ISSN:1306-3111
e-Journal of New World Sciences Academy
2007, Volume: 2, Number: 1
Article Number: A0016

NATURAL AND APPLIED SCIENCES
ENGLISH (Abstract: TURKISH)
NWSA Received: October 2006
NWSA Accepted: January 2007

Hasan Bayındır
University of Dicle
hbayindir@dicle.edu.tr
Batman-Turkey

PERFORMANCE EVALUATION OF A DIESEL ENGINE FUELED WITH COTTON OIL-KEROSENE BLENDS

ABSTRACT

In this study, cotton oil blended with kerosene at various rates. The mixtures were tested in a four stroke, one cylinder and air cooled diesel engine. Engine performance was observed and diesel fuel (D2) was used as a basis for comparison. The effect of using different blended cotton oil-kerosene (COK) on engine power, torque, brake specific fuel consumption and brake specific energy consumption were studied. Experimental results indicated that engine power, torque and brake specific fuel consumption was slightly differ from D2 usage. However, using COK fuel for so long in unmodified diesel engine can partly cause injection system faults and carbon soot problems.

Keywords: Cotton Oil, Kerosene, Biodiesel, Alternative Fuels, Engine Performance.

PAMUK YAĞI-GAZ YAĞI KARIŞIMI KULLANILAN BİR DİZEL MOTORUNUN PERFORMANS DEĞERLENDİRMESİ

ÖZET

Bu çalışmada, pamuk yağı değişik oranlarda gaz yağına katılarak hazırlanan yakıt karışımı(COK), 4 zamanlı, tek silindirli hava soğutmalı bir dizel motorunda test edilmiştir. Değişik oranlarda hazırlanan karışımlar kullanılarak motor gücü, motor momenti, özgül yakıt tüketimi ve özgül enerji tüketimi parametreleri tespit edilmiş ve dizel yakıtı ile karşılaştırılmıştır. Deneysel sonuçlar motor gücü, motor momenti ve özgül yakıt tüketimi gibi parametrelerin dizel yakıtına göre çok az farklı olduğunu göstermiştir.

Anahtar kelimeler: Pamuk Yağı, Gaz Yağı, Alternatife Yakıt, Motor Performansı.

1. INTRODUCTION (GİRİŞ)

Many scientific researches have indicated that petroleum reserves in the world will completely be used up in several decades. Therefore, this reality drive scientist to research on alternative fuels. Vegetable oil is one of the most attractive alternative fuels to be studied [1 and 2].

Some scientific experiments indicated that using vegetable oil in diesel engine has many negative effects like stickiness, plugging injectors [3 and 4]. When fuel is not sufficiently pulverized into cylinder, thermal efficiency decreases, lubrication oils solidifies and piston and piston rings stuck together [5 and 6].

Especially when vegetable oils are used in diesel engines as fuel, it negatively effects on engine performance and maximum cylinder pressure. These negative effects are because of high viscosity of vegetable oils [7 and 8].

Different techniques have been developed to produce biodiesel from vegetable oils, and the quality of a biodiesel depends on the vegetable oil and the production process [9, 10, 11, 12, 13, and 14]. Kerosene can as a thinner be added into diesel fuel to reduce viscosity and can be used especially in colder climate [15 and 16].

As can be seen in Table.1, when kerosene is blended with cotton oil, the viscosity of blend reduces, because kerosene has both lower viscosity and higher heating values. Another purpose of using kerosene was because of its dependability on process.

Table 1. Physical specifications of fuels that were tested in this work (TÜPRAŞ/BATMAN).
(Tablo 1. Çalışmada test edilen yakıtların fiziksel özellikleri (TÜPRAŞ/BATMAN))

Fuel	Heating value KJ/Kg	Density g/cm³	Viscosity (C.S) 27°C	Cetane number	Freezing point °C	Ignition point °C
D2	42900	0,820	4,3	47	-12	58
Kerosene	43500	0,780	1,4	<40	-	39
Cotton-oil	38350	0,912	50	48,1	-10	210
COK25	42213	0,813	3,75	<40	-28	56
COK30	41956	0,820	4,3	40	-27	56
COK35	41698	0,825	4,8	41	-26	56

Table 2.Chemical specifications of D2, kerosene and cotton oil(17)
(Tablo 2. Dizel yakıtı, gaz yağı ve pamuk yağının kimyasal özellikleri)

Fuels	Chemical Formula	%Composition			
		C	H	S	O
D2	$C_{16}H_{34}$ - $C_{18}H_{38}$	86,3	12,8	0,9	-
Kerosene	$C_{10}H_{22}$ - $C_{16}H_{34}$	86,3	13,6	0,08	-
Cotton oil	$C_{55}H_{102}O_{6}$	76,9	11,9	-	11,2

Viscosity is one of the most important fuel properties. The effects of viscosity can be seen in the quality of atomization and combustion as well as engine wearing.

The higher viscosity of biodiesel fuel compared to diesel makes it an excellent lubricity additive [18 and 19]. On the other hand, the high viscosities of biodiesel fuels are reportedly responsible for premature injector fouling leading to poorer atomization [19].

When viscosity is higher, decomposing of fuel molecules gets harder. Therefore, larger particles are existed. Large particles can penetrate deepen. Fuels that of lower viscosity can cause to leaking problems in oil pump [21]. During pulverization of vegetable oil in combustion chamber, large particles of the fuel make combustion process difficult. Therefore, combustion process could not be completed. As a result unburned Hydrocarbon (UHC) emission and exhaust gasses temperature slightly increase [20 and 21].

Increase on combustion efficiency has a major effect on engine performance and on exhaust emissions. It is resulted from that in internal combustion engines the heat energy is converted to mechanical energy [22].

The physical and combustion properties of vegetable oils are close to those of petro-Diesel fuel, and in this context, vegetable oils can stand as an immediate candidate to substitute for stored fuels. Vegetable oils are produced from processing the seeds of various plants and, thus, are renewable in nature. Sustainable development of a country depends on the extent that it is managing and generating its own resources [23].

The use of Cotton oil-kerosene blends as fuel is an important alternative strategy for gradually replacing hydrocarbon fuels for a renewable and sustainable source in a view of a future expected petroleum depletion.

2. EXPERIMENTAL PROCEDURE (DENEYSEL ÇALIŞMA)

Experiments were conducted on a four stroke, air cooled, one cylinder diesel engine (type Lamborghini). The engine specifications are shown in Table 3.

Table 3. Technical specifications of test engine
(Tablo 3. Deney motorunun teknik özellikleri)

Lamborghini 6LD 400	
Four stroke and direct injection	
One cylinder	
Dimension x stroke	86x68 mm^2
Cylinder volume	395 cm^3
Compression ratio	18:1
Max. torque (2200 rpm)	19,5 Nm
Injection pressure	200 bar

Before experiments, the engine’s maximum torque was observed by 2200 rpm and torque of engine was 20 Nm. Tests were carried out with throttle opening position of 1/4, 2/4, 3/4 and 4/4.

Engine power, maximum torque, fuel consumption, brake specific fuel consumption and exhaust gasses temperature of test engine were studied using different blended fuels under various throttle valve openings.

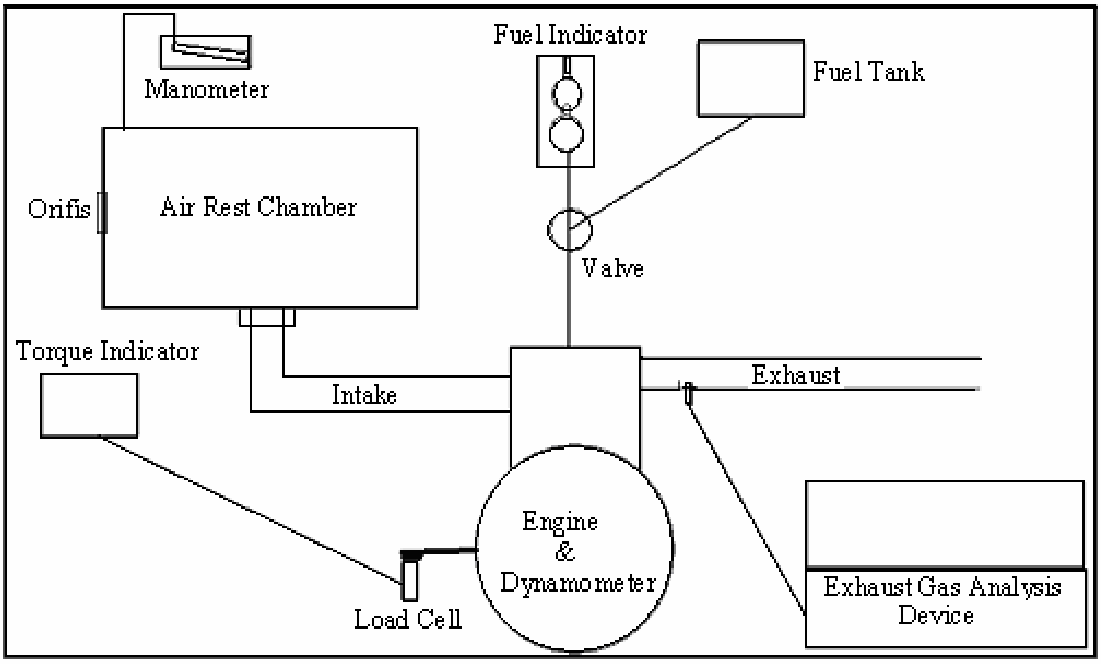

Figure 1. Schematic diagram of experimental setup
(Şekil 1. Deney tesisatının şematik görünümü)

A Cussons type standard engine test equipment consists of an electrical dynamometer, measurement instruments was used in the experiments. The dynamometer is a DC machine rated at 24.1 NM, 4750 rpm. Robic SC-700 model chronometer was used with an accuracy of 0.01 s for time measurement. Exhaust emissions were determined by MRU/3 CD type emission analyzer. Before the experiments the emission analyzer was calibrated. The schematic view of the test equipments is shown in Fig.1.

The engine was started and allowed to warm up to 80 °C. The required engine load was obtained through a dynamometer control. Before start the engine to testify a new fuel blend, it was allowed to run for sufficient time to consume the remaining fuel from the previous experiment. Each experiment was carried out at 78-80 °C engine oil temperature.

Fuel blends that were used in experiments were at the following proportions by volume: 25% Cotton oil and 75% Kerosene (COK25), 30% Cotton oil and 70% Kerosene (COK30), and 35% Cotton oil and 65% Kerosene (COK35). Each of blends, including D2 was conducted over the same range of engine loads and engine speed.

3. FINDING AND RESULTS (SONUÇLAR VE BULGULAR)

3.1 Engine Power, Torque Output and Fuel Consumption (Motor Gücü, Motor Momenti ve Yakıt Tüketimi)

Engine performance can be defined with following parameters;

Power:

$$P= [\ \eta_f\ m_a\ N\ Q_{HV}\ (F/A)\ ]\ /\ n_R \quad (1)$$

Torque:

$$T= [\ \eta_f\ \eta_v\ V_d\ Q_{HV}\ \rho\,(F/A)\ ]\ /\ 4\Pi \quad (2)$$

As can be seen in Fig. 2 the engine speed was fixed at 2200 rpm. For a fixed engine speed a higher throttle opening can cause more fuel to burn and can provide more energy input. Therefore, engine power was increased with the increase of the throttle valve opening. Fig. 2 also indicates that fuel consumption was found slightly higher by using COK25, COK30 and COK35 fuels in comparison to D2.

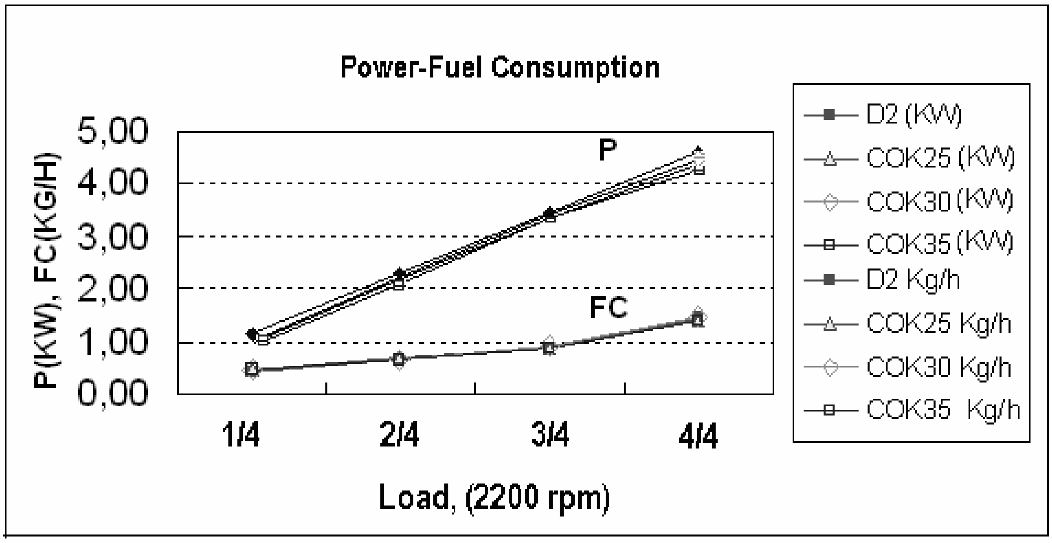

Figure 2.The engine power of test engine using different blended fuels under various throttle opening positions
(Şekil 2. Gaz kelebeğinin değişken konumlarında motor gücünün karışım durumuna bağlı değişimi)

Fuel consumption of the test engine was found lower when COK25 was used compared to COK30 and COK35 respectively.

3.2 Brake Specific Fuel Consumption(Özgül Yakıt Tüketimi)

From the experimental results, we can calculate the brake specific fuel consumption (bsfc), to understand the variation of fuel consumption in the test engine using different Cotton Oil- Kerosene blends. The bsfc (g/kJ) is defined as the ratio of the rate of fuel consumption (g/sec) and the power (kW). Brake specific fuel consumption can be defined with following equation;

$$bsfc(g/kwh) = \dot{m}_f(g/h)/P(kw) \quad (3)$$

The fuel viscosity has a great effect on brake specific fuel consumption. When the fuel viscosity was increased brake specific fuel consumption was increased proportionally.

Fig.3 indicates the brake specific fuel consumption of the engine using different blended fuels in comparison to D2.

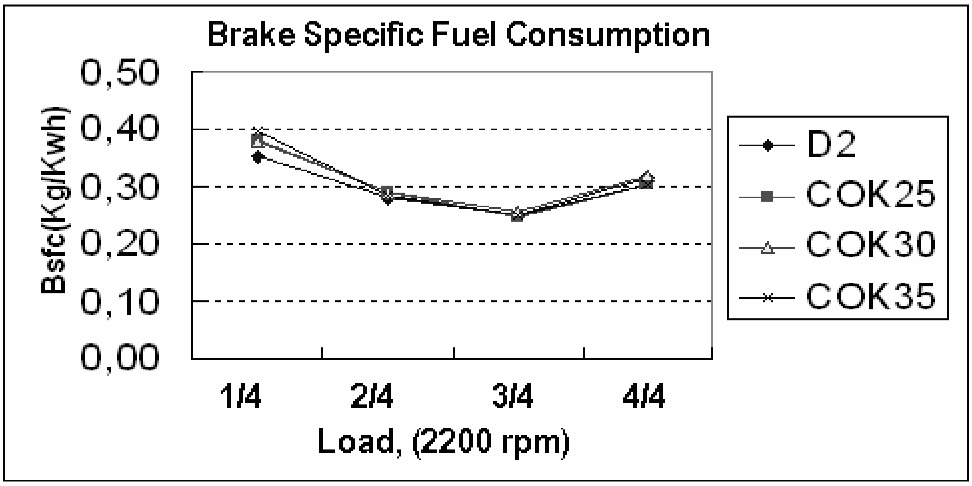

Figure 3.The variation of the bsfc for different blended fuels under fixed to 2200 rpm engine speed and various throttle opening position.
(Şekil.3 Değişik gaz kelebeği konumlarında, 2200 d/d sabit motor devrinde özgül yakıt tüketiminin karışımlara göre değişimi)

Brake specific fuel consumption of the engine was observed highest for 1/4 throttle opening position and was observed lowest for 3/4 throttle opening position for all of different blended fuels as well as D2. It is because of that the power is lowest at 1/4 throttle position and the friction is highest at 4/4 throttle position. All values obtained from using different blended fuels were similar to D2 using.

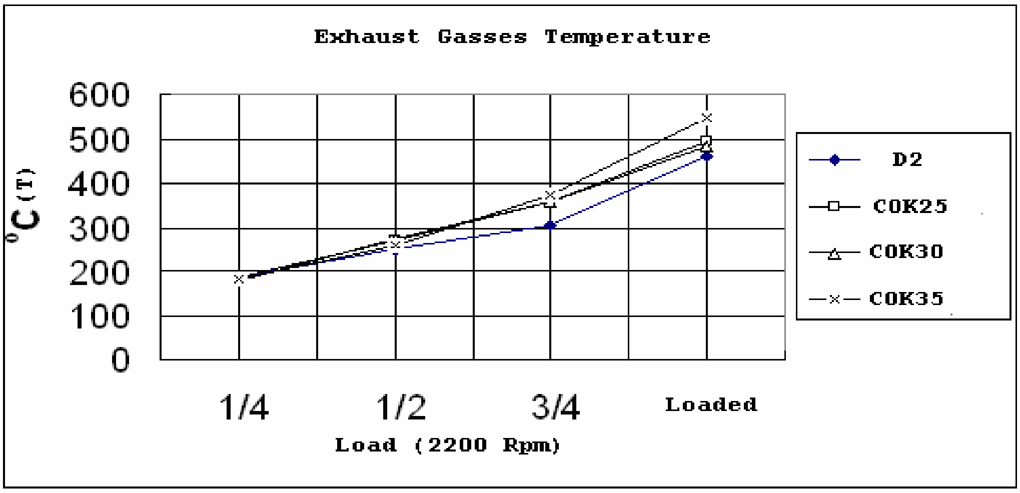

Figure 4.Variation of the Exhaust gasses temperature of the engine using different blended fuel in comparison to D2.
(Şekil 4. Değişken karışım durumlarında deney motorunun egzoz gazlarının sıcaklığının dizel yakıtına göre farklı yük durumlarındaki değişimi)

Fig.4 indicates the exhaust gasses temperature of the engine using different blended fuels in comparison to D2. When engine load was increased, exhaust gasses temperature was increased. The more combustion is incomplete in combustion chamber the higher exhaust gas temperature is. This attribute that when cotton oil rate is increased the combustion is remaining incomplete and exhausts gasses temperature increases.

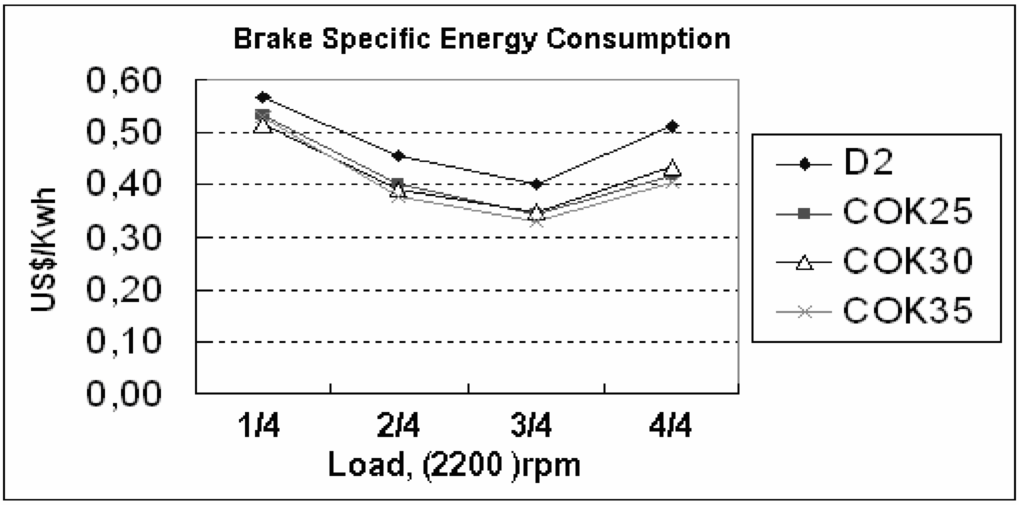

Figure 5. The variation of the brake specific energy consumption for different blended fuels with 2200 rpm fixed engine speed and various throttles opening position.
(Şekil 5. Değişik gaz kelebeği konumlarında, 2200 d/d sabit motor devrinde özgül enerji tüketiminin karışımlara göre değişimi)

Figure 5 indicates the variations of brake specific energy consumption and throttle opening position of engine. When diesel fuel costs in Turkey is considered, specific energy cost can be observed lower on average by 15% for using COK blends in comparison to diesel fuel usage.

4. CONCLUSIONS (SONUÇLAR)

The test result indicates that due to the quite comparable costs, availability and the real advantages in terms of performance efficiency, up to 25% COK can be regarded as candidates to be put on stream for full scale usage in Diesel engines. When D2 was used in same engine, torque as well as power was found higher in comparison to COK fuels.

During tests, exhaust emissions values obtained from COK's were lower than D2. However, for long time use of cotton oil, injection system was badly affected and carbon soot was existed. Therefore, negative values were observed. When both fuel conversion efficiency and process costs are considered together, the advantage of refining method comes to light.

- The decomposing handicap was not observed.
- The problem of starting the motor was not faced with using any kind of blends.
- Because of the lower heating values of the COK35, brake specific fuel consumption of blend was just a little bit more in comparison to D2.
- Because of the low freezing point of the COK25 (-28°C), it can be used in diesel engine in cold climate successfully.
- When COK25, COK30 and COK35 were used at from 3/4 to 4/4 throttle opening positions, brake specific fuel consumption of test engine was observed lower than D2. This indicates that each blend has its own combustion specification and tendency.

Not only does using COK as a fuel help reduce Turkish dependence on foreign oil, but because COK is produced from cotton grown in the Turkey, it can also help stabilize oil and fuel prices. As a result, COK can be regarded as a future alternative fuel for internal combustion engines. It can be recommended that this new fuel should be studied more.

NOMENCLATURE (BİLİMSEL ADLANDIRMA)

D2 : Diesel fuel (No: 2)
COK : Cotton oil–kerosene blend
COK25 : 25% cotton oil-75% kerosene blend
COK30 : 30% cotton oil-70% kerosene blend
COK35 : 35% cotton oil-65% kerosene blend
F/A : Fuel-air ratio
N : Crankshaft rational speed
P : Power (kW)
RPM : Revolution per minute
T : Torque (Nm)
η_f : Fuel conversion efficiency
m_a : Air mass (kg)
n_R : Number of crank revolutions per power stroke
Q_{HV} : Fuel heating value (kJ/kg)
η_v : Volumetric efficiency
V_d : Displaced cylinder volume (cm^3)
bsfc : Brake specific fuel consumption (g/kWh)
bsec : Brake specific energy consumption (US$-kWh)
$\dot{m}_f$: Fuel mass flow rate (g/h)

REFERENCES (KAYNAKLAR)

1. Strayer, R.C., Blake, J.A., Craig W.K., (1983). Canola and high erucic rapeseed oil as substitutes for diesel fuel. Preliminary Test. JAOCS. Vol:60, Num: 8.
2. William, A. and Ani, F., (1990). The use of palm oil as alternative diesel fuel. IMcehE, MEP, London.
3. Ziejewski, M., and Kaufman, K.R., (1983). Laboratory endurance test of sunflower oil blends in a diesel engine. JAOCS, Vol:60, Num:8.
4. Engler, C.R., Johnson, L.A., Lepori, W.A., and Yarbrough, C.M., (1983). Effect of processing and chemical characteristics of plant oils on performance of an indirect-injection diesel engine. JAOCS, Vol:60, No:8.
5. Clarc, S.J., Wagner, L., Schrock, M.D., and Piennaar, P.G., (1984). Methyl and ethyl soyabean esters as renewable fuels for diesel engines. JAOCS, Vol:61 No:10.
6. Pryde, E.H., (1983). Vegetable oil as diesel fuels. JAOCS, vol:60 no:8.
7. Jankowski, A., Seczyk J., Reksa, M., and Sitnik, L., (1984). Rape seed oil methyl ester fuel as alternative diesel fuels for high speed diesel engines. JAOCS, Vol:1 No:10.
8. Pryde, E.H., (1983). Vegetable oil as fuel alternatives-Symposium Overview JOACS, Vol:61, No:10.
9. Agarwal, A,K., and Das, L.M., (2001). Biodiesel development and characterization for use as a fuel in compression ignition engines. J Eng Gas Turbine Power Trans ASME 123, pp:440–447.
10. Ma, F., and Hanna, M.F., (1999). Biodiesel production: a review. Bioresource Technol Vol:70, pp:1–15
11. Karaosmanoglu, F., (1999). Vegetable oil fuels: a review. Energy Source. Vol:21, pp:221–231.
12. Demirbaş, A., (2003). Biodiesel fuels from vegetable oils via catalytic and non-catalytic supercritical alcohol transesterifications and other methods: a survey. Energ Convers Manage. Vol:44, pp:2093–2109.

13. Demirbas, A., (2002). Biodiesel from vegetable oils via transesterification in supercritical methanol. Energ Convers Manage. Vol:43, pp:2349–2356.
14. Ozaktaş, T., Cigizoglu, K., B. and Karaosmanoglu, F., (1997). Alternative diesel fuel study on four different types of vegetable oils of Turkish origin, Energ Source. Vol:19, (2), pp:173–181.
15. Bradin, D.S., (1995). Biodiesel fuel. United States Patent Vol:5, Num:578-090.
16. Jonson, L.A., Hammond E, (1996). Soybean oil ester fuel blends United States , Patent Num:5, pp:520-708.
17. Altin, R., (1998). Experimental research for using vegetable oils in diesel engines. Gazi University Graduate School of Natural and Applied Sciences Department of Mechanical Education. PhD Thesis. Ankara, Turkey.
18. Graboski, M.S., (1998). McCormick. Prog Energy Combust. Sci. Vol:24, pp:125–164.
19. Schumacher, L.G., Van Gerpen, J., and Adams, B.T, (2003). An ASAE Meeting Presentation pp: 36-36.
20. Heywood, J.B., (1998). Internal combustion engine fundamental. Mc Graw-Hill Book Comp. New York.
21. Police, G., Prati, M. V., Auriemma M., and Alfuso, S., (1993). Regulated emissions of di diesel engines fuelled with methyl ester rape seed oil. IMcehE, MEP, London.
22. Bayındır, H., (1998). The effects of ethanol gasoline blends on engine characteristics and air pollution in gasoline engines. Firat University Graduate School of Natural and Applied Sciences Department of Mechanical Education. PhD Thesis. Elazig, Turkey.
23. Amba, G., Prasad, R.P., and Rama, M., (2003). Effect of supercharging on the performance of a DI Diesel engine with cotton seed oil. Energy conversion and management. Vol:44, Num:6, pp:937-944.