essential oils as fuel additives in internal combustion diesel engines was investigated.Salvia candidissiman was preferred as essential oil raw material due to its oil efficiency.The essential oil of salvia candidissima plant biomass was obtained by hydro distillation method.The essential oil obtained was then converted into biofuel by transesterification reaction.Biofuel is added to diesel fuel at a rate of 10% by volume and is named [SB-10].DF] and [SB-10] fuels were tested in a variable compression ratio diesel engine at fixed 1550 rpm.Results: It showed that the [SB-10] fuel produced 2.46 Nm more torque and 4.29 HP more power than DF fuel. When looking at the combustion data, 4.99% in the pressure values of the fuel [SB-10], 16.72% in gas temperatures, % in the rate of increase in pressure. 22.84 and 2.85% more in cumulative heat release values.

ÖZET

Bu çalışmada, uçucu yağların içten yanmalı dizel motorlarında yakıt katkı maddesi olarak kullanılabilirliği araştırılmıştır. Uçucu yağ hammaddesi olarak, yağ verimliliğinden dolayı, salvia candidissimanı tercih edilirmiştir. salvia candidissima bitki biokütlesinin uçucu yağı hidro distilasyon yöntemi ile elde edilmiştir. Elde edilen uçucu yağ daha sonra transesterifikasyon reaksiyonu ile biyoyakıta dönüştürülmüştür. Biyo yakıt, dizel yakıtına hacimsel olarak % 10 oranında ilave edilmiştir ve [SB-10] olarak isimlendirilmiştir. DF] ve [SB-10] yakıtları, sabit 1550 devrinde, değişken sıkıştırma oranına sahip bir dizel motorda test edilmiştir. Sonuçlar: [SB-10] yakıtının DF yakıtından 2.46 Nm daha fazla tork, 4.29 HP daha fazla güç ürettiğini göstermiştir. Yanma verilerine bakıldığında [SB-10] yakıtının basınç değerlerinde % 4,99, gaz sıcaklıklarında % 16.72C, basınç artış oranında % 22.84 ve kümülatif ısı salınım değerlerinde ise %2.85 daha fazla oluştuğu belirlenmiştir.

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1. INTRODUCTION

The total population of the world stands at around 8 billion. Experts estimate that this number will reach approximately 10 billion by the middle of the 21st century and 11 billion by the end of the century. Furthermore, reports by the International Energy Agency predict that energy use and demand will increase by about 50 percent within a quarter of a century[1]. While the amount of energy consumed by countries depends on various factors, such as the level of industrialization, the level of technology usage and the population of the world, it is well recognized that the demand for energy from all countries is increasing[2]. Fossil fuel stocks, which have a large share of the energy types currently used, will continue to decline and, with this rising demand, stocks will rapidly decline [3]. In addition to the fact that fossil fuels are exhaustible, the damage they do to the atmosphere and life during use is at a level that can not be ignored. Renewable energy sources are becoming increasingly important for the environment and living conditions, taking into account these existing shortcomings. Renewable energy sources account for 5 percent of today's total energy production in the world. However, these resources are known as the energy resources of the future. It is anticipated that investments in sectors where $155.4 billion was invested in 2008 alone would cross $600 billion by 2020. The source of renewable energy is defined as "the energy source that may be present the next day in the natural cycle"[4]. They are often not depleted by their use[5]. Conventional energy sources are not regarded as green energy sources by definition. [4]. Renewable energy sources are therefore making promising strides in meeting the world's energy demand, at least in the near future, and have begun to step up their activities and policies in this area. These new renewable energy policies have given priority to solar energy, wind energy and biodiesel obtained from vegetable oils[6]. The alternative diesel fuel derived from renewable sources such as animal or vegetable oils is biodiesel. Chemically, mono alkyl ester can be classified as a long-chain fatty acid [7]. Compared to other renewable sources of energy, such as wind and solar energy, the fact that biodiesel production is less expensive and easy to produce has enabled its production to become more widespread. Contributing. However, the rapid growth of biodiesel technology is triggered by the fact that biodiesel production enables, in particular, the agricultural, manufacturing and environmental sectors to work together and offers additional jobs and income opportunities for those sectors. [8]. In this research, apart from conventional biodiesel sources, essential oil has been used as an innovation. Due to its high percentage of oil yield, Salvia candidissima has been used as an essential oil plant. In nature, this plant develops spontaneously. It is ample and its oil production is higher than other herbs of essential oil.

2. MATERIAL AND METHOD

2.1 Essential oils

Essential oil, plants, animals and species such as microorganisms. The substances created are volatile. "As they look like oil, these compounds, which are usually fragrant, are called" essential oil "or" ethereal oil[9-10]. Distillation of essential oils by boiling or moving water vapor through the material with water from the material in which they are contained, cold pressing and organic solvents or liquefied It can be obtained through the consumption of gases. Essential oils float on water, with the exception of a few, such as clove oil, since they are lighter than water and are obtained after distillation by being quickly removed from water. Air, light and heat are negatively affected by essential oils, As they lose their properties, they should be stored in a cool position, full and tightly closed in colored glass or aluminum containers. Chemical drying and filtration methods often strip away the water found in the essential oil. The most substantial variations between essential oils and fixed oils are They are dropped on absorbent paper and when exposed, they travel without leaving any traces. The consistency of the essential oil is established by the volatile compounds it contains. A Unpredictable Hundreds of chemicals, large and small, can often be contained in the oil's composition. These Gas Chromatography / Mass Spectrometry compounds Separated by a sophisticated technique called (GC / MS) from each other They can be characterized The key variables influencing consistency are odor and chemical composition. The sales. What gives each essential oil its characteristic, therefore, To be present in certain quantities, natural chemicals are required [20].

2.2 Critical Oils composition

In the composition of essential oils, terpenic or non-terpenic components exist. There are hydrocarbons and their derivatives oxygenated by them. Nitrogen or sulfur can be present in certain materials. There are alcohol, acid, ester, epoxy, aldehyde, ketone, âmine, sulfide, and form compositions. Terpenes are structures that are formed by isoprene units being connected to each other. The composition of essential oils contains the bulk of monoterpenes, sesquiterpenes and diterpenes. In addition, the essential oil composition can also be composed of fatty acids and esters and their degradation products [11].Table 1. Key types containing essential oil are presented.

Table 1. Key species containing essential oils

1.	Zingiber officinale.	6.	Lavandula angustifolia.
3.	Pinus spp.	7.	Salvia officinalis.
4.	Cinnamonum cassia.	8.	Cuminum cyminum.
5.	Mentha piperita.	9.	Zingiber officinale.
6.	Origanum vulgare.	10.	Pinus ssp.

2.3 Salvia family

Turkey species[12] are represented in warm temperate regions with herbaceous species and genus Salvia, such as bush 88. In our country, salvia species consist of either bushy or herbaceous species. Bushy animals can grow to about 1.5 m. S. With wiedemannii, S. Examples of shrubby species can be provided as tchihatcheffii from the Central Anatolia Region. In all regions of our nation, herbaceous species are distributed. All of our country's recognized species of Salvia are biennial or perennial, except for S. (one year old) viridis. One of the most important characters used in the differentiation of species is the feathers contained in the leaves, calyx and flowers. In the Salvia genus, a wide range of feather forms are observed [13]. Figure 1. Images and features of Salvia Candidissima is presented.


Figure 1. *Salvia candidissima*

2.4 Hydrodistillation – HD

Distillation is called the method of separating two or more liquid components from a mixture depending on the difference in boiling point or volatility[33].It is a conventional method of extracting volatile compounds that is widely used. Process. Water distillation, fresh and dry vegetables that do not deteriorate can be added to the substance when boiled. Not appropriate for essential ester-containing oils. The basis of the method; water and plant material are boiled for 2 to 8 hours in a glass flask connected with the cooler, and the oil molecules pass with the water vapor are boiled. It is based on condensation and isolation from water in the cooler. In water distillation, vegetable matter is still in close contact with water [34, 35, 25]. The distillation process, which is produced in small-scale production with a Clevenger-type apparatus, is carried out in industrial applications in large distillation boilers (retort). The volumetric quantity of essential oil obtained is expressed. For powdered materials, water distillation works best.[14]. Clevenger instruments have been used in this process. The herbal biomass and water were boiled together in a glass flask for 2–8 hours for the extraction of Salvia

candidissima oil. The shaped molecules of water vapor and plant oil come to the cooler and He was isolated from the water as it condensed. By volume, the amount of essential oil obtained was 7-9 g / ml. Among plants having essential oil, this value is high. The method of hydro-distillation is shown in Figure 2, and the vegetable oil components are shown in Table 2.
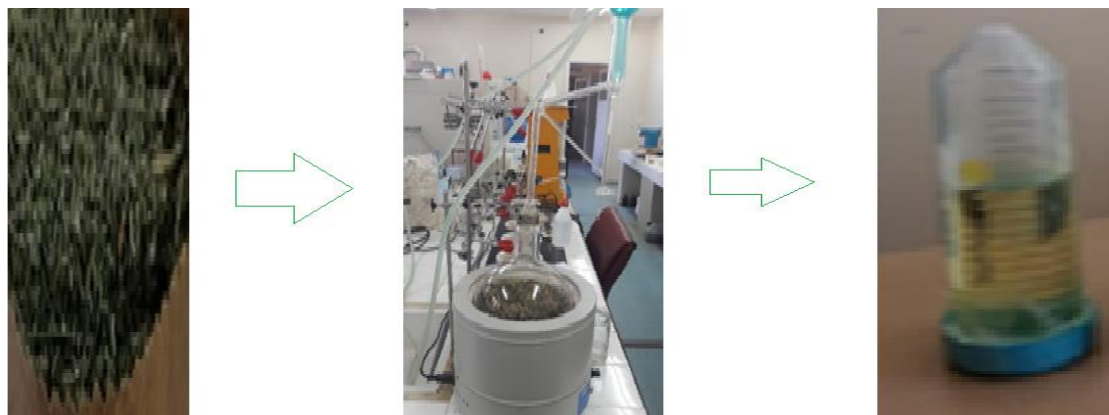
Figure 2. *Ground biomass, hydro distillation essential oil samples*

Table 2. Essential oil components

Salvıa Sp				
Pk	Rt	Area Pct	Library/Id	Qual
1	7,78	0,36	Tricyclene $$ Tricyclo[2.2.1.0(2,6)]Heptane, 1,7,7-Trimethyl- (Cas)	96
2	8,03	0,28	.Alpha.-Thujene $$ Bicyclo[3.1.0]Hex-2-Ene, 2-Methyl-5-(1-Methylethyl)-(Cas)	94
3	8,28	15,24	.Alpha.-Pinene $$ 2-Pinene	97
4	8,84	8,54	Camphene (Cas) $$ Bicyclo[2.2.1]Heptane, 2,2-Dimethyl-3-Methylene- (Cas)	98
5	10,03	4,82	.Beta.-Pinene $$ Bicyclo[3.1.1]Heptane, 6,6-Dimethyl-2-Methylene-	97
6	10,27	0,51	1 Octen 3 Ol $$ 1-Octen-3-Ol $$ Oct-1-En-3-Ol $$ Octan-3-One	90
7	10,58	0,16	3-Octanone (Cas) $$ Eak $$ Octan-3-One $$ N-Octanone-3 $$ Amyl Ethyl Ketone	96
8	10,79	1,13	.Beta.-Myrcene $$ 1,6-Octadiene, 7-Methyl-3-Methylene- (Cas)	97
9	11,86	0,28	.Alpha. Terpınene $$ Para-Mentha-1,3-Dıene	98
10	12,53	43,20	Eucalyptol	99
11	13,83	0,54	.Gamma.-Terpinene $$ 1,4-Cyclohexadiene, 1-Methyl-4-(1-Methylethyl)- (Cas)	97
12	14,18	0,11	Trans-Sabınene Hydrate $$ 4-Thujanol, Stereoısomer	94
13	15,21	0,21	.Alpha.-Terpınolene $$ Cyclohexene, 1-Methyl-4-(1-Methylethylidene)- (Cas)	97
14	17,74	11,67	Camphor	98
15	18,80	6,65	Endo-Borneol $$ Endo-2-Hydroxy-1,7,7-Trimethylnorbornane	97
16	19,34	0,96	3-Cyclohexen-1-Ol, 4-Methyl-1-(1-Methylethyl)- (Cas) $$ 4-Terpineol	96
17	20,23	0,56	Bicyclo[3.1.1]Hept-2-Ene-2-Methanol, 6,6-Dimethyl- $$ 2-Pinen-10-Ol $$ Myrtenol	96
18	24,34	1,75	Bornyl Acetate $$ Bicyclo[2.2.1]Heptan-2-Ol, 1,7,7-Trimethyl-, Acetate, Endo-	99
19	30,03	0,99	Caryophyllene	99
20	30,92	0,32	.Alpha.-Guaiene	95
21	31,42	0,19	.Alpha.-Humulene (Cas)	97
22	31,74	0,19	1h-Cycloprop[E]Azulene, 1a,2,3,4,4a,5,6,7b-Octahydro-1,1,4,7-Tetramethyl-, [1ar-	96
23	32,56	0,16	Germacrene-D	97

2.5 Fuel conversion with transesterification

Due to its short reaction time and high efficiency, the chemical transesterification method has been favored in biodiesel production. Transesterification is the ester and glycerol-forming reaction of oil with alcohol [Figure 3.]. Fatty acid methyl esters and glycerin are formed as the main product through the reaction of monohydric alcohol (ethanol or methanol) and catalysts (acidic and basic catalyst enzymes). [28], [29-30]. Because of the economic nature of the transesterification reaction of salvia oil, methanol was chosen in the experiments as alcohol and potassium hydroxide (KOH) as the catalyst. The catalyst volume was 1.5 percent, the alcohol / oil ratio was 6: 1 and the reaction time was 60 minutes in our experimental sample. At a steady stirring speed of 500 rpm, all experiments were performed. The temperature of the reaction was kept constant at 60 ° C [31]. Alcohol and catalyst are combined with an appropriate blender in this process, then the alcohol catalyst mixture is added to the heated vegetable oil. After 60 minutes of mixing this total mixture together, it is left to stand for 24 hours and the process is completed.[16-15]. The shaped biodiesel and glycerin are separated by centrifugation from the gravity differences and the excess alcohol is extracted by flash evaporation or distillation process in each step. From the glycerin obtained, water and alcohol are extracted and purified for other uses. Finally, in order to eliminate residual catalysts and soaps, biodiesel is washed with warm water. [32].
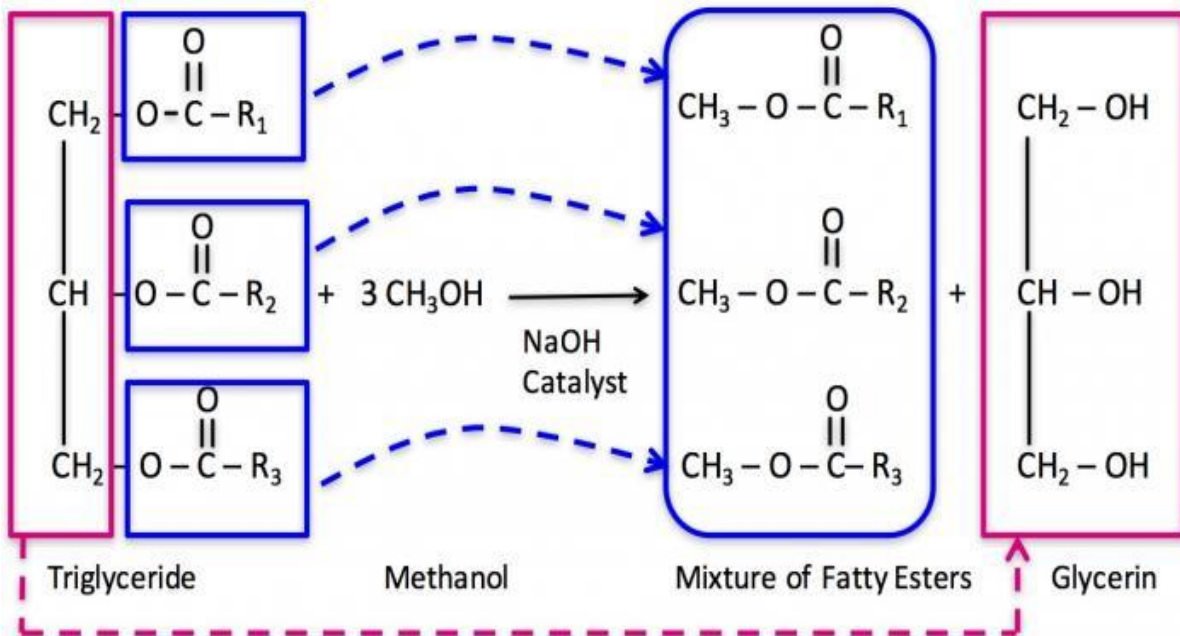

Figure 3. *Esterification reaction[26]*

3. EXPERIMENTAL SETUPS

The fuels of the study were tested using a Kirlaskor brand diesel engine. While doing this work, the engine speed was kept constant at 1550 rpm. Each test fuel was tested at 8 kg (16%) loading. 10 cycle maximum values and crank angles at which these maximum values were obtained for each test fuel were taken. The study was done firstly with diesel fuel [DF] used as reference fuel and then with mixed fuel. Engine power in operation. Engine torque and combustion analysis data were obtained. The technical characteristics of the test engine used in the study. Tab 3. The photo of the test setup is given in figure 4.
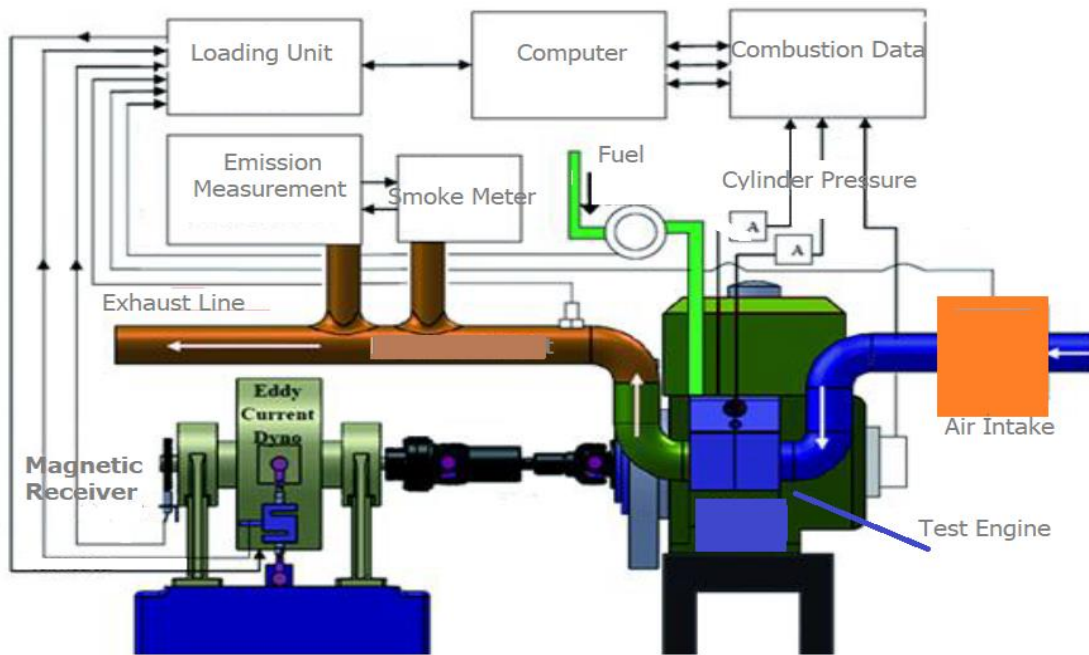
Figure 4. *Experimental setup* [27]

Table 3. Specifications of the diesel engine

Model	Kirlaskor TV-1
Motor Power (Kw)	3.5 kW
Engine Capacity (cc)	661
Cylinder Diameter (mm)	87
Stroke Length (mm)	110
Compression Rate	17/1
Number of Srok	4
Number of Cylinders	1
Cooling Type	Water
Dynamometer Type	Eddy Current
Load Indicator	Digital, 0-50 kg

4. EXPERIMENT RESULTS

4.1. Motor Control and Motor Torque

The power determined at the crankshaft end of the engine by a brake mechanism from the pulley or flywheel is called brake power. The effective power of the engine is this energy received. It is less than that of the engine 's internal power[16]. The explanation is that friction, pumps and dynamos are reserved for some of the internal strength. Illustration 5. It was shown that SC-10 mixed fuel provided 3.4 HP percent more engine power and 1,98 Nm percent more engine torque values when effective power and engine torque values were examined. Higher cylinder pressure values[17] depend on the increase in the power and moment curves in favor of the SC-10. Biodiesel fuel has a greater enthalpy of evaporation than diesel fuel; this increases the density of air fuel, which increases[18].
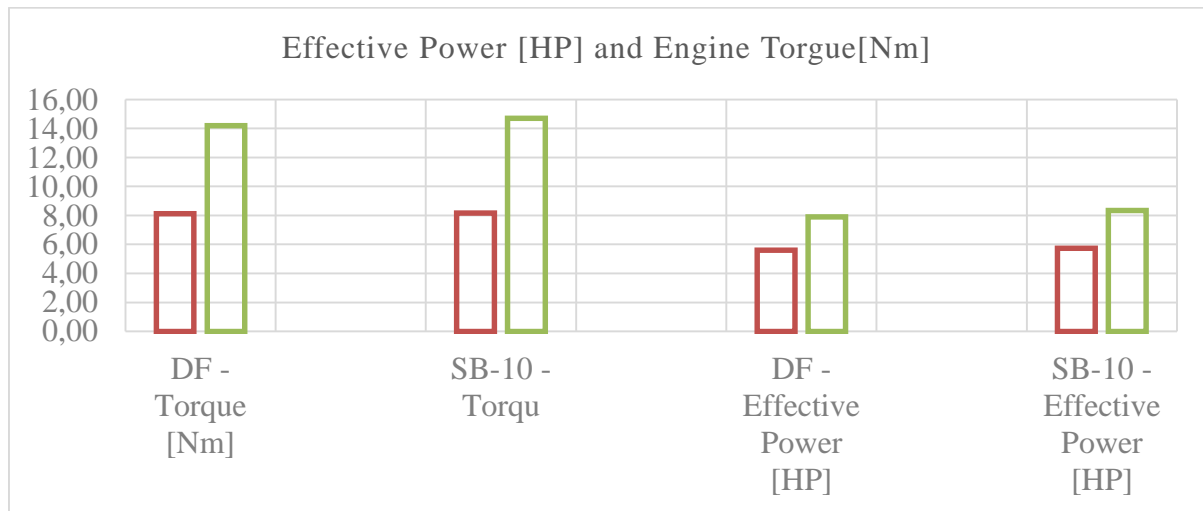

Figure 5. *Load dependent variation of Nm / HP*

4.2. Cylinder Pressure [bar]

Maximum cylinder pressure is determined as the highest point in the pressure diagram obtained with the aid of a pressure sensor placed in the combustion chamber of the internal combustion diesel engine. The maximum pressure values in the cylinder at a fixed motor speed of 1550 are shown in Figure 6. Here, a difference between the cycles of each fuel occurs because of cyclical differences. The crank angles at which the maximum cylinder pressure values of the experimental fuels were obtained were seen to be similar, occurring after the upper death point. When the values were examined between the experimental fuels, it was seen that the pressure values of the SC-10 fuel cylinder were higher than those of the DF fuel values. The increase in the maximum cylinder pressure values in favor of the mixed fuel depends on the increase in the filling quantity of the latent evaporation heat of the biodiesel fuel taken into the combustion chamber[19].
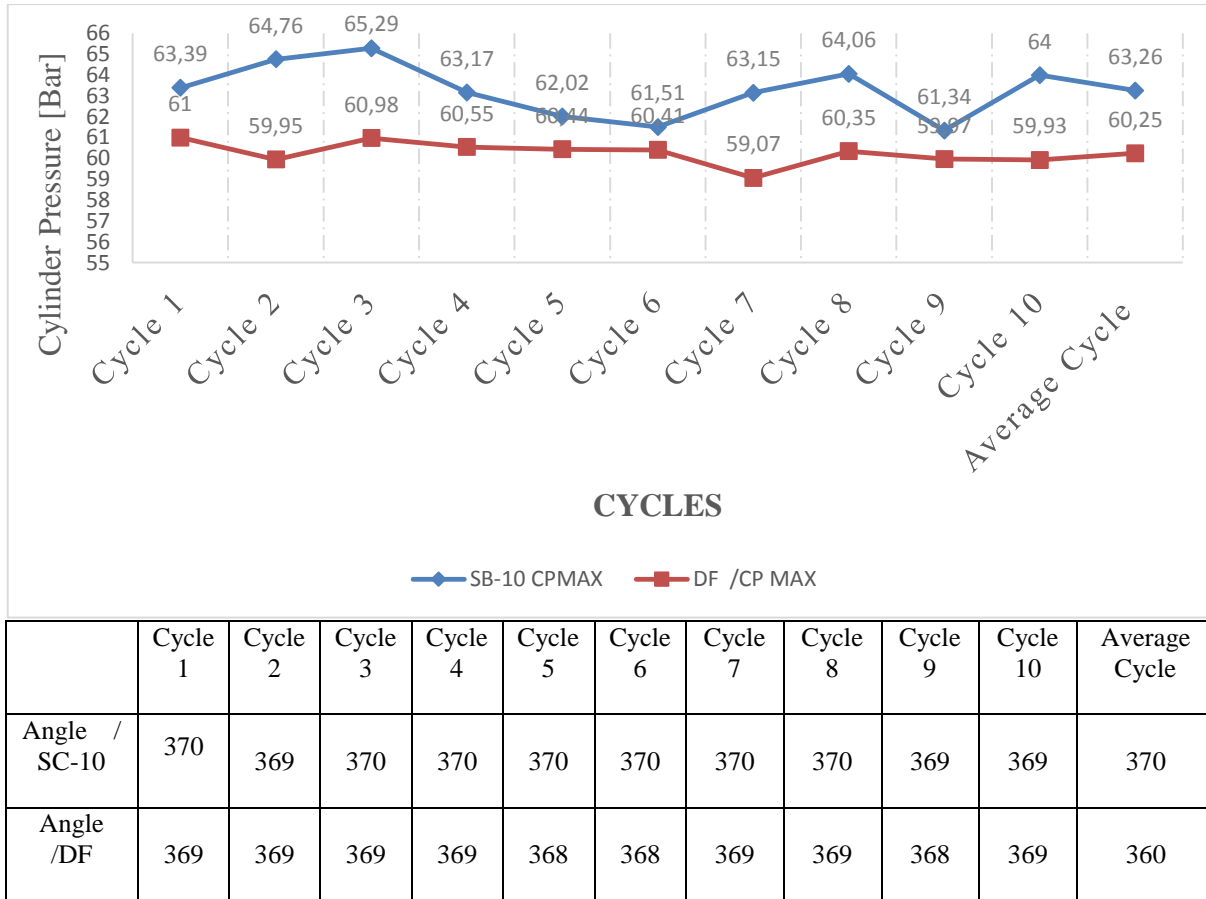
	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Average Cycle
Angle / SC-10	370	369	370	370	370	370	370	370	369	369	370
Angle /DF	369	369	369	369	368	368	369	369	368	369	360

Figure 6. *Load-dependent variation of Cylinder Pressure [bar]*

4.3. Gas Temperature [ºC]

Illustration 7. The study reveals that the fuel [SB-10] generates higher average gas temperature values than the fuel [DF] in all ten cycles. In support of SB-10, the difference between the averages of the temperature values formed by the experimental fuels is 16.72 percent. These higher average gas temperatures were assumed to occur because the combustion was more stable due to the excess oxygen content of biodiesel] [fuels[19]. In addition, it was determined that the highest average gas temperature values occurred in both test fuels at approximately 18-22 crank angles after the upper dead point. The crank angles at which the maximum gas temperature values of the SB-10 fuel are produced are close to the crank angles where the maximum gas temperature value of the DF is given.
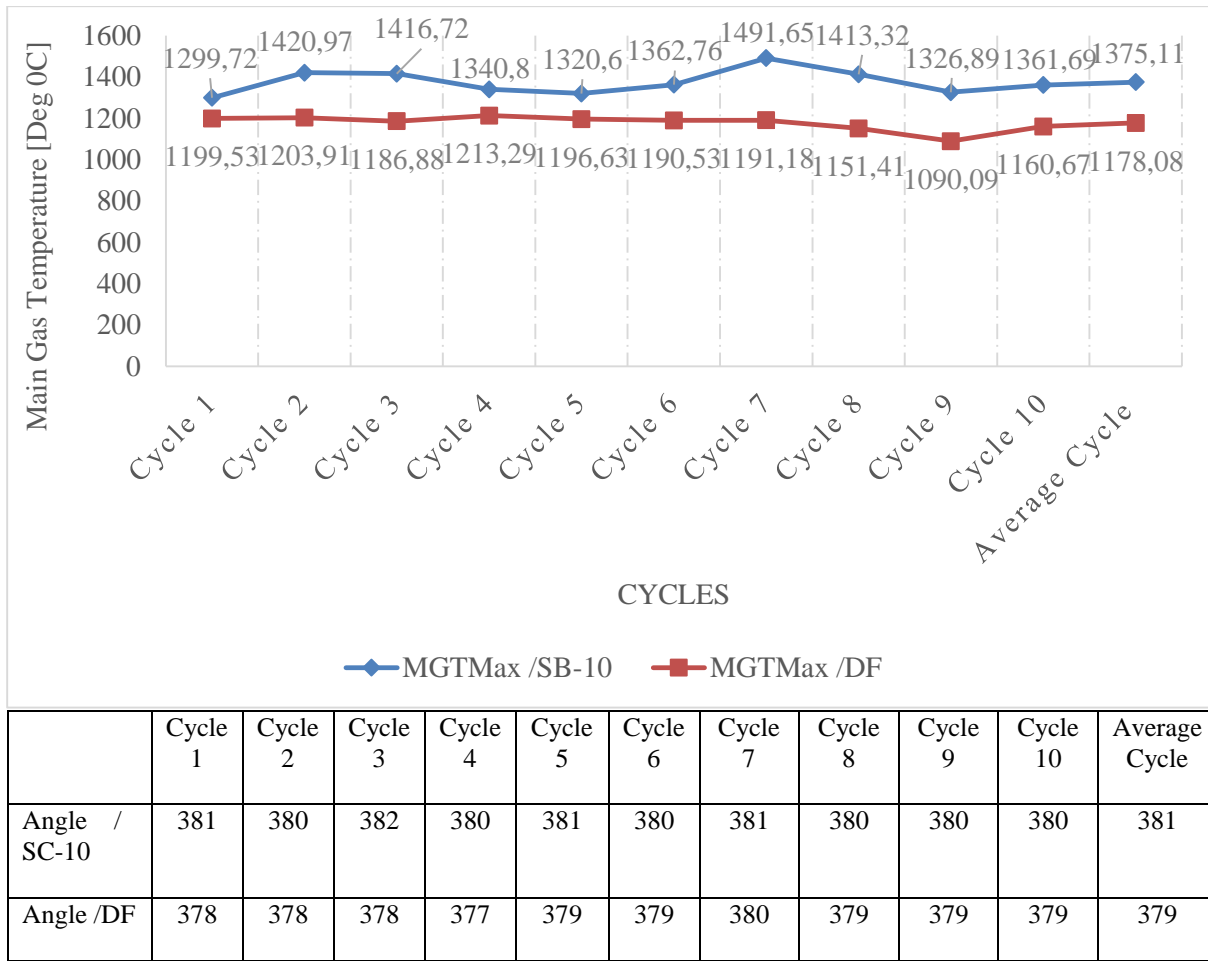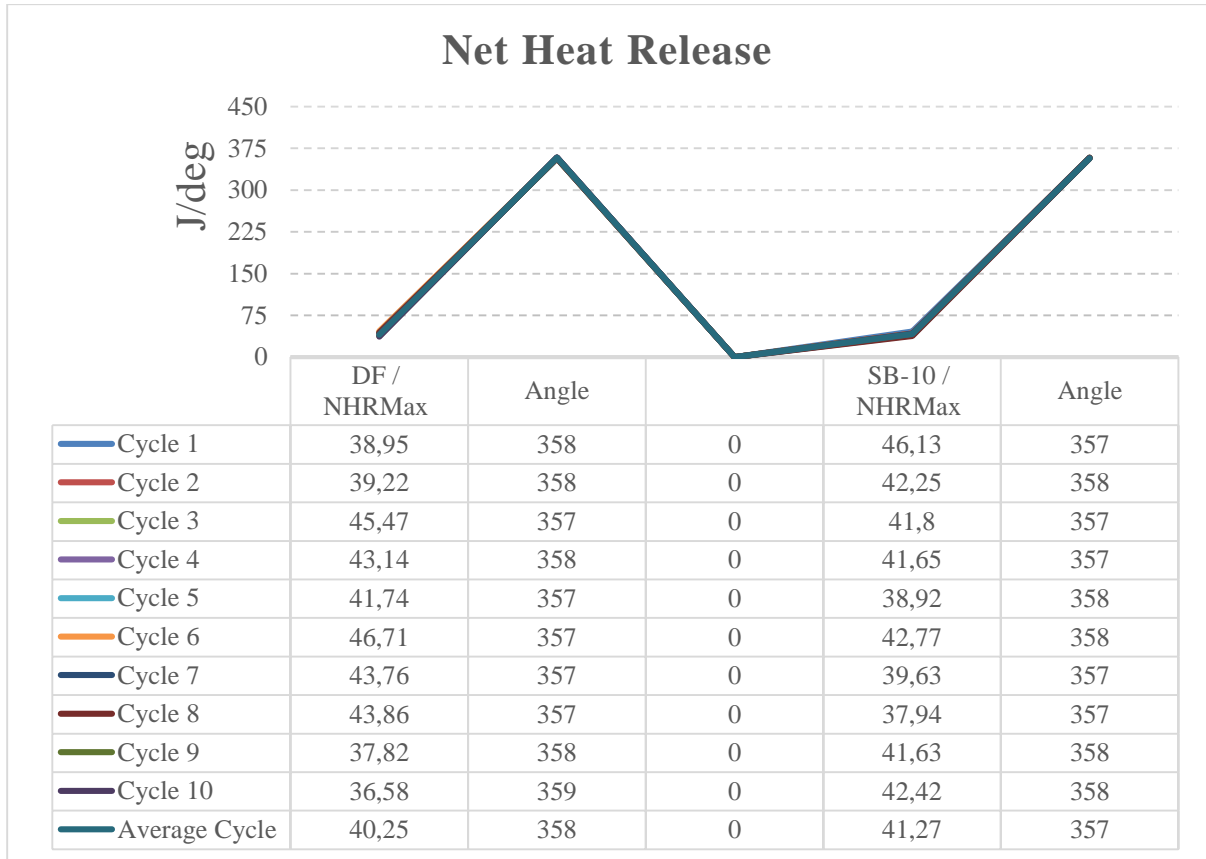
	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Average Cycle
Angle / SC-10	381	380	382	380	381	380	381	380	380	380	381
Angle /DF	378	378	378	377	379	379	380	379	379	379	379

Figure 7. *Load-dependent variation of MGT*

4.4. Net Heat Release [NHR – j / deg]

Depending on the crank angle, Figure 8 shows the changes in the net heat release values, which are formed by taking the maximum values of 10 cycles. While the difference between the highest value and the lowest value was 21.68 % between the cycle values of the DF fuel, the SC-10 fuel cyclical difference was 17.75%. This is because the content of oxygen makes combustion more stable[erdal]. With the SC-10 fuel usage, the difference between the average maximum values of the experimental fuels was 2.53 percent higher. The high biodiesel fuel evaporation enthalpy reduces the ambient temperature and increases the filling. The amount of oxygen also improves the level of combustion [21]-[22].

Net Heat Release

	DF / NHRMax	Angle		SB-10 / NHRMax	Angle
Cycle 1	38,95	358	0	46,13	357
Cycle 2	39,22	358	0	42,25	358
Cycle 3	45,47	357	0	41,8	357
Cycle 4	43,14	358	0	41,65	357
Cycle 5	41,74	357	0	38,92	358
Cycle 6	46,71	357	0	42,77	358
Cycle 7	43,76	357	0	39,63	357
Cycle 8	43,86	357	0	37,94	357
Cycle 9	37,82	358	0	41,63	358
Cycle 10	36,58	359	0	42,42	358
Average Cycle	40,25	358	0	41,27	357

Figure 8. *Heat release graph*

4.5. Rate of Pressure Rise [RPR - dp/dQ]

The rate of increase in pressure [23] is an indicator of the energy released during the combustion process in internal combustion engines. Changes in the rate of increase in pressure depending on the crank angle (Figure 9) are provided. The pressure increases the difference between the lowest value and the highest value of 10 cycles obtained with SC-10 when Figure 9 is examined. Increased rate values between fuels in comparison to pressure The difference was 18.59 percent between the mean values. Higher pressure rise values were created by the mixed fuel than by DF fuel. Therefore, as the rate of increase in pressure increases with the sudden combustion of the amount of mixed fuel accumulated in the cylinder, the engine will operate as a stroke and will increase the temperature in the cylinder.

Rate Of Pressure Rise

	sb-10 / RPRMax	Angle		DF / RPRMax	Angle
Cycle 1	4,34	358	0	3,17	360
Cycle 2	4,02	358	0	3,15	360
Cycle 3	3,94	358	0	2,96	360
Cycle 4	3,55	359	0	3,17	360
Cycle 5	3,73	359	0	3,13	360
Cycle 6	3,79	358	0	2,75	361
Cycle 7	3,84	359	0	2,89	360
Cycle 8	3,4	359	0	2,86	360
Cycle 9	3,59	359	0	3,16	360
Cycle 10	3,68	359	0	2,96	360
Average Cycle	3,71	358	0	3,02	360

y-axis: [dp/do], values 0, 50, 100, 150, 200, 250, 300, 350, 400
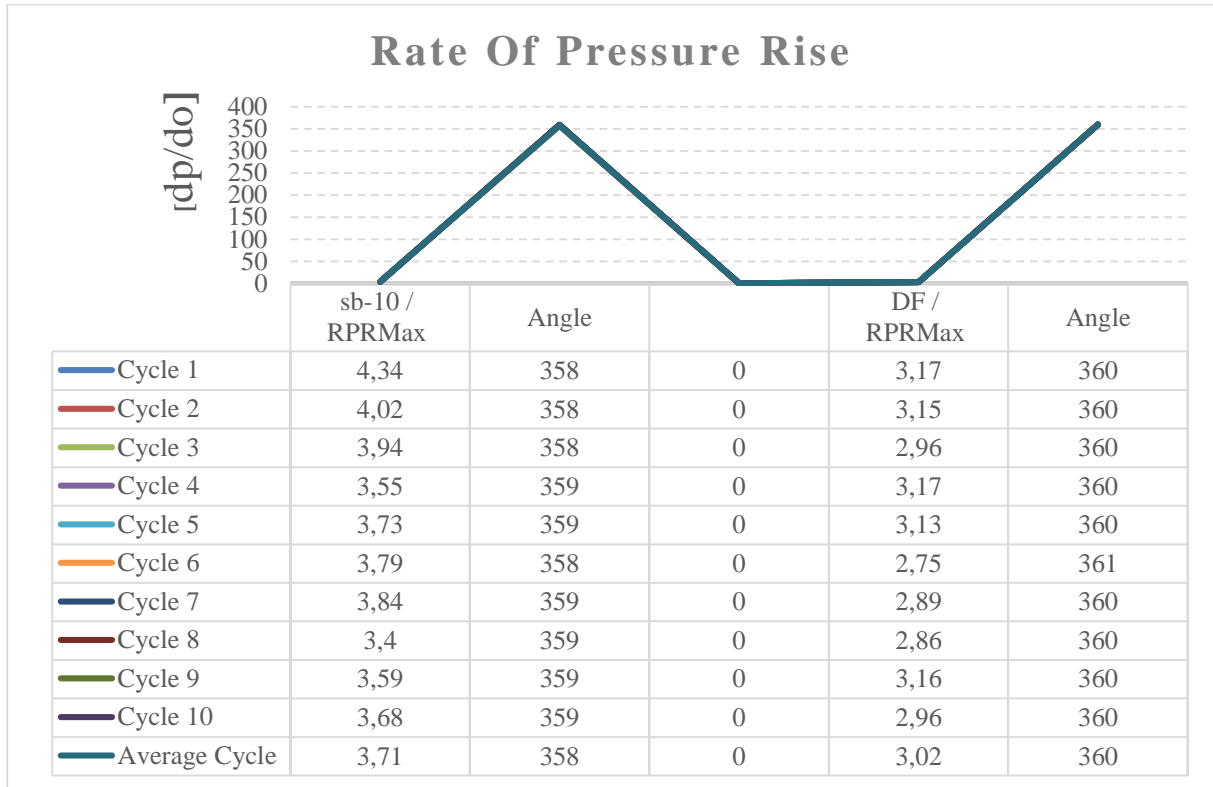
Figure 9. *Pressure increase rate graph*

4.6. Cummulative heat release [CHR - kJ]

The sum of the heat emissions released during the combustion process forms the cumulative value for internal combustion four-stroke diesel engines[24]. When the graph of the cumulative heat release values [Figure10.] is examined, the crank shaft angle, where the maximum values of the sc-10 fuel are formed, is seen after the upper dead point [ATDC] 46 crank shaft angle. It was observed that, with a delay of 3o [CA] compared to SC-10 blended fuel, the average crank angle at which maximum values were formed for DF fuel was [ATDC] 49 crank angle [CA]. Furthermore, it was seen that the cumulative temperatures were 2.77 percent higher with the use of SC-10 fuel than DF fuel. This difference is due to the prolongation of the delay in ignition [ID] and the increase in the amount of filling received depending on the height of the latent heat vaporization of the fuel mixture [25].
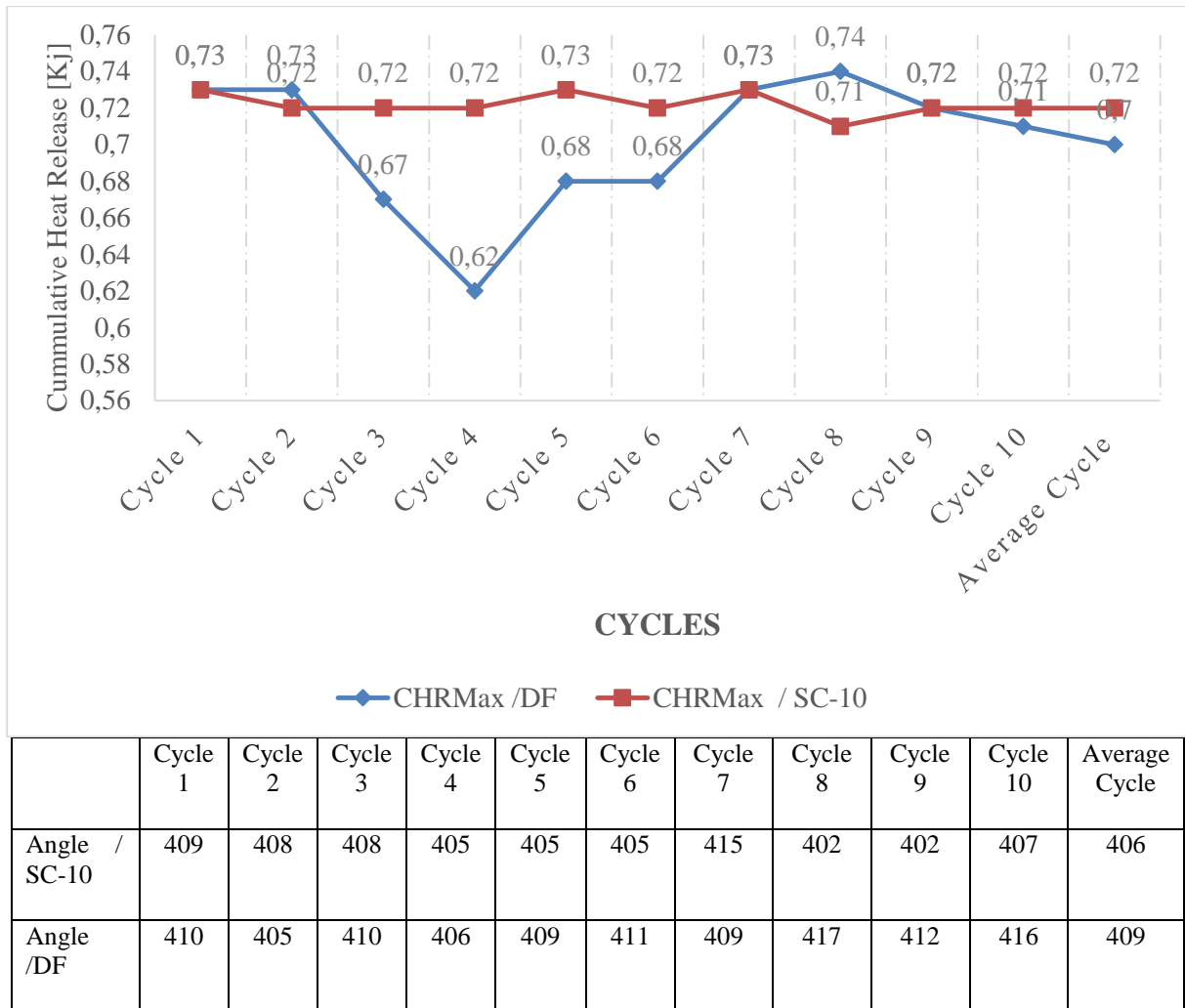
	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Average Cycle
Angle / SC-10	409	408	408	405	405	405	415	402	402	407	406
Angle /DF	410	405	410	406	409	411	409	417	412	416	409

Figure 10. *Cumulative Heat release graph*

5. CONCLUSION

The data obtained by testing the essential oil obtained in a diesel test engine from the Salvia candidissima plant is given below. In comparison with the engine torque values produced by the DF and SC-10 fuels burned in the test engine, higher values of 1.9 Nm were obtained by using SC-10 fuel. It was shown that there was an improvement of 3.4 HP in the comparison of motor effective power values, which is one of the engine output values, and it was in favor of SC-10 petrol. 4.99 percent at the full cylinder gas pressure value of the SC-10 mixture gasoline fuel, when the combustion data are analyzed in detail, In their values, the maximum cumulative heat release is 2.85 percent The rate of maximal pressure increase in its values is 22.84 percent. At a maximum net heat release rate of 2.53 percent, And at average gas temperature levels of 16.72 per cent. If all the data obtained from the studies are analyzed as a whole, it can be seen that this new source of biodiesel fuel derived from essential oils provides the whole study with substantial overall improvements.

ACKNOWLEDGMENT

CONFLICTS OF INTEREST

No conflict of interest was declared by the author.

REFERENCES

[1]   IEA, OECD and Non-OECD Countries Energy Statistics International Energy Agency, http://www.iea.org/stats/index.asp (Erişim Tarihi: 12.11.2012).

[2]   EIA, International Energy Outlook. 2011. Energy Information Administration, www.eia.gov/ieo (Erişim Tarihi:08.02.2013).

[3]   EIE, Rüzgâr Enerjisi Potansiyel Atlası ve İşletmedeki RES santraller http://www.eie.gov.tr/yenilenebilir/ruzgar.aspx (Erişim Tarihi: 02.09.2012).

[4]   H. Kum, Yenilenebilir Enerji Kaynakları: Dünya Piyasalarındaki Son Gelişmeler Ve Politikalar, Erciyes Üniversitesi İktisadi Ve İdari Bilimler Fakültesi Dergisi, Sayı: 33, Temmuz-Aralık 2009, S.207-223.

[5]   H. Kumbur, Z. Özer, D. H. Özsoy, E. D. Avcı, Türkiye'de Geleneksel ve Yenilenebilir Enerji Kaynaklarının Potansiyeli ve Çevresel Etkilerinin Karşılaştırılması, III. Yenilenebilir Enerji Kaynakları Sempozyumu, Bildiriler, (2005).

[6]   http://www.ekoses.com/ekolojikyasamportali/bpg/publication (Erişim tarihi 25.11.2005).

[7]   E. Alptekin, M. Çanakçı, Biyodizel ve Türkiye'nin Durumu, Mühendis ve Makine Dergisi, 47(561), 57-64. 2006.

[8]   A. Sabancı, B. Yaşar, H. H. Öztürk, M. N. Ören, M. Atal, Türkiyede Biyodizel ve Biyoetonal Üretiminin Tarım Sektörü Açısından Değerlendirilmesi, Çukurova Üniversitesi, Adana 2010.

[9]   N. Yaylı, Uçucu Yağlar ve Tıbbi Kullanımları, Karadeniz Teknik Üniversitesi Eczacılık Fakültesi Yayınları, 2013; 1-2-4.

[10]   M. K. Sakar ve M. Tanker, Fitokimyasal Analizler, Ankara Üniversitesi Eczacılık Fakültesi Yayınları No:67, Ankara, 1991; 128-129-189.

[11]   H. C. Başer, Uçucu Yağlar Ve Aromaterapi, Anadolu Üniversitesi Eczacılık Fakültesi, 2009; 9-12-13-17-18-19-20-21.

[12]   Güner, A., Akyıldırım, B, Alkayış, M.F., Çıngay B., Kanoğlu, S.S., Özkan, A.M., Öztekin, M. ve Tuğ, G.N. (2012). Türkiye Bitkileri Listesi (Damarlı Bitkiler). Nezahat Gökyiğit Botanik Bahçesi ve Flora Araştırmaları Derneği Yayını, İstanbul.

[13]   Davis PH, Mill RR, Tan K (1988). Flora of Turkey and the East Aegean Islands (Suppl. l), Vol. 10. Edinburgh: Edinburgh University Press, pp. 114–124.

[14]   H.F. Linskens, J.F. Jackson, 1997a Modern Methods of Plant Analysis, Vol. 19: Plant Volatile Analysis, Springer, Germany.

[15]   L. Pizarro and E. Park, Lipase Catalyzed Production of Biodiesel Fuel from Vegetable Oils Contained in Waste Activated Bleaching Earth. Process Biochem. 8 (2003): 1077-1082.

[16]   C. İlkılıç, S. Aydın, R. Behçet, and H. Aydın, Biodiesel from safflower oil and its application in a diesel engine. Fuel Processing Technology, 92(3), 291-716.

[17]   H. Bayraktar, Experimental and theoretical investigation of using gasolineeethanol blends in spark-ignition engines. Renew energy 2005;30(11): 1733e47.

[18]   Celik M. B. Experimental determination of suitable ethanol-gasoline blend rate at high compression ratio for gasoline engine. APPLIED THERMAL ENGINEERING, cilt.28, ss.396-404, 2008

[19]   Uyumaz, A., Solmaz, H., Boz, F., Yılmaz, E., Polat, S. (2017). Reaktif kontrollü sıkıştırma ile ateşlemeli (RCCI) bir motorda lamdanın yanma karakteristiklerine etkileri. Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, 17(3), 1146-1156.

[20]   K. H.C. Baser, (2016). Pharmacological Effects of Essential Oils and Their Constituents from Plants of Kazakhstan' And 'Research İnto Aromatic Plants of Northern Cyprus'.

[21]   Naber, JD, Siebers, DL. (1998) Hydrogen combustion under diesel engine conditions, Int. J Hydrogen Energy; 23(5):363–71.

[22]   J. Ghojel and D. Honnery, Heat release model for the combustion of diesel oil emulsions in di diesel engines, Applied Thermal Engineering, 25(14–15):2072– 2085, 2005.

[23]   Anonim, European pharmacopoeia, Council of Europe, Strasbourg, 1387, 2000.

[24]   M. Al-Hasan, Effect of ethanoleunleaded gasoline blends on engine performance and exhaust emission. Energy Convers Manag 2003;44(9):1547e61.

[25]   R. O. B. Wıjesekera, The Medicinal Plant Industry, Crc Press Llc, A. B. D., 1991.

[26]   J.A. Dutton, Alternative Fuels from Biomass Sources egee 439.e. Education İnstitute.

[27]   A. Beytekin, Demir Klorür (Feci3) Katkili Biyodizel - Dizel Yakit Karişimlarinin Bir Dizel Motorda Kullanimi, Otomotiv Mühendisliği Anabilim Dalı, Yüksek Lisans Tezi, Batman Üniversitesi, 2019.

[28]   Anonim, Bitkisel Atık Yağların Yönetimi, T.C. Çevre ve Orman Bakanlığı Çevre Yönetimi Genel Müdürlüğü, Ankara, 2010.

[29]   E. Alptekin ve M. Çanakçı, Biyodizel ve Türkiye'deki Durumu Mühendis ve Makina, 47:561, 57-64, 2006.

[30]   D. M. Haagenson and D. P. Wiesenborn, Impact of the North Dakota Growing Location on

Canola Biodiesel Quality, Journal of American Oil Chemists Society, 88, 1439-1445, 2011.

[31]   S. B. Lee, K. H. Han, J. D. Lee and I. K. Hong, "Optimum process and energy density analysis of canola oil biodiesel synthesis" Journal of Industrial and Engineering Chemistry, 16, 1006–1010, 2010.

[32]   D.M. Haagenson, R. L. Brudvik, H. Lin and D. P. Wiesenborn, "Implementing an in Situ Alkaline Transesterification Method for Canola Biodiesel Quality Screening" Journal of American Oil Chemists Society, 87, 1351-1358, 2010.

[33]   I. M. Mujtaba, Batch Distillation Design and Operation, Series on Chemical Engineering, Vol. 3, Imperial College Press, London, 2004.

[34]   M. Tanker and N. Tanker, Uçucu Yaglar, Farmakognozi Cilt 2, Ankara Üniversitesi.

[35]   B.B. Thapa, Extraction of Essential Oil, National Workshop On Chemical Investigation and Processing of Aromatic Plants, Nepal, 71-81 (1989).