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Research Article

Investigation of the Potentials of Oilseed Crops used as a First-Generation Feedstocks in the Production of Environmental Friendly Fuel Biodiesel in Terms of Sector

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Abstract

Our agricultural system is struggling to respond to increasing demands for food and renewable energy. We need to bring our local biofuel feedstocks production to the fore by using energy diversification, whose raw material is based on agriculture. The total area reserved for oilseed production in Turkey is still deficient, 4% of the entire arable land. First-generation oilseed crops are mainly used in biodiesel production in the world and our country. The number of licensed biodiesel production companies that cannot operate regularly due to lack of raw materials is rapidly decreasing. Potential biodiesel volumes were calculated for sunflower, cottonseed, rapeseed, and safflower, determined as the oilseed crops with the highest share in production in our country. Biodiesel volume was found insufficient for rapeseed and safflower crops. The total potential biodiesel volume of sunflower and cottonseed was calculated as 593 338 554 liters. For the continuity of companies in the biodiesel production sector, cultivation using alternative oil plants is of great importance.

Key words: Biodiesel volume, oilseed crop, energy

Çevre Dostu Yakıt Biyodizel Üretiminde Birinci Nesil Hammadde Kaynağı Olarak Kullanılan Yağlı Tohum Bitkilerinin Potansiyellerinin Sektörel Açıdan İncelenmesi

Öz

Tarım sistemimiz, artan gıda ve yenilenebilir enerji taleplerine yanıt vermekte zorlanmaktadır. Hammaddesi tarıma dayalı olan enerji çeşitlendirmesine gidilerek yerel biyoyakıt hammadde kaynaklarımızı ön plana çıkarmamız gereklidir. Türkiye'de yağlı tohum üretimi için ayrılan toplam alan, tüm ekilebilir arazinin %4'ü kadardır ve yetersizdir. Biyodizel üretiminde dünyada ve ülkemizde ağırlıklı olarak birinci nesil yağlı tohum bitkileri hammadde olarak kullanılmaktadır. Ülkemizde özellikle hammadde eksikliği nedeniyle yıl boyunca sürekli faaliyet gösteremeyen lisanslı biyodizel üretim şirketlerinin sayısı hızla azalmaktadır. Ülkemizde üretimde en yüksek paya sahip yağlı tohum bitkileri olarak belirlenen ayçiçeği, pamuk tohumu, kolza ve aspir için potansiyel biyodizel hacimleri hesaplanmıştır. Biyodizel hacmi kolza ve aspir bitkileri için yetersiz bulunmuştur. Ayçiçeği ve pamuk tohumlarının toplam potansiyel biyodizel hacmi 593 338 554 litre olarak hesaplanmıştır. Biyodizel üretim sektöründeki firmaların faaliyetlerinin devamlılığı için alternatif yağ bitkilerini kullanarak yapılacak yetiştiricilik büyük önem taşımaktadır.

Anahtar kelimeler: Biyodizel hacmi, yağlı tohum bitkileri, enerji

Giriş

In our world, where the need for energy is increasing day by day, the importance of renewable energy sources is increasing at that rate. The use of renewable energy sources is indispensable in order to ensure energy supply and security in our country. Biomass energy has an important place among these resources. Biomass is defined as all non-fossil organic matter of biological origin, which can be regenerated in less than 100 years, including plants growing on land and water, animal wastes, food industry, forest by-

products, and urban waste. Since the basis of biomass energy is based on the photosynthesis of plants, biomass energy can also be expressed as the energy of organic substances in which solar energy is stored as chemical energy (Altın et al., 2001). Biomass energy sources; Since they are generally heterogeneous, contain high water and oxygen, have low density and calorific value, fuel quality is adversely affected by these qualities. These negative qualities of biomass are eliminated through various physical and transformation processes (Agarwal, 2007).

Biofuels are produced from biomass through physical processes such as size reduction, pelletizing, briquetting, grinding, filtration and extraction, and biochemical and thermochemical conversion processes. Vegetable and animal oils are the raw materials of biodiesel production, an important place among biofuels. Plants with oil content exceeding 15% are called oil crops. These are canola, sunflower, safflower, soybean, cottonseed, poppy, flax, and peanut, produced by field cultivation and oil from their seeds (Altın et al., 2001; Kıllı and Beycioğlu, 2019). Considering the need for vegetable oil to be used in the food and energy sector for the future, taking into account the population of Turkey, which exceeds 82 million with an increase of 1.5%, the importance of oilseed production becomes evident (Kadakoğlu ve Karlı, 2019). Biofuels can be produced domestically, which could lead to lower fossil fuel imports (Huang et al., 2013). First generation biofuels are made from sugar crops, starch crops, oil seed crops, and animal fats. Sugar and starch crops are converted through a fermentation process to form bioalcohols(ethanol, butanol, and propanol). Oils and animal fats can be processed into biodiesel. Second generation biofuels are made from cellulose, which is available from non-food crops and waste biomass. Third generation biofuels use algae as a feedstock. First-generation biofuel feedstocks include many crops that would otherwise be used for human consumption directly, or indirectly as animal feed. Diverting these crops to biofuels may lead to more land area devoted to agriculture, increased use of polluting inputs, and higher food prices. Cellulosic feedstocks can also compete for resources (land, water, fertilizer, etc.) that could otherwise be devoted to food production. As a result, some research suggests that biofuel production may give rise to several undesirable developments (Akınerdem ve Öztürk, 2014; Karaosmanoğlu, 2019).

Oilseed cultivation areas in the world increased by 176% in 2017 and reached 256.5 million hectares. Soybean, 13.5% canola, 12.9% cotton seed, 10.9% peanut, 10.3% sunflower, 3% of the total oilseed cultivation areas. It consists of 9% sesame and 0.3% safflower (Kadakoğlu and Karlı, 2019). The total agricultural area planted in Turkey in 2017 is 23 million 819 thousand hectares, 6% of which consists of oil seeds. Oilseed production was carried out in an area of 1 million 427 thousand hectares in 2017 (TUIK, 2019). Only sunflower and cotton seed cultivation areas make up 89.8% of the total oilseed cultivation areas. 50.8% of this belongs to sunflower. In this period, sunflower cultivation areas increased 7.9 times. Production of oilseed crops in our country is insufficient and cannot meet the needs of the food industry. Therefore, the import of oilseeds and their derivatives has been increasing over the years.

In accordance with the regulation that entered into force in January 1, 2018 by the Energy Market Regulatory Board (EPDK) in our country, it has become mandatory to blend 0.5% biodiesel into diesel fuel. In other words, as of the beginning of 2018, 0.5% of our total diesel consumption for one year, that is, approximately 125 000 tons of biodiesel, needs to be produced and blended. Biodiesel production in our country is met from domestic agricultural products and used waste oil. While our oilseed production cannot meet the needs of the food sector, obtaining the required amount of oil for energy production brings the food sector and the energy sector face to face. In order for the biodiesel production sector to work continuously and to provide the necessary oil raw materials for diesel fuel, it is necessary to switch to alternative oilseed plants in our agricultural system and to use our idle lands for energy plant production.

Significant financial incentives for biofuel production are given in almost all countries in the world. In some countries, direct subsidies are made per hectare for biofuel production, while in some countries, biofuels are excluded from taxation or taxed at lower rates. Countries make it compulsory to sell a certain amount of biofuel to fuel companies with the laws they have enacted, and they increase the required mixing ratios every year. Public incentives to the biofuel sector; It employs in agriculture, industry, and transportation sectors make a significant contribution to the foreign trade balance by reducing oil dependence, provides new taxation opportunities by opening new production facilities, increases environmentally friendly production opportunities, and increases farmer incomes by opening unused agricultural areas to agriculture. (Çelebi and Uğur, 2015).

In this study, the potentials of oilseed crops, which are the source of feedstoks for the biodiesel production sector, which cannot work continuously throughout the whole year, mainly due to raw material constraints, were investigated in our country.

Material and Methods

Materials

This study investigated sunflower, cotton, rapeseed, and safflower as the oilseed crop with the largest cultivation area in Turkey's biodiesel production sector. Data were taken from the public, online sources. Food and Agriculture Organization (FAO) of the United Nations Statistics Division (FAOSTAT) was used as the source. Biodiesel volumes of all feedstocks are calculated based on export statistics from FAOSTAT 2021.

Biodiesel Production Companies in Turkey

With the Council of Ministers Decision dated 25 February 2011 and numbered 27857 published in the Official Gazette on Biodiesel Production in Turkey, a special consumption tax application was introduced for auto biodiesel and fuel biodiesel. The biodiesel sector loses its competitiveness because raw materials constitute the most significant part of biodiesel production costs and costs increase with taxes. In our country, 80 enterprises have obtained biodiesel processing licenses since 2005, and by 2018, 25 of these licenses were terminated, and 43 of them were canceled. In 2018, only 14 business licenses were in effect. Although the total product processing capacity of the enterprises is around 1.5 million tons, together with the enterprises whose assignments are not canceled or terminated, the enterprises are mainly idle. Although many companies with official processing and distribution licenses in previous years were biodiesel processing companies, five companies are seen in the Biomass Energy Potential Atlas (BEPA), revealing Turkey's biomass energy potential in January 2020. If new regulations are not made, and the obstacles that caused their closure are not overcome, new facilities can't be operational soon.

First-Generation Biodiesel Feedstocks of the Turkey

Figure 1 shows the types and usage rates of oil raw materials used in the biodiesel sector in our country in 2018. As a result of this research, 30% of the raw materials used consisted of waste vegetable oils and 70% of the oil obtained from cottonseed oil and other vegetable oil seeds, with the largest share of 35 000 tons.

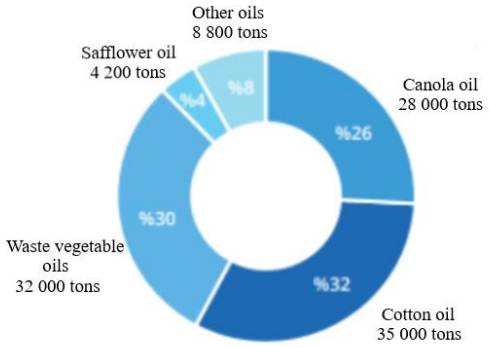

Figure 1. Feedstock sources are commonly used in biodiesel production in Turkey (Biyodizel Endüstri Raporu 1, 2019)

Potential Biodiesel Volume Calculations of Feedstocks

The potential biodiesel volume (PBV) for sunflower, cotton seed, rapeseed, and safflower feedstocks were calculated using the following equation.

$$PBV = LV \times CR \quad (1)$$

$$LV = \frac{EQ \times 1000}{OD} \quad (2)$$

where LV is the lipid volume of biodiesel feedstocks in our country, and CR (0.98) is the volumetric conversion ratio from oil to biodiesel (Chong et al., 2021; Johnston and Holloway, 2007). EQ is the export quantity of feedstock, and OD is the oil density. A minimum threshold value of 10 000 tons has been set for the export quantity. Any export quantity of vegetable oils lower than the threshold is considered inadequate for potential biodiesel production. The threshold value is based on a generic biodiesel plant with a capacity of 10 million liters per annum (Chong et al., 2021; USDA, 2017). The export quantity which reaches the threshold value is used in the calculation of the potential biodiesel production.

Results and Discussion

Sunflower, cotton seed, rapeseed, and safflower places as the first-generation feedstocks sources in biodiesel production sector in our country. Table 1 and Table 2 shows the oil and fuel properties of this feedstocks. Table 3 shows the cultivation areas, yield, and production information of sunflower, cotton seed, rapeseed, and safflower oilseed crops for 2019 according to FAOSTAT 2021 data.

Table 1. Properties of first generation edible vegetable oil feedstock used in biodiesel production in Turkey

Feedstocks	Oil content (wt%)	Oil density (kg/L)	Energy content (Mj/kg)	Reference
Sunflower	30	0.916	39.53	Altın et al. (2001), Karmakar et al. (2010)
Rapeseed	42	0.912	37.62	Altın et al. (2001),Karmakar et al. (2010)
Cotton seed	21.5	0.915	39.65	Agarwal (2007), Altın et al. (2001), Chong et al. (2021)
Safflower	40	0.914	39.50	Singh and Singh (2010), Agarwal (2007)

Table 2. Fuel properties of first-generation biodiesel feedstock in Turkey.

Feedstocks	Fuel density (kg/L)	Cetane number	Kinematic viscosity (mm^2/s)	Oxygen content (wt%)	Reference
Sunflower	0.883	51.90	4.53	10.92	Viola et al. (2011), Sinha et al. (2008), Chong et al. (2021)
Rapeseed	0.882	54.10	4.63	10.87	Giakoumis (2013), Viola et al. (2011), Chong et al. (2021)
Cotton seed	0.879	53.30	4.70	11.13	Giakoumis (2013), Chong et al. (2021)
Safflower	0.884	51.80	4.10	10.90	Giakoumis (2013), Viola et al. (2011), Chong et al. (2021)

Table 3. Production statistics of oilseed crops in 2019 sowing season in Turkey.

	Area harverted (ha)	Yield (kg/ha)	Production (tons)
Sunflower	751 693	27 937	2 100 000
Cotton seed	477 807	46 044	2 200 000
Rapeseed	52 510	34 279	180 000
Safflower	15 860	13 798	21 883

Table 4 shows the change in the export quantity amount of sunflower, cotton seed, rapeseed, and safflower oil in our country in 2019. When the table is examined, when the export quantity of first-generation oilseed feedstocks of our country are concerned, the lowest rate belongs to rapeseed. At the same time, there is no data for safflower.

Table 5 shows the statistical and computational values of the parameters used to calculate the potential biodiesel volume of the sunflower, cotton seed, rapeseed, and safflower feedstock that the Turkey operates in the first place in biodiesel production. Equations 1 and 2 were used in the calculations.

Table 4. Export quantity of oilseed crops in Turkey.

	Export Quantity (tons)
Sunflower	544 593
Cotton seed	9986
Rapeseed	968
Safflower	No data

Table 5. Statistical and computational values of oilseed crops for potential biodiesel volume

Feedstocks	Production Quantity (tons)	EQ (tons)	OD (kg/L)	LV	PBV (L)
Sunflower	2 100 000	544 593	0.916	594 533 842	582 643 166
Cotton seed	2 200 000	9986	0.915	10 913 661	10 695 388
Rapeseed	180 000	968 (< 10 000)	0.912	-	-
Safflower	21 883	No data	0.914	-	-

The export quantity reaching the threshold value is used in the calculation of potential biodiesel production. A minimum threshold value of 10 000 tons has been determined for the export quantity. As shown in Tables 4 and 5, export quantitys for rapeseed and safflower oil are below 10 000 tons. The export quantity of cottonseed oil remained at the total threshold value. Any vegetable oil export quantity below the threshold is considered insufficient for potential biodiesel production. Biodiesel volume was inadequate for safflower and rapeseed, among the top oilseed crops for our country. While the potential biodiesel volume of sunflower was 582 643 166 liters, the potential biodiesel volume of cottonseed was calculated as 10 695 388 liters.

Conclusions

Our biodiesel production, which is included in biofuels, which has particular importance in energy supply security and the environment, is at risk. This study examined whether the production amounts of sunflower, cottonseed, rapeseed, and safflower, the most produced oilseed crops in our country, are sufficient for the biodiesel production sector. In the calculations based on the export quantity of oil obtained from these four essential oilseed crops, the potential biodiesel volume for sunflower and cotton seeds was sufficient. In contrast, the potentials of rapeseed and safflower plants were insufficient for biodiesel production. The total possible biodiesel volume of sunflower and cottonseed plants is 593 338 554 liters. The main reason for the continuous decrease in the number of companies producing biodiesel is the inadequacy of raw material supply. In the short term, it is not possible to supply second and third-generation feedstocks in our country as in the whole world. Therefore, for the continuity of the sector, it is imperative to produce new oil crop varieties that do not threaten the food industry with low water needs and are resistant to dry conditions in these periods when we are also faced with climate change and water stress problems. In our country, it is vital to prioritize the cultivation of energy crops, especially in fallow areas.

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