



DETERMINATION OF BIODIESEL PRODUCTION VOLUME OF SUNFLOWER AS THE MAJOR OILSEED CROP IN TURKEY

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Abstract: Our agricultural system is struggling to respond to increasing demands for food and renewable energy. We need to prioritize our production of local biofuel feedstocks by going through energy diversification, whose raw material is based on agriculture. The need for biofuels, which are among the renewable energy sources in our country, is increasing day by day, especially in terms of energy security and sustainability. Sunflower, cotton, safflower, and rapeseed are among the vegetable oil feedstock sources of biodiesel production, an important place among biofuels in our country. The most abundant source of oil raw material belongs to sunflower. In this year 2019 sowing season in our country, 2 100 000 tons of sunflower were harvested with a yield of 27 937 kg per hectare during the planting works carried out on 751 693 hectares of land. This study aimed to determine the potential biodiesel volume of the sunflower plant according to the data of 2019. As a result of the calculations, this oilseed plant's potential biodiesel production volume in our country has been determined as 582 643 166 liters. For the biodiesel sector to produce uninterruptedly, the production studies of second-generation biodiesel raw materials, which are not used in the food sector, are compatible with the conditions of our country, especially in low water demand, and can be grown quickly in marginal areas.

Keywords: Sunflower, Oil seed crop, Biodiesel volume, Biofuel

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1. Introduction

Global warming and the resulting climate change primarily affect agriculture, livestock and clean water resources. According to the World Energy Council Turkey (2020) report, countries like our country, which do not have rich fossil-based resources and have a large foreign dependency on energy, should focus on the production of local biofuel raw materials by going the way of energy diversification in today's conditions where environmental problems are increasing exponentially day by day. This will also be an important driving force for the country's economy. It is an agricultural country that has signed the United Nations Framework Convention on Climate Change on September 30, 2015, and prepared the Greenhouse Gas Inventory, which is a party to the Kyoto Protocol, aiming to reduce greenhouse gas emissions by 21% until 2030, and carries out the studies of the National Climate Change Action Plan. Environmentally friendly biofuels are indispensable alternatives for Turkey (Aknerdem, 2014; Karaosmanoğlu, 2019).

Different forms of energy are absolutely necessary for the growth and development of countries all over the world. It is possible to say that a country whose energy resources are renewable and easily accessible will have a great development potential in all aspects, both industrial and agricultural. In this context, each country

has entered into an unlimited search for different energy sources. Statistics for 2020 have shown that there is an excessive dependence on fossil fuels to meet energy demands all over the world. Turkey, which is developing and whose energy demand is increasing day by day, meets about 72% of its energy demand from imported sources. In addition, 70% of electrical energy is obtained from fossil fuels that cause environmental pollution (TUIK, 2020).

Biodiesel is an environmentally friendly renewable fuel whose raw material is vegetable or animal oil. Being biodegradable, non-toxic, high cetane number, and having lower pollutant emissions than diesel fuel are its prominent advantages. The most significant cost element in the production of biodiesel fuel belongs to the raw material. Every country should be able to ensure energy security by creating diversity in energy resources. In our country, biodiesel is among the renewable energy sources. The raw material of this fuel is usually waste or vegetable oils. The sustainability of this fuel depends on meeting the oil demand of the biodiesel sector by using local varieties suitable for each country's own geographical and climatic conditions (Altın et al., 2001; Agarwal, 2007; Çanakçı and Şanlı, 2008)

Oilseed cultivation areas in the world increased by 176% in 2017 and reached 256.5 million hectares. Soybean, 13.5% canola, 12.9% cottonseed, 10.9% peanut, 10.3%



sunflower, 3% of the total oilseed cultivation areas. sesame and 0.3% safflower (Kadakoğlu and Karlı, 2019). The main factor threatening the sustainability of biodiesel fuel in the world and in our country is the lack of sufficient oil feedstock. According to Turkish Statistical Institute (TUIK) data, oil crop production in our country in 2020 is 2 620 486 tons. With this production amount, the share of oilseeds in plant production is 3.8%. 3% of this share belongs to sunflower. The remaining 0.8% share belongs to other oilseed plants of our country. While this share was 4.2% in 2019, it decreased by 1.7% in 2020. At these rates, it shows that the oil seeds we produce as an agricultural country cannot even meet the edible oil needs of the food sector and the oil needed by the sector is provided through imports. It is known that almost all of the imported products can be produced in our country with the agricultural potential of Turkey.

Sunflower oil is the most preferred and consumed vegetable oil in our country. (TUIK, 2020). Sunflower has an essential place among oilseed crops due to its high oil content. Two as oil and snack variety is grown. Oilseed sunflower oil, pulp, and biodiesel are used for production purposes. After meeting the needs of the food industry, it is appropriate to use the remaining oil for biodiesel production. The oil raw material source, which is the most abundant and suitable for easy cultivation for each country, will also be the first choice feedstock in terms of biodiesel production. Sunflower crops for oil production in Turkey are mainly produced in Thrace Region and Konya. As of 2018, Tekirdağ (22.8%), Edirne (14.7%), Kırklareli (11.6%), and Konya (11.2%) constitute 60% of the oil sunflower cultivation area (Killı and Beycioğlu, 2019).

With the Energy Market Regulatory Board (EPDK) decision, as of January 1, 2018, blending biodiesel at a rate of 0.5% in diesel fuel has become mandatory in our country. In other words, it is obligatory to add 1 liter of biodiesel to every 200 liters of diesel fuel. Biodiesel from domestic agricultural products and waste oils must be added to diesel fuel. This application is aimed to reduce

foreign dependency on energy, increase resource diversity, reduce environmental pollution and adapt to the renewable energy policies of the European Union. Considering that the biodiesel blended in our country in 2018 was only 110 thousand tons, it can understand that Turkey is at the beginning of the path of harmonization with the European Union legislation. As of 2017, although Turkey has 23 million 375 thousand hectares of arable land, biodiesel production was 74 thousand tons (Karaosmanoğlu, 2019).

Figure 1 shows the types and usage rates of oil feedstocks 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.

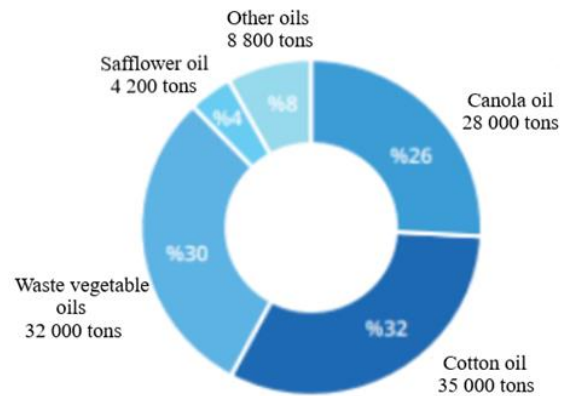


Figure 1. Feedstock sources are commonly used in biodiesel production in Turkey.

Figure 2 shows the most widely used biodiesel feedstock of 84 countries on the world map. Palm is commonly used in 23 countries, rapeseed in 17, sunflower in 14, and the remaining seven feedstocks are widely used in 30 countries (Chong et al., 2021). In the figure, sunflower is shown as the feedstock source used in enormous biodiesel production in our country.

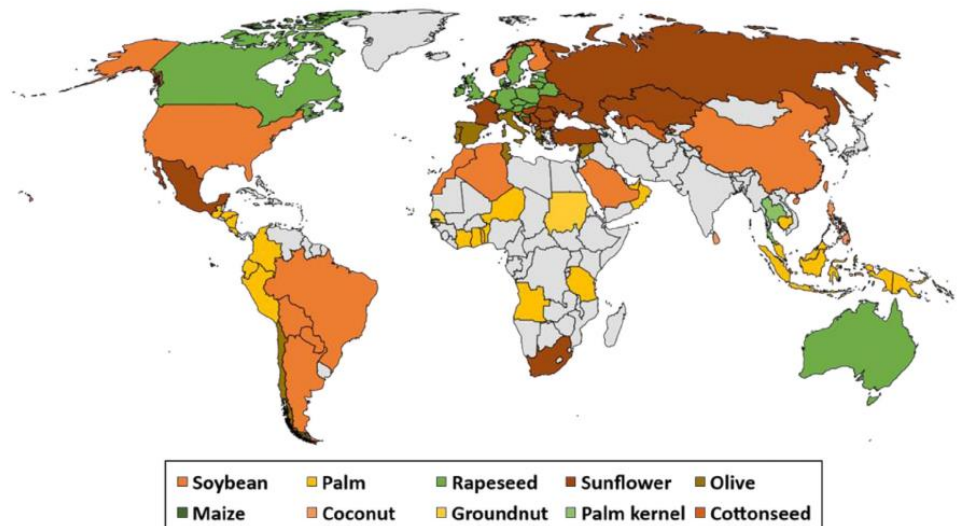


Figure 2. Potential widely used first-generation biodiesel feedstock of every country around the world.

In Table 1, there are sunflower seed sowing areas, production amounts, and yield values in Turkey during the five years between 2014-2019 (TUIK, 2020).

Table 1. Sunflower production values

Years	Seed production (tons)	Cultivation area (ha)	Yield (kg/ha)
2014/15	1 480 000	530 000	2 169
2015/16	1 500 000	569 000	2 640
2016/17	1 500 000	616 780	2 431
2017/18	1 800 000	681 397	2 641
2018/19	1 800 000	648 934	2 773

For the biodiesel industry to operate uninterruptedly every month of the year, there is a need for regular raw material arrivals. In this study, the potential biodiesel volume of the sunflower plant, which has the highest production as a first-generation feedstock source in biodiesel production in our country, was investigated.

2. Materials and Methods

2.1. Materials

In this study, sunflower was used as the oilseed crop with the highest cultivation rate in our country. Data were taken from the public, online sources. Turkish Statistical Institute (TUIK), Food and Agriculture Organization (FAO) of the United Nations Statistics Division (FAOSTAT) were used as the source. All biodiesel volumes are based on processed oils and fats export statistics from FAOSTAT 2017. This study presumes non-exported lipids are required for domestic uses, including food demands.

Table 2. Vegetable oil and fuel properties of sunflower crop

	Sunflower	References
Oil content (wt%)	30	Altın et al. (2001), Chong et al. (2021)
Oil density (kg/L)	0.916	Altın et al. (2001), Karmakar et al. (2010)
Energy content (Mj/kg)	39.53	Chong et al. (2021), Karmakar et al. (2010)
Biodiesel density (kg/L)	0.883	Chong et al. (2021), Viola et al. (2011)
Cetane number	51.90	Sinha et al. (2008), Chong et al. (2021)
Kinematic viscosity (mm ² /s)	4.53	Chong et al. (2021), Viola et al. (2011)
Oxygen content (wt%)	10.92	Viola et al. (2011), Sinha et al. (2008)

In the 2019 planting season, 2 100 000 tons of sunflower seeds were harvested from 751 693 hectares of area with a yield of 27 937 kg per hectare in Turkey (TUIK, 2020). Table 3 shows the change in the export quantity amount of sunflower oil in our country between 2015-2019. The lowest sunflower oil export quantity these years was in 2018 (FAOSTAT, 2021).

2.2. Volume Calculations

The potential biodiesel volume (PBV) for sunflower feedstock was calculated using the following equations 1 and 2.

$$PBV = LV \times CR \tag{1}$$

$$LV = \frac{EQ \times 1000}{OD} \tag{2}$$

Where;

LV is the lipid volume of sunflower seed 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,

OD is the oil density. A minimum value of 10 000 tons has been determined for the export amount. Any vegetable oil export amount below this value is considered insufficient for potential biodiesel production (USDA, 2017).

3. Results and Discussion

Although our country is very productive in terms of agricultural lands, it has enough land to grow the products needed by the food sector and to do energy agriculture. Biofuels play an important role in the security and sustainability of the energy sector. Sunflower, cotton, rapeseed, and safflower take the first four places as the first-generation feedstocks sources in biodiesel production in the Turkey. The oil and fuel properties of sunflower, which is the most preferred first-generation edible vegetable oil feedstock in our country's biodiesel sector, are shown in Table 2.

Table 3. Export quantity of sunflower oil in Turkey

Years	Export Quantity (tons)
2015	617 924
2016	599 663
2017	537 436
2018	416 895
2019	544 593

Table 4 shows the statistical and computational values of the parameters used to calculate the potential biodiesel volume of the sunflower feedstock that the Turkey

operates in the first place in biodiesel production. Equations 1 and 2 were used in the calculations.

Table 4. Statistical and computational values of sunflower feedstock for potential biodiesel volume

Feedstock	Production Quantity (tons)	EQ (tons) (2019)	OD (kg/L)	LV	PBV (L)
Sunflower	2 100 000	544 593	0.916	594 533 842	582 643 166

In biodiesel production, fundamental problems such as the inability to provide a continuous raw material supply throughout the year and food and water stress are encountered. The critical factor in determining the production volume is the export quantity of crude plant oil. For the biodiesel production volume to be considered sufficient, this value should not be below 10 000 tons. In terms of our country, the export quantity of sunflower oil was 544 593 tons in 2019. The biodiesel production volume of the sunflower crop was calculated as 582 643 166 liters for the same year. Although the production volume of biodiesel is sufficient, sunflower oil is mainly used in our country to meet the edible oil needs in the food sector. Therefore, for the sustainability of the biodiesel production sector in our country, it is crucial to produce second-generation biodiesel feedstocks consisting of oils that are not used in the food sector.

4. Conclusion

Oilseed crops to be grown primarily in marginal areas and with the dry farming system will be the energy crops of the near future. In this way, it will prevent water and food stress. The potential biodiesel production volume of sunflower, the most cultivated oilseed plant in our country was determined.

Author Contribution

The idea of researching the article, obtaining the data, calculations, comments, writing, and editing of the article was made by HK.

Conflict of Interest

The author declared that there is no conflict of interest.

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