Chapter 3

An Turkey's Biodiesel Potential and the Economics of Related Agricultural Products

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Abstract

With the rapid increase in the world population and the intensification of industrialization, the need for energy to sustain human life is also increasing day by day. As the use of energy resources has reached a significant level today, environmental pollution, greenhouse gas emissions, and the resulting climate change, along with the limited capacity of raw materials and energy sources, have led people to seek alternative energy sources.

Renewable energy sources are becoming increasingly important due to their low cost, minimal environmental impact, and very low levels of greenhouse gas emissions. These renewable energy sources include solar, wind, geothermal, and biomass energy.

Biomass is an energy source derived from all natural materials of non-fossil origin, including plant- and animal-based matter. The most important characteristics of biomass are its environmental friendliness and sustainability.

Biodiesel is a biomass-derived energy source in liquid form. It is obtained through processing oils derived from oilseed crops as well as used cooking oils.

This study examines the production quantities and cultivation areas of vegetable oils used in biodiesel production, along with the import and export statistics of these products in Turkey. Based on these data, the potential of biodiesel production and its evaluation have been assessed.

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https://doi.org/10.58830/ozgur.pub862.c3486

1. Introduction

As a result of rapid population growth and industrialization worldwide, the demand for energy—an essential input for sustaining human life—is steadily increasing. Since the 1970s, energy consumption across all sectors has become one of the most critical issues globally. Following the oil crises of 1973 and 1979, countries around the world began to show increased interest in energy conservation measures. In the 1980s, attention shifted primarily to environmental pollution caused by the use of fossil fuels.

In recent years, energy consumption, greenhouse gas emissions, and their potential impacts on global climate change have become some of the most widely discussed topics. One of the most effective ways to reduce energy consumption in industry, transportation, commerce, housing, and agriculture is by improving energy efficiency.

Today, the use of energy and other natural resources has reached a significant level in the industrial world. As a result, the availability of natural resources has started to decline on one hand, while environmental degradation, such as pollution, continues to increase on the other. Moreover, technical improvements in energy conversion have not been implemented effectively enough.

In both developed and developing countries, several factors must be considered to determine future levels of energy production and consumption. These include population growth, economic productivity, consumer behavior, and technological advancements. Öztürk, H. H. (2006)

Despite the limited capacities of raw materials and energy resources, the continuous and rapidly increasing demand for both, along with the finite reserves of primary energy sources, compels humanity to seek alternative and non-conventional energy sources. In addition to the limited reserves of primary energy sources, factors such as rising fuel prices, population growth, industrialization, the necessity of utilizing national resources, the negative environmental impacts of conventional fuels, and the issue of climate change make the use of renewable energy sources essential within the scope of new energy technologies. Kapluhan, E. (2014)

Atmospheric carbon dioxide levels have been steadily increasing since the beginning of the Industrial Revolution, and this trend is expected to accelerate further as the global economy continues to grow. Significant climate changes are strongly associated with the rising atmospheric concentrations of certain gases, particularly carbon dioxide. Compared to

fossil fuels, renewable energy technologies generate very low or near-zero greenhouse gas emissions. Çoban, O. R. H. A. N., & Kılınç, N. Ş. (2016)

The importance of renewable energy sources is increasingly growing today as an alternative to fossil-based fuels. The renewable nature of these sources, their lower costs, and the relatively minimal negative environmental impacts associated with their use contribute to the rising demand. Solar energy in particular, along with wind, geothermal, and biomass energy, are among the primary renewable energy sources. Kayişoğlu, B., & Diken, B. (2019).

Plant-based energy sources are solid, liquid, or gaseous fuels of agricultural origin that are commonly found in nature and produced through various physical, chemical, or biological methods. These fuels possess commercial value and standardized fundamental properties. Biomass refers to non-fossil organic matter of biological origin. All natural materials of plant or animal origin, whose main components are carbohydrate compounds, are defined as biomass energy sources, while the energy derived from these sources is referred to as biomass energy.

Among the resources capable of meeting the world's growing energy demand driven by increasing population and industrialization biomass energy stands out as perhaps the most important one due to its environmentally friendly and sustainable nature. Biomass is considered a suitable and significant energy source because it is inexhaustible, can be cultivated almost anywhere, and contributes to the socioeconomic development of especially rural areas. Kapluhan, E. (2014).

Liquid biomass energy sources, also known as biofuels, primarily include biodiesel and bioethanol. These fuels are produced through the transesterification reaction of oils derived from oilseed crops such as rapeseed (canola), sunflower, soybean, safflower, coconut, and hemp, as well as from animal fats and waste cooking oils. In this process, the oils react with a short-chain alcohol in the presence of a catalyst to produce compounds that can be used as fuel. Biodiesel is obtained by using these products either as a direct replacement for fossil-based diesel fuel or by blending them in specific proportions with conventional diesel.

When examining developments in the field of alternative energy sources, the global advancement of biofuels such as biodiesel and bioethanol is particularly noteworthy. Unlike many other energy sources, biofuels do not rely on intermittent resources and are relatively easy to store, which has contributed to their growing popularity in recent years.

According to Yaşar (2008), the fact that biofuels are derived from agricultural products makes the topic even more significant from the perspective of the agricultural sector and producers. Moreover, since biofuels degrade rapidly and easily in nature, they do not pose toxic effects. In addition, during the cultivation of agricultural crops used in their production, carbon dioxide is absorbed through photosynthesis, thus biofuels do not contribute to the greenhouse effect. Akman, S. (2015).

2.MATERIAL AND METHODS

This study was conducted to identify Türkiye's biodiesel production potential and to evaluate the production economics of the main agricultural crops used in biodiesel production, namely sunflower, soybean, rapeseed, and cottonseed. The research material consists of data on the production quantities, cultivation areas, import and export figures of these crops, as well as biodiesel production statistics.

The data used in the study were compiled from annual statistics published by the Turkish Statistical Institute (TURKSTAT) and the Food and Agriculture Organization of the United Nations (FAO). TURKSTAT data provide information on agricultural production quantities, cultivated areas, and foreign trade statistics (import and export volumes) in Türkiye. The data were analyzed on an annual basis covering the period from 2019 to 2023.

The numerical data were organized into tables, and the production and foreign trade trends of agricultural products associated with biodiesel production were evaluated. In addition, changes in Türkiye's biodiesel production over the years were examined through a comparative analysis with European Union countries. Descriptive statistical methods were employed in the analysis of the data.

3.RESULTS

Table 1. Biodiesel production in the world

Year	Biodiesel(TJ)
2012	1.023.107
2013	1.139.626
2014	1.305.543
2015	1.226.872
2016	1.355.608
2017	1.483.283
2018	1.669.668
2019	1.813.034
2020	1.766.038
2021	1.963.657
2022	2.166.833

Source: FAO 2025

Between 2012 and 2022, global biodiesel production has generally shown an upward trend. Although there was a decline in production in 2020 due to the COVID-19 pandemic, production increased again in the following years.

Table 2. Biodiesel production in some EU countries

	Biodiesel (TJ)			
COUNTRY	**2019**	**2020**	**2021**	**2022**
Germany	131.854	115.074	124.310	129.941
France	74.754	72.637	56.607	52.819
Italy	32.085	38.175	45.522	43.095
Spain	73.065	67.909	65.111	64.378
Hungary	6.182	5.336	6.587	6.955
Czech Republic	9.142	9.518	9.008	8.907
Austria	10.969	9.657	11.241	12.684
Poland	35.341	35.064	36.315	36.647
Portugal	14.455	12.292	11.870	11.330

Source: FAO 2025

When we look at biodiesel production in some European Union countries, Germany is the country with the highest biodiesel production. Between 2019 and 2020, there was a decline due to the COVID-19 pandemic, but

it has increased since 2021. When we look at France and Spain, production has gradually decreased over the years, while Italy has seen an increase.

Table 3. Biodiesel production in Turkey

Year	Biodiesel(TJ)
2012	662
2013	810
2014	1.325
2015	2.539
2016	2.318
2017	2.455
2018	4.027
2019	4.453
2020	2.774
2021	2.297
2022	3.749

Source: FAO 2025

When we look at biodiesel production in Turkey, we see an increase between 2012 and 2015. After 2019, there was a decline due to the COVID-19 pandemic, but production increased again in 2022.

Planting Areas and Production Quantities of Products Used in Biodiesel Production in Turkey

	Production (t)				
Crop	2019	2020	2021	2022	2023
Sunflower	2.100.000	2,100,000	2.415.000	2.550.000	2.198.000
Soybean	150,000	155,225	182,000	155,000	137,500
Canola	180,000	121,542	140,000	150,000	120,000
Cotton Seed	1.320.000	1.064.189	1.350.000	1.650.000	1.260.000

Source: TUIK2025

When we look at the production quantities of products used for biodiesel production in Turkey, sunflower is the most preferred product in biodiesel production. Rapeseed is the most common raw material used in biodiesel production in Europe and has potential in Türkiye, but it is not in the race since its production is low. When we look at the table, there was a decrease in production in 2020 due to the covid 19 pandemic. Although there was an increase in production in 2021-2022, there is a decrease again in 2023.

	Area Harvested (ha)				
Crop	2019	2020	2021	2022	2023
Sunflower	752,632	728,854	901,154	980,974	952606
Soybean	35,295	35,135	43,893	38009	32,685
Canola	52.515	34989	37602	41146	32291
Cotton Seed	477868	359,22	432,279	573,161	477,438

Source:TUIK 2025

When we look at the planting areas, there is a decrease in 2020, an increase in 2021-2022 and a decrease again in 2023. This explains the change in production amounts.

Import and Export Quantities of Products Used in Biodiesel Production in Turkey

	Export quantity (t)				
Crop	2019	2020	2021	2022	2023
Sunflower	1,939,887	2,024,944	2.764,529	3,402,238	3,671,152
Soybean	39,263	61,442	135,711	71,228	69,817
Canola	6,82	37,852	39,479	66,4	38,722
Cotton Seed	80,006	84,412	53,798	61,548	68,809

Source: TUIK 2025

Sunflower showed a steady increase from 2019 to 2023. Soybean experienced a decline in 2001, rapeseed began to decline after 2022, and cotton fluctuated between 2019 and 2023 but then increased.

	Import quantity (t)				
Crop	2019	2020	2021	2022	2023
Sunflower	3,301,301	3,135,431	4,406,760	5,830,020	4,592,650
Soybean	3,038,957	2,745,415	2,949,273	2,888,084	3,252,299
Canola	15,975	25,807	19,753	227,203	38,322
Cotton Seed	22,784	44.710	39,911	33,094	57,092

Source: TUIK 2025

Sunflower has shown a continuous increase between 2019 and 2022. In 2022, imports increased to 5,830,000 tons, which shows that Türkiye is both an importer and an exporter of sunflower. However, being an importer is much more important. Soybeans have shown a continuous increase, although there are fluctuations in imports. Imports and exports are balanced in cotton.

4. Conclusions

Turkey's biodiesel production has shown significant development over the past decade. Production increased from 662 TJ in 2012 to 3,749 TJ in 2022. However, compared to European Union countries, this growth remains limited. Foreign trade data indicate a substantial dependence of Turkey on imports for biodiesel raw materials. Import volumes of sunflower and soybean considerably exceed exports, which adversely affects the sustainability of biodiesel production.

Based on these data, in order for Turkey to fully realize its biodiesel potential, it is necessary to:

- Increase domestic raw material production,
- Align agricultural policies with biodiesel production,
- Develop strategies to reduce foreign dependency.

Biodiesel production not only contributes to energy supply security but also supports rural development by providing an additional income source for the agricultural sector. Therefore, the biodiesel sector should be regarded as both a strategic and economic opportunity for Turkey

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