PROCEEDINGS BOOK OF 9. EUROPEAN SUNFLOWER BIOTECHNOLOGY CONFERENCE SUNBIO 2025

19-21 NOVEMBER, 2025

Megasaray Westbeach Hotel, Antalya, Turkey

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Organized by

Trakya University
International Researchers Association
International Sunflower Association

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WELCOME NOTES

You are welcome to our 9th European Sunflower Biotechnology Conference which is organized by International Researchers Association and the in cooperation with Trakya University and International Sunflower Association. The conference will be held in Megasaray Westbeach Hotel, Antalya, Turkey, on November 19-21, 2025 with the support of several national and international partners with normal as well as with online participation. The program will include oral talks by invited prominent scientists and oral and e poster presentations by participants in selected topics. The Conference is intended that the subjects to be kept broad in order to provide opportunity to the science and research community to present their works as oral or poster presentations in a friendly environment of Antalya, Turkey to share their knowledge and experience and benefit from each other.

The 9th conference will gather scientists from around the world, and present their recent achievements. The attendees will have ample opportunities for learning, reconnecting, engaging and networking with colleagues from academia and industry as well as meeting with various exhibitors.

As there have been many different scientific meetings around the world, we aimed to bring three different communities together, namely science, research and private investment groups considering practical information sharing that is of value for researchers and scientists from around the world, in a friendly environment of Antalya, Turkey to share their knowledge and experience and benefit from each other as well as prospects to overcome the limitation for sustainable crop production to feed the world.

There are 40 papers contributed by about 150 authors from 14 different countries from the world. 12 oral and 20 poster presentations existed in the conference program both joining and presenting normal and online presentations by 87 normal and 3 online as total by 90 participants.

With care for our nature and environment, we aim the green conference, meaning that as little as possible papers will be used. Abstract book is published in electronic book and is distributed to the participants by e mail for online participants. All the e-posters are prepared in electronic form and then submit to via the conference e mail and exhibited in electronical poster boards as well as in online e poster hall in our web page during the conference.

The Conference topics will cover on sunflower:

Plant Breeding and Genetics, Molecular Genetics and Biotechnology, Biology and Physiology, Genetic Resources, Plant Protection, Agronomy, Economy, Trade, Quality, etc.

We would like to thank all of you for joining this conference and we would like to give also special thanks to our sponsors and collaborators for giving us a big support to organize this event.

Prof Dr Yalcin KAYA
Head of the Organizing Committee

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CONTENTS

SUNFLOWER SEED BASED FAT REPLACERS (FR) : THE BIOTECHNOLOGICAL SUSTAINABLE ASSESMENT OF FR MANUFACTURING STRATEGIES ON FOOD QUALITY APPLICATIONS

Özlem TOKUŞOĞLU[1,2]

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ABSTRACT

Sunflower meal is the most important by-product of sunflower oil production, accounting for 36% of the processed mass of sunflower seeds and the agronomical quality of crop gives the efficiency to the meal product. The protein content of sunflower seeds is approximately 20%, while the protein content of sunflower meal ranges from 30% to 50%. Fat replacers are food additives that provide the benefits of fat to zero-calorie or low-calorie foods. They perform the functions of fat, imparting a soft texture, pleasant mouthfeel, and flavor to foods. Different types of baked goods use different types of fat replacers. Carbohydrate-based fat replacers have been reported to bind water, adding volume, moisture, and a pleasant mouthfeel. FRs are utilized to reduce trans-fat and total fat content while maintaining consumer acceptance. A variety of fat replacers have been explored for use in baked goods, including complex polysaccharides, gums and gels such as cookies, cakes, and crackers can contain high levels of trans fats as whole food matrix structures, and combinations thereof. The application of SUN based FR to popular and frequently consumed gelled/emulsified meat products such as frankfurters is particularly interesting due the obtained technological and nutritional properties of SUN may improve the formulation of these products, resulting in healthier meat products.

Keywords; Sunflower Seed, Fat Replacer, Biotechnology, Agronomical Quality, Food Quality

INTRODUCTION

Regarding Sunflower Seed

Sunflower seed is the fourth most important oil crop worldwide, after palm oil, soybean oil and rapeseed oil. Sunflower meal is the most important by-product of sunflower oil production, accounting for 36% of the processed mass of sunflower seeds and the agronomical quality of crop gives the efficiency to the meal product. The protein content of sunflower seeds is approximately 20%, while the protein content of sunflower meal ranges from 30% to 50%. Moreover to protein, sunflower meal contains other valuable nutrient constituents as vitamins, minerals, and polyphenols. Because of this, sunflower meal is not only mainly utilized as animal feed but also used the potential human consumption agent owing to it has good water holding capacity.

Sunflower meal has been biotechnological upgraded to a versatile food-grade defatted sunflower meal (SUN) with a variety of potential food and beverage applications. Phenolic acids (PA), especially quinic acid derivatives of caffeic acid or ferulic acid, have previously been considered the most important phenolic compounds in sunflower seeds and especially in sunflower meal otherwise Pas as hydroxybenzoic acid, vanillic acid, sinapinic acid, quinolactones of caffeic acid, 1,2-diesinaroylgentiobiose, and hydroxyphenylpropionic acid 3,4-dihydroxyphenyl-2-oxopropionic acid. The applied biotechnological manufacturing SUN based fat replacer (FR) has been reported to increase total phenolic content, antioxidant capacity, and improve the nutritional profile.

Fats are a general term for oils and fats widely found in animal and plant bodies, mainly divided into vegetable oils (liquid at room temperature) and fats (solid at room temperature). They are an important source of nutrition and energy for the human body and a crucial component of food (German, 2011). Fats are a primary raw material in modern food processing and play a vital role in food quality. For example, fats not only dissolve flavor compounds, thereby improving the taste and aroma of food, but also give food a smooth texture, a glossy appearance, and a unique shape (Omayma & Youssef, 2007).

Fat Replacer Functions

Fat replarcers reduce calorie intake by partially or completely replacing the fat content in foods, and their properties are similar to those of fat (Anand et al., 2022; Saeed et al., 2023). Furthermore, these fat substitutes perform multiple functions in foods, such as improving texture, stabilizing, emulsifying, gelling, and thickening (Anand et al., 2022; O'Connor, 2016). They also help prevent the negative effects of excessive fat intake. Despite the rapid development of various types of fat substitutes, such as protein-based, carbohydrate-based, and lipid-based fat substitutes, significant quality losses still exist. These include technological differences (texture, water retention, hardness, oxidative stability, cooking loss, etc.) and sensory characteristics (texture, taste, odor, color, viscosity, juiciness, overall acceptability, etc.) (Bourouis, Pang & Liu, 2023), all of which reduce consumer acceptance of fat substitutes. For example, reducing the fat content in solid foods leads to increased elasticity and crispness of the solid network, resulting in increased food hardness and elasticity, as well as reduced melting capacity. Similarly, reducing the fat content in ice cream results in problems such as ice crystals, coarse texture, brittleness, and shrinkage in the final product.

The fat replacers market is forecast to expand from USD 2.9 billion in 2025 to USD 5.3 billion by 2035 at a 6.2% CAGR over the assessment period Figure 1 shows fat replacer market analysis as 2025-2035 (Figure 1.).

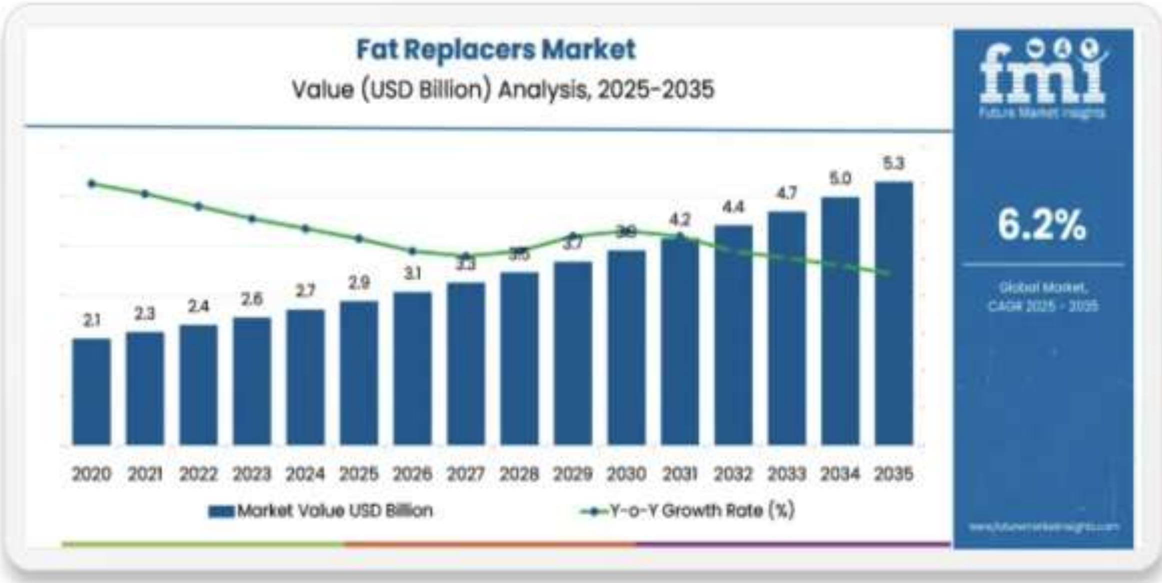


Figure 1. Fat Replacer Market Analysis as 2025-2035.

Removing fat from cheese leads to a hardened texture, loss of flavor, bitterness, reduced solubility, and poor color (Zhao, Khalesi, He & Fang, 2023). Therefore, developing environmentally friendly and healthy fat alternatives that do not impair food texture, sensory experience, and flavor has become an important research direction. This article outlines the classification and mechanisms of action of fat alternatives, as well as methods for assessing consumer perception and conducting sensory testing of fat alternatives. Its aim is to lay a theoretical foundation for the research and industrial development of novel low-fat, high-nutrient foods.

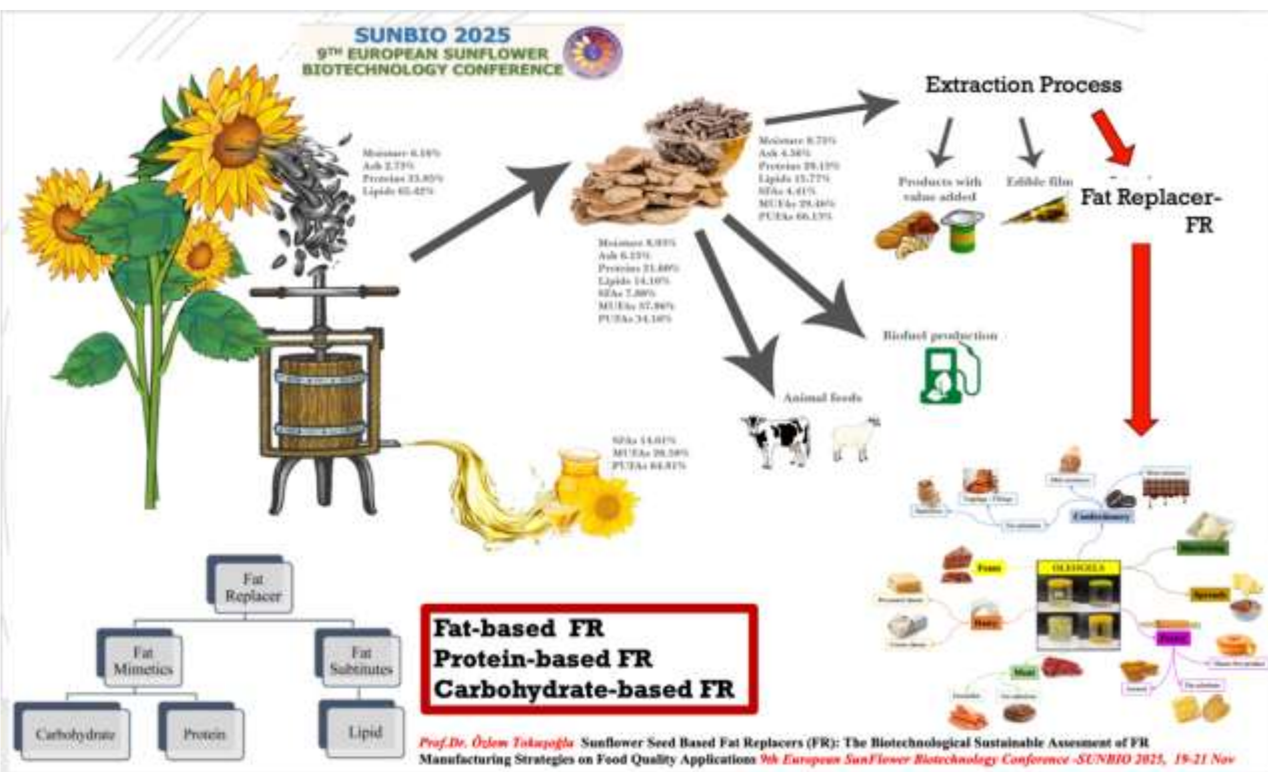
Lipid Based / Carbohydrate-Based Fat Replacers and Composite Fat Replacers

Lipid-based fat substitutes are produced through fatty acid esterification reactions, such as chemical synthesis, oil derivatives, and oil modification. They possess physicochemical properties similar to natural fats and can impart specific flavor and texture characteristics to foods. Theoretically, lipid-based fat substitutes can replace fats 1:1, but in practice, they are not equivalent. Vegetable oils, due to their rich nutritional components, including unsaturated fatty acids, fat-soluble components, and polyphenols, are considered ideal substitutes for saturated fatty acids in food processing (Espert et.al., 2023; Monteiro et.al.,2017). Lipid-based fat substitutes are produced through fatty acid esterification reactions, such as chemical synthesis, oil derivatives, and oil modification. They possess physicochemical properties similar to natural fats and can impart specific flavor and texture characteristics to foods. Vegetable oils, due to their rich nutritional components, including unsaturated fatty acids, fat-soluble components, and polyphenols, are considered ideal substitutes for saturated fatty acids in food processing (Espert et.al., 2023; Monteiro et.al.,2017). Carbohydrate-based fat replacers and their application to food products.The search for appropriate fat replacers for use in high-calorie foods is essential due to the negative health implications of consuming high amount. Among several carbohydrate-based alternatives, starch has gained significant attention due to the availability, affordability, and common application as a stabilizer, thickener, and gelling agent (Heydari and Razavi, 2021). The main mechanism of replacement by stabilizing water into a gel-like matrix, which provides the product cream-like characteristics and flows comparable with fat (Zhang et al., 2018).Composite fat replacers means that here is no single fat replacer that fully process all the characteristics of natural fat. Therefore, to simulate more characteristics like fat and achieve a fat replacer that closely resembles full fat, many studies have combined similar or diverse types of fat replacers based on the optimal formula. Several studies have shown that polymer particles or microparticles formed by proteins and polysaccharides through covalent bonds or electrostatic interactions can mimic fat droplets similar tothose found in milk, cream, and other foods.

SUNFLOWER BASED FOOD REPLACERS

The sunflower (Helianthus annuus L.) belongs to the Asteraceae family and is an annual crop. It is the world's third-largest oilseed crop, fourth-largest vegetable oil crop, and third-largest oilseed meal crop, and is also an important source of protein. The sunflower is a globally important oilseed, food, and ornamental crop, with its seeds accounting for approximately 10% of the world's edible vegetable oil supply

Oil seed-based fat replacers are suitable sustainable alternatives of conventional shortenings. Sunflower seed powder (SSP) was found to be loaded with fats, proteins, fiber and ash contents. High contents of phenolics, flavonoids, and antioxidant activity were observed in SSP extracts. Increment in nutritional and phytochemical profiles of cookies was observed that were developed using SSP as fat replacer (Figure 2.).



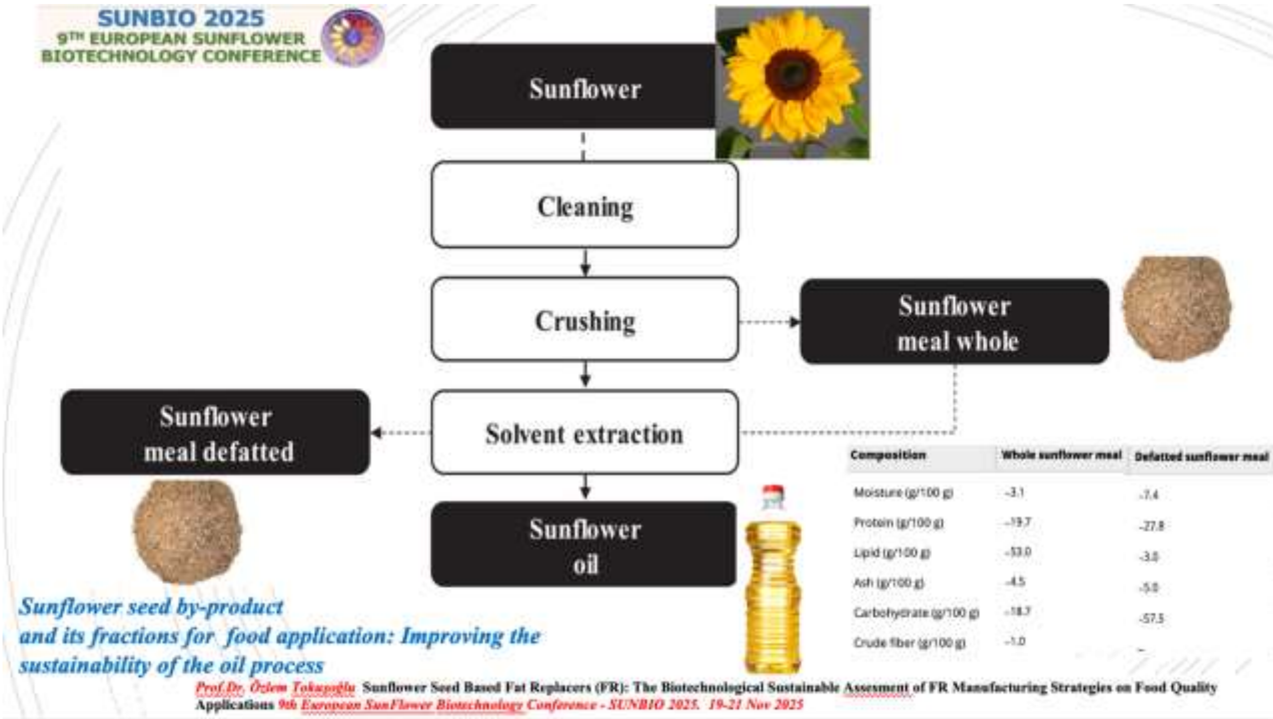


Figure 2. Sunflower-Based Fat Replacer Manufacturing Flow

The applied biotechnological manufacturing SUN based fat replacer (FR) has been reported to increase total phenolic content, antioxidant capacity, and improve the nutritional profile.

A variety of fat replacers have been explored for use in baked goods, including complex polysaccharides, gums and gels such as cookies, cakes, and crackers can contain high levels of trans fats as whole food matrix structures, and combinations thereof.

The application of SUN based FR to popular and frequently consumed gelled/emulsified meat products such as frankfurters is particularly interesting due the obtained technological and nutritional properties of SUN may improve the formulation of these products, resulting in healthier meat products (Figure 3.).

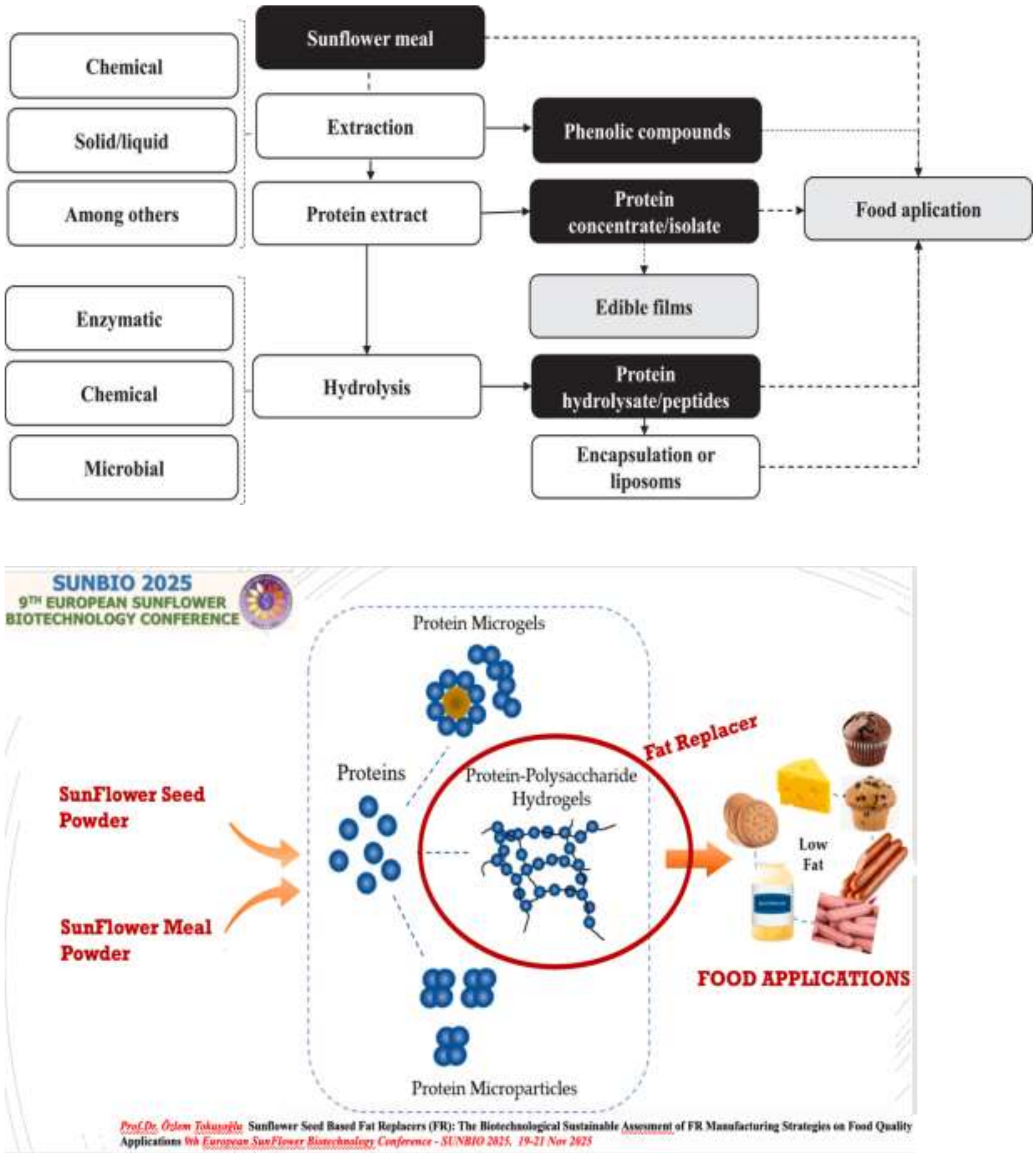


Figure 3. Detailed Manufacturing Flow of Sunflower-Based Fat Replacers (Above Figure) and Sunflower Seed and Sunflower Meal Powder Utilization as Fat Replacers for Food Applications (Below Figure).

Bakery Products / Sausages and Sunflower Based Fat Replacers

Baked goods such as cookies, cakes, and crackers may contain high levels of trans fats. However, there is a growing demand for healthy snack alternatives with low trans fat content. Trans fats pose serious health risks, particularly in industrially produced shortening and baked goods, and are strongly linked to cardiovascular disease. The main reason for replacing shortening in baked goods is its high content of trans and saturated fatty acids, which are associated with a range of health problems. In addition, some shortenings undergo transesterification, a process that has no nutritional value and may itself pose health risks. Using fat substitutes can reduce trans fat and total fat content while maintaining consumer satisfaction. A variety of fat substitutes for baked goods have been explored, including complex polysaccharides, gels and gels, whole food matrix structures, and combinations thereof. Each fat substitute has specific properties that affect the quality of the food (Figure 4.).

Dry fermented sausages sausages are a popular traditional meat product in many countries. They have a long shelf life and can be stored without refrigeration. However, in addition to being high in sodium, they are also high in fat, and their fatty acid composition is mainly derived from animal products. Therefore, from a health perspective, excessive consumption is not recommended (Figure 4.).

Bread	Increased protein content (17.2%–377.6%) and trypsin inhibitors (82–140 TIU/g)
Chapatis, biscuits, and pakodis	Increased protein (22.7%–55.9%, 40.3%–99.1%, and 14.6–35.8, respectively), lipid (20.9%–54.9%, 3.8%–20.9%, and 4.6%–25.4%, respectively), and fiber contents (157.6%–439.2%, 203.3–951.6, and 201.4%–415.1%, respectively)
Biscuits	Increased protein content (35.3%–50.0%), phenolic compounds (−42.8 and 85.7%), antioxidant capacity (−166.7% and 350.0%) and hardness (22.6–30.0%)
Muffins	Increased protein (19.4%–37.3%) and ash contents (23.9%–47.0%), product height, pore density, and dark color Decreased carbohydrate content (1.7%–4.8%) and elasticity (1.0%–4.7%)
Sausage	Increased protein (6.1%–12.1%), and mineral (mainly magnesium (67.2%–135.4%), potassium (26.8%–37.3%), copper (133.3%–250%) and manganese (200.0%–383.3%), contents, phenolic compounds (49.0%–82.3%), and hardness (4.3%–23.7%) Decreased lipid content (37.1%–37.9%)

Figure 4. After Sunflower Based Fat Replacer Applications, Some Baked Goods and Sausage Foods Profile.

CASE STUDY ON SUNFLOWER

CASE STUDY : SUNFLOWER SEED FLOWER AS A FAT REPLACER IN COOKIES

Development of Sunflower Seed Powder (SSP)

For the development of SSP, first of all sunflower seeds were cleaned to separate out any foreign materials, then the seeds of uniform, color, shape and size, which were free from any defects were selected for drying in a hot air oven.

Powder of sunflower seeds was obtained through conventional hot-air drying method, at 60 °C for 24 h. in a hot air oven (TS–2266). When the seeds attained a uniform moisture level, the grinding of dried seeds was performed using a laboratory scale spice grinder (PS-110, Panasonic, Japan), until fine powder was prepared.

These seeds were powdered, having a particle size of 30 µm, and packed in airtight bags to avoid moisture regain.

Preparation of Cookies

Already adopted method for the development of cookies, was modified slightly to develop the cookies, in which shortenings were replaced with SSP at various levels. The process of cookie development involved the mixing of shortening and eggs to a creamy consistency. Then wheat flour, baking powder, SSP and salt were slowly introduced to the mixture and kneading was done till elastic and smooth batter obtained. Then batter was rolled out, shaped into cookie, baked at 180 °C for 10–12 min, allowed to cool, and packed in zip bags for further analysis (Figure 5.).

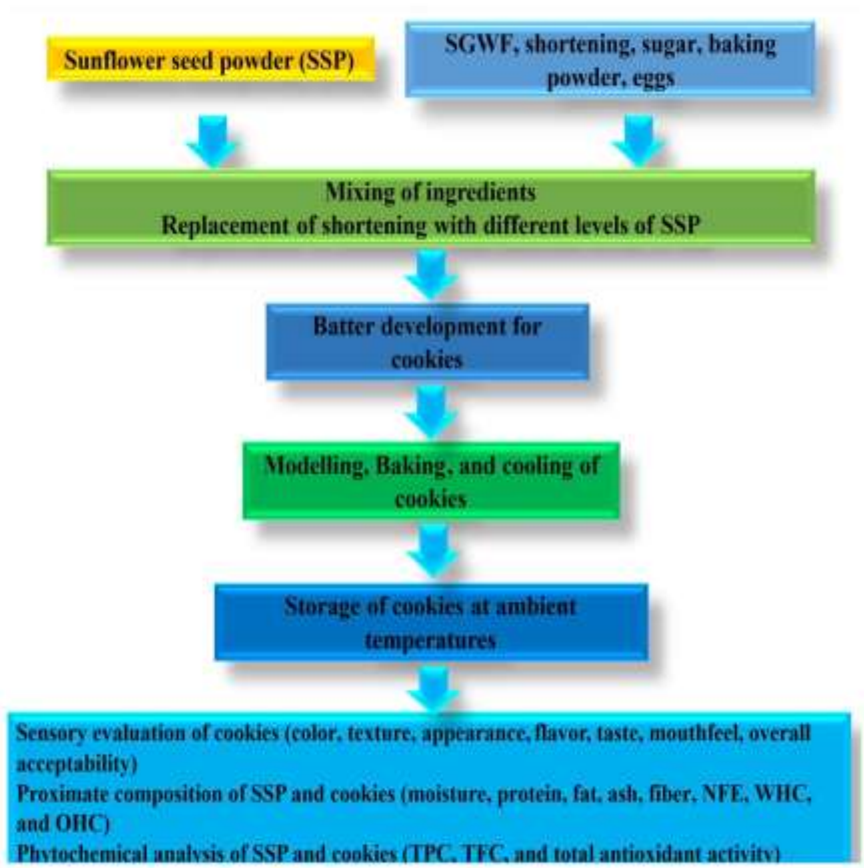


Figure 5. Fortification Flow Diagram for Sunflower Seed Powder Application

Proximate Analyses of SSP and Developed Cookies

The moisture, fat, ash, crude protein, crude fat, and crude fiber contents of the SSP and the prepared biscuits were determined according to the AACC standard procedure with necessary modifications. The nitrogen-free extract (NFE) was calculated using the following formula. All analyses were performed in triplicate, and the average value was calculated.

$$NFE(\%) = 100 - (moisture\% + ash\% + crudeprotein\% + crudefibre\% + Crudefat\%)$$

Development of Extracts

Adopted methods were adjusted for the creation of SSP extracts. In a nutshell, 10 g of each powdered sample was soaked in 100 mL of 80% ethanol for 1 h. while being stirred in an orbital shaker at room temperature. After that, the suspension was run through Whatman No. 1 filter paper. The final solutions produced were kept as a stock solution in a freezer at −80 °C until they were used to calculate the total phenolic and flavonoid content and antioxidant activity.

T0: Shortening 100%, SSP 0%, **T1:** Shortening 90%, SSP 10%, **T2:** Shortening 80%, SSP 20%, **T3:** Shortening 70%, SSP 30%, **T4:** Shortening 60%, SSP 40% proportions were studied. Determination of total phenolic contents (TPC) of SSP and developed cookies, determination of total flavonoid contents (TFC) of SSP and developed cookies, determination of total antioxidant activity (TAA) of SSP and developed cookies, physical analysis of the cookies, sensory evaluation of the cookies were carried out.

CONCLUSION

In this study, SSP was used as fat replacer at various levels for preparation of cookies, successfully without affecting physical and sensory properties. The chemical and bioactive analysis of SSP showed that it is a good source of protein, ash, fat, fiber, TPC, TFC, and TAA. Analysis of the formulated cookies showed that the protein, ash, and fiber content of the cookies significantly ($p < 0.05$) rose when SSP was used as a substitute of shortenings in the cookie production process, as did the antioxidant capacity, TPC, and TFC of the cookies. SSP successfully worked as fat replacer and reduced the fat content in the cookies without adversely affecting the sensory score of the product.

It was concluded from this research work that cookies with better chemical composition, TPC, TFC, and TAA can be prepared without compromising organoleptic quality, by relacing commercial shortening with up to 40% SSP. However, in future research more elevated levels of SSP as a fat replacer could be tested to develop cookies and other bakery products, to check the effects on the physicochemical, textural, bioactive, and antioxidant properties.

Oil seed-based fat replacers are suitable sustainable alternatives of conventional shortenings. Sunflower seed powder (SSP) was found to be loaded with fats, proteins, fiber and ash contents. High contents of phenolics, flavonoids, and antioxidant activity were observed in SSP extracts. Increment in nutritional and phytochemical profiles of cookies was observed that were developed using SSP as fat replacer. Cookies fat replaced by 40% SSP, did not deteriorated the organoleptic quality of cookie.

REFERENCES

Anand A., Kaushal M., Vaidya D., Gupta A., Saini H.K., Ruchi Sharma C.T., Shukla, R. A. T. (2022). Simulated and low-fat foods: A review. The Pharma Innovation Journal, 11(2), 2170–2175.

Bourouis I., Pang Z., & Liu X. (2023). Recent advances on uses of protein and/or polysaccharide as fat replacers: Textural and tribological perspectives: A review. Journal of Agriculture and Food Research, 11. https://doi.org/10.1016/j. jafr.2023.100519

Espert M., Wang Q., Sanz T., & Salvador A. (2023). Sunflower oil-based Oleogel as fat replacer in croissants: Textural and sensory characterisation. Food and Bioprocess Technology, 16(9), 1943–1952. https://doi.org/10.1007/s11947-023-03029-w

German J.B. (2011). Dietary lipids from an evolutionary perspective: Sources, structures and functions. Maternal & Child Nutrition, 7, 2–16. https://doi.org/10.1111/j.1740-8709.2011.00300.x

Heydari A., & Razavi S.M.A. (2021). Evaluating high pressure-treated corn and waxy corn starches as novel fat replacers in model low-fat O/W emulsions: A physical and rheological study. International Journal of Biological Macromolecules, 184, 393–404. https://doi.org/10.1016/j.ijbiomac.2021.06.052

Monteiro G.M., Souza X.R., Costa D.P.B., Faria P.B., & Vicente J. (2017). Partial substitution of pork fat with canola oil in Toscana sausage. Innovative Food Science & Emerging Technologies, 44, 2–8. https://doi.org/10.1016/j.ifset.2017.07.013

O'Connor, T. P. (2016). Reference module in food science. In, 1-5. Reference module in food science. https://doi.org/10.1016/B978-0-08-100596-5.00648-X

Omayma, E., & Youssef, M. M. (2007). Fat replacers and their applications in food products: A review. Alexandria Journal of Food Science and Technology, 4(1), 29–44. https://doi.org/10.21608/ajfs.2007.19631

Saeed S.M.G., Ali S.A., Naz J., Mirza M., Elkhadragy M.F., Yehia H.M., & Giuffre A.M. (2023). Techno-functional, antioxidants, microstructural, and sensory characteristics of biscuits as affected by fat replacer using roasted and germinated chickpea (Cicer arietinum L.). International Journal of Food Properties, 26(1), 2055–2077. https://doi.org/10.1080/10942912.2023.2242602

Zhang M., Sun C., Li Q. (2018). Interaction between the polysaccharides and proteins in semisolid food systems. Encycl. Food Chem. https://doi.org/10.1016/B978-0-12-814026-0.21474-1.

Zhao Y., Khalesi H., He J., & Fang Y. (2023). Application of different hydrocolloids as fat replacer in low-fat dairy products: Ice cream, yogurt and cheese. Food Hydrocolloids, 138. https://doi.org/10.1016/j.foodhyd.2023.108493.

REVIEW OF THE NUTRITIONAL AND HEALTH BENEFITS OF SUNFLOWER SEEDS

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is a species of the Asteraceae family. Sunflower seeds are edible and have excellent nutritional value due to their richness in nutrients and biological activities. The inclusion of sunflower seeds in the diet may provide health benefits. This review summarizes the currently recognized but understudied nutritional and medical importance of sunflower seeds by highlighting the potential benefits of their phytochemical constituents, including phenolic acids, flavonoids, and tocopherols that act as antioxidants, which help prevent free radical damage. The objective is to provide scientific evidence to improve the food and pharmaceutical applications of this common but popular crop as a functional food. Sunflower seeds have been pharmacologically studied for their anti-inflammatory, antimicrobial, and wound healing properties. They also have cardioprotective, antitumor, antidiabetic, and cholesterol-lowering effects. Although sunflower seeds are a healthy food, there are some risks to be aware of.

Keywords: Sunflower seeds, Nutritional value, Phytochemicals, Medicinal uses

THE EFFECTS OF PRICE AND SUPPORT POLICIES ON SUNFLOWER PRODUCTION IN TURKEY ON THE WELFARE OF PRODUCERS

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ABSTRACT

This study provides an overall assessment of sunflower production, which is important for the Turkish economy and agriculture, in terms of price and agricultural support policies. Oilseed crops are among the strategic products with a supply gap in Turkey's agricultural production. Turkey ranks second after the EU in global sunflower imports. Turkey, which has a significant production gap in oilseed crops and vegetable oil production, is projected to have a total import value of $5.6 billion by 2025. While the current price of sunflower seeds increased by 145% between 2022 and 2025, area-based support increased by 450%. When the product price is adjusted according to the Consumer Price Index (CPI) based on 2003, the highest unit price was observed in 2020 at 0.88 TL. In terms of subsidies, it has been calculated that a sunflower producer receiving a total of 696.50 TL/da in current prices in 2024 will receive 20.03 TL/da in real terms and 20.40 $/da in dollar terms. This figure is expected to be 732 TL/da at current prices, 25.39 TL/da at real prices, and 25.76 $/da in dollar terms under the new support model to be implemented as of 2025. In Turkey, a sunflower producer received total support amounting to 54% of their total income per decare in 2006, whereas this figure has declined to 18% in 2025. Developing price and support policies that will reduce Turkey's dependence on imports in sunflower agriculture is crucial for all stakeholders.

Keywords: Keywords: Agriculture, Sunflower, Agricultural Support

COMBINATIONS FOR AGROFORESTRY PROJECTS OF RURAL HOUSEHOLDS IN BOSNIA AND HERZEGOVINA THAT INCLUDE PLANTING SUNFLOWERS

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ABSTRACT

One way to include sunflowers more in the production processes in Bosnia and Herzegovina is to start planting them more intensively on private farms of farmers in Bosnia and Herzegovina. Private farms are fragmented to a certain (relatively high) percentage in Bosnia and Herzegovina, especially in those areas where the processes of land consolidation and arondation during the former state system (Socialist Federal Republic of Yugoslavia) were complicated or incomplete. Certain cantons (for example, the Sarajevo Canton) are characterized by a high degree of underutilization of agricultural land, but this is the case in many parts of the country.
One way to intensify agricultural production is to encourage local rural households to grow sunflowers and to inform them about the possibility of starting their own business and agroforestry-oriented production. Agroforestry projects enable the population to grow plants for private production, including plant species whose parts are used for human food, animal feed, for breeding and feeding bees, for the production of basketry (baskets, wicker furniture for personal use), timber for personal use (fences, roofing material, livestock houses) and for the purpose of improving the quality of air, water and microclimate on private property (greenery, shade, water filtration on private property, noise reduction). Agroforestry projects in Bosnia and Herzegovina could be supported (logistically and financially) by the competent ministries and municipal structures (local and agricultural development offices), which could be an additional help for the population inhabiting rural areas in Bosnia and Herzegovina. Sunflower is one of the plants grown on agricultural plots in the country, and is widely used in oil production. It is necessary to investigate what other crops and tree species can be combined on private properties. Some of the proposals are certainly growing together with soybeans, clover, linden, acacia, willow, poplar, tobacco (where permitted) and on more compact land plots characterized by a wealth of diversifiable micro-localities with mosaic soils and brown soils. This paper could serve as the first such review of the above-mentioned plant species for Bosnia and Herzegovina. There are indications that the cultivation of acacia and linden would help feed bees, while the creation of a good climate for sunflower growth could eventually affect the health of sunflower plants in the area and abundant pollination. This is very important from the perspective of climate change, which threatens populations of insects that are important for pollination.

Keywords: Sunflower, lime, Agroforestry, rural households, Bosnia and Herzegovina, climate change, bees populations

EFFECTIVENESS OF A STATIONARY FIELD INFECTIOUS BACKGROUND FOR ASSESSING SUNFLOWER RESISTANCE TO ALTERNARIA LEAF BLIGHT IN THE NORTHERN STEPPE OF UKRAINE

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ABSTRACT

A stationary field infectious background was created at the Institute of Oilseed Crops of NAAS (IOC NAAS) (Zaporizhzhia, Ukraine) in 2005. High infectivity of the background was ensured by constant sowing of sunflower in the same field (monocrop) and deliberate inoculation of infectious agents of the most harmful diseases that are common in the northern steppe of Ukraine. Sunflower fallen seed is managed annually in accordance with the methodology developed at the Institute. In the first three years after the artificial infectious background organization, a pure culture of the pathogen, Alternaria helianthi (Hansford) Tubaki, which was isolated in the laboratory from a local population of the pathogen, was inoculated into the soil of the experimental field. Subsequently, sunflower plant residues collected from the fields of the study region that were significantly affected by Alternaria leaf blight and other pathogens were dispensed into the soil annually. On plants grown on the stationary infectious background, Alternaria parasitized alone or in a combination with three other foliar fungal pathogens - Plasmopara halstedii (Farl.) Berl. et. de Tony, Embellisia helianthi (Hansf.) Pidolp and Phoma macdonaldii Boerema. There were 30% of plants affected by Alternaria leaf blight and downy mildew simultaneously, 35% of plants affected by Alternaria leaf blight and Embellisia simultaneously, and 75.9% of plants affected by Alternaria leaf blight and black stem disease simultaneously. In accessions susceptible to Alternaria leaf blight, the number of plants simultaneously infected with two pathogens amounted up to 83.4%, while in accessions that were more resistant to Alternaria leaf blight, there were up to 41.2% of plants infected with two pathogens. In 2024–2025, 15 accessions (self-pollinated lines, hybrids) bred at the Yuriev Plant Production Institute of NAAS (YPPI NAAS) (Kharkiv) and 17 accessions bred at the IOC NAAS were examined on the stationary infectious background. The accessions were evaluated using a nine-point scale. Five relatively resistant accessions bred at the IOC NAAS and six accessions bred at the YPPI NAAS were identified. The maximum resistance score to Alternaria blight disease in combination with resistance to Plasmopara halstedii and Phoma macdonaldii was shown by hybrids ‘Ahent’, ‘Ahronomichnyi’, ‘Vilnyi’, and ‘Serpanok’, which had been bred at the IOC NAAS.

Keywords: Sunflower, monocrop, infectious background, Alternaria leaf blight, resistance, self-pollinated lines, hybrids

RESOURCES FOR SUNFLOWER BREEDING FOR BIOTIC AND ABIOTIC FACTORS

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ABSTRACT

Sunflower seed yield is limiting by abiotic and biotic factors and an important pool gene is represented by sunflower wild species. Helianthus argophyllus is annual wild specie used in sunflower breeding programs, especially for drought resistance. For resistance/tolerance at parasite broomrape (Orobanche cumana Wallr), in our breeding program at National Agricultural Research and Development Institute Fundulea, Romania, we use perennial wild species Helianthus maximiliani, Helianthus mollis and annual wild species Helianthus neglectus, Helianthus praecox. In year 2023, in Braila, in natural infested field with broomrape, sunflower genotypes 10B x Helianthus maximiliani, 15C x Helianthus neglectus and 17C x Helianthus mollis has 0% attack degree with Orobanche cumana. In year 2024, in Braila, in natural infested field with broomrape only sunflower genotype 15C x Helianthus neglectus has 0% attack degree, that means virulence of Orobanche cumana increase.

Keywords: Sunflower, breeding, wild species

NEW SUNFLOWER STARTING MATERIAL OF THE NATIONAL PLANT GENE BANK OF UKRAINE

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ABSTRACT

Expansion of the genetic diversity of starting materials is critically important in sunflower breeding to increase yield, product quality, resistance to diseases, pests and tolerance to adverse environmental conditions, which is especially vital in the context of climate change. Gene banks play an important role in such expansion; their activities are aimed at forming collections, introducing, and preserving accessions of domestic plants and wild species. The National Center for Plant Genetic Resources of Ukraine of the Yuriev Plant Production Institute of NAAS has built up a sunflower collection, which comprises 802 accessions, including 175 breeding cultivars, 19 landraces, 463 self-pollinated lines, 72 genetic lines, and 73 related wild species from 22 countries worldwide. In 2020-2025, 173 new sunflower lines created at the Yuriev Plant Production Institute of NAAS were added to the National Plant Gene Bank of Ukraine. The new sunflower lines were evaluated for a set of economic and biological characteristics and described by distinctness traits in accordance with guidelines. These lines are included in the European Search Catalogue for Plant Genetic Resources (EURISCO) and available on requests under authors' terms (http://EURISCO.ipk-gatersleben). Based on examination results, 23 sunflower lines - pollen fertility restorers (RfRf) have been registered as sources of a set of valuable traits, which combine resistance to biotic and abiotic factors, high quality and valuable economic characteristics. The new lines were selected for early ripeness, cold tolerance at early stages of plant development, resistance to downy mildew, resistance to sunflower broomrape, and altered composition of tocopherol isomers in seeds.

Keywords: Sunflower, genetic resources, cultivar, landrace, line, wild species, valuable trait

XYLEM CHARACTERISTICS OF WILD HELIANTHUS GERMPLASM AS A SOURCE FOR DROUGHT TOLERANCE IN CULTIVATED SUNFLOWER

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ABSTRACT

Cultivated sunflower is moderately drought tolerant crop. However, insufficient water supply during the key stages of its growth and development significantly reduces sunflower seed yield. Considering that wild Helianthus species inhabit different habitats, including desert areas, they can represent a significant source of desirable traits for improving drought tolerance in cultivated sunflower. It is known that xylem architecture in plants is related to drought tolerance. In this regard, our research provides a comparative overview and detailed characterization of the xylem of the vegetative organs and parts of the reproductive region of 19 perennial wild sunflower species. Cross sections were obtained from the middle part of petiole, lamina main vein and peduncle, using cryotechnic procedure. Observations and measurements of the vessels of all vascular bundles in cross sections were carried out using the light microscope with Image Analyzing System. The obtained results of the comparative xylem anatomy revealed significant phenotypic variability among analyzed species. According to the results of the Discriminant Analysis, characteristics of vascular tissue such as size of lumen, number of vessels, as well as the % of vessels with small lumen (leaf < 100 µm2; peduncle < 150 µm2) mostly contributed to the discrimination among the analyzed species. Species H. californicus, H. divaricatus, H. maximiliani, H. nuttalli, H. pauciflorus and H. salicifolius in which the xylem of the leaf and peduncle are predominantly (60-99%) made up of vessels with small lumen may indicate their xeromorphic structure and greater tolerance to drought. The observed differences in xylem characteristics among the analyzed species may be a consequence of their developmental adaptability. These findings hold valuable implications for shaping upcoming breeding approaches aimed at enhancing drought tolerance in sunflower cultivars.

Keywords: anatomy, drought, wild sunflower, xylem.

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ACTIVITY OF ANTIOXIDANT ENZYMES IN SUNFLOWER LEAVES CO-CULTIVATED WITH FUNGAL STRAINS

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is a globally important oilseed crop. Its productivity and seed quality are significantly constrained by both biotic and abiotic stresses, particularly under current climate change conditions. One of the biotic factors affecting the crop is seed-borne fungal strains, including various species of Fusarium, Rhizopus, Alternaria, Penicillium, and Curvularia, which negatively impact seed quality, germination, and plant development. Exposure to biotic and abiotic stresses often leads to an overproduction of reactive oxygen species (ROS), such as superoxide radicals and hydrogen peroxide, which can cause oxidative damage to proteins, lipids, nucleic acids, and other cellular components. To survive and adapt, plants have evolved complex antioxidant defense systems that mitigate ROS accumulation. Key enzymes such as superoxide dismutase (SOD), catalase, and ascorbate peroxidase function synergistically to detoxify ROS, maintaining cellular redox homeostasis. Among these, plays a primary role in enzymatic defense by catalyzing the conversion of superoxide radicals into less harmful hydrogen peroxide, which is subsequently detoxified by other antioxidant enzymes. The efficiency of these adaptive mechanisms is critical for plant resilience under stress conditions, influencing growth, development, and yield stability. Therefore, assessing SOD activity provides valuable insights into the plant's capacity to mitigate oxidative stress and serves as an important indicator of tolerance to biotic stresses, such as fungal infections. In the present study, the activity of SOD was analyzed in various local sunflower genotypes co-cultivated with different fungal strains (Fusarium oxysporum, Rhizopus arrhizus, Alternaria alternata, Aspergillus niger) to assess their oxidative stress response and adaptive capacity. SOD activity was determined spectrophotometrically, based on inhibition of nitro blue tetrazolium reduction. Results showed a significant increase in SOD activity in plants co-cultivated with F. oxysporum and Rh. arrhizus (by 25-35% compared to the control, depending on hybrid). These increases were associated with improved biomass accumulation and root elongation, suggesting an effective and regulated oxidative defense mechanism. In contrast, sunflower plants exposed to Alternaria alternata exhibited only slight, statistically insignificant increases in SOD activity, correlating with pronounced reductions in shoot length and biomass, indicating a less efficient antioxidant response and more severe oxidative damage. Overall, the study highlights the critical role of SOD as an early and sensitive biomarker of oxidative stress in sunflower under biotic stress conditions. Furthermore, it emphasizes genotype-specific variability in antioxidant responses, providing valuable insight into breeding strategies for improved fungal resistance and stress resilience in sunflower crops.

Keywords*:* *Helianthus annuus*, fungal strains, biotic stress, reactive oxygen species, superoxide dismutase

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LIPID PROFILE OF SUNFLOWER POLLEN OIL

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ABSTRACT

Pollen grains are complex structures that contain a wide range of lipid compounds with essential roles in plant biology, including reproductive signaling, protection against environmental stress, and attraction of pollinators. Among the lipid components, fatty acids and their derivatives are especially important due to their multifunctional biological properties. Helianthus annuus L., being an entomophilous species, produces large quantities of pollen that are readily accessible throughout its flowering period. This makes sunflower pollen a promising biomass resource that can be valorized as a byproduct, contributing to more circular and sustainable agricultural practices. Despite this potential, the lipid profile of sunflower pollen remains insufficiently explored. In the present study, fatty oil was extracted from the pollen of a single sunflower genotype collected from three different locations and analyzed using gas chromatography–mass spectrometry (GC-MS). The results revealed a complex and diverse chemical composition. Organic acids, particularly monocarboxylic acids and their methyl esters, dominated the profile (34.77–44.43%) and are known for their antioxidant and anti-inflammatory activities. Diterpenic esters were also abundant (26.12–40.46%), offering potential regenerative and therapeutic effects. Additionally, the oil contained considerable amounts of ketones (9.00–14.16%), which may contribute to fragrance and biological activity, and lipid-soluble vitamins (1.72–3.41%) that support nutritional and skin-protective functions. Minor components such as monoterpene hydrocarbons and oxygenated monoterpenes further enriched the oil's bioactive profile and may contribute to its stability. These findings underscore sunflower pollen as a rich and promising source of bioactive lipids with potential applications in dermatological formulations, functional foods, and natural pharmaceuticals. The integration of pollen-derived lipids into such products represents a novel opportunity to enhance the economic value of sunflower crops while aligning with principles of sustainable resource use.

Keywords: Helianthus annuus, Sunflower pollen, Lipid composition, Fatty acids, Bioactive substances

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BY-PRODUCTS FROM SUNFLOWER OIL PRODUCTION AS VALUABLE SOURCES OF BIOACTIVE COMPOUNDS

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ABSTRACT

In the context of global efforts toward sustainable development and resource efficiency, the agri-food sector is under increasing pressure to minimize waste and to maximize the valorization of secondary raw materials. The United Nations 2030 Agenda emphasizes the sustainable management of natural resources through the prevention, reduction, recycling, and reuse of production residues. Within this framework, the vegetable oil industry represents a major source of agro-industrial by-products that remain largely underexploited, despite their significant potential for value addition. Sunflower (Helianthus annuus L.), one of the world's most important oilseed crops cultivated for edible oil and biodiesel production, generates large amounts of residual biomass during industrial processing. Oil extraction results in secondary products that represent approximately 30–35% of the processed seed mass. Although sunflower seed by-products, such as hulls, expelled cakes, or extracted meal, are mainly used in the animal feed industry or as organic fertilizers, their rich composition in bioactive compounds, including phenolic compounds, flavonoids, and tocopherols, has recently attracted growing scientific interest. Particular attention has been directed toward their potential applications in agriculture, where bioactive extracts and derived formulations can act as natural stimulants or antifungal agents, offering alternatives to synthetic agrochemicals. The present study focuses on evaluating the bioactive potential (stimulant and antifungal) of novel products obtained from residues generated by the cold pressing of sunflower seeds. Through this approach, the research aims to explore the possibility of transforming low-value agro-industrial residues into high-value bioresources, thereby contributing to environmental sustainability and the development of innovative bio-based products for agricultural use.

Keywords: sunflower by-products; antifungal activity; biostimulants; sustainable agriculture

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APPLICATION OF MINIRHIZOTRONS IN SUNFLOWER ROOT RESEARCH

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ABSTRACT

Unlike humans and animals, plants cannot move and go where the conditions for their life and development are more favorable. Where we saw plants, they stayed there. That is why the adaptation of plants, both the aerial part of the plant and the root system, is extremely important. The aerial part of the plant has been the subject of a large amount of research, but the root has been significantly less researched in comparison to its importance. The reasons should be sought in the more complicated process of such research. However, we have decided that, in addition to more research and phenotyping on the aerial part of sunflowers, we will focus part of our efforts on the roots as well. Our primary task was to observe root growth in early developing sunflower plants using a minirhizotron. This technology has been massively used in research at KWS since 2015, but it has been directed first at sugar beet and later on corn mostly in the study of roots and its connection with drought tolerance. In sunflower, we focused our research more on seed treatments with biostimulators, which does not mean that we will not extend them to other areas in the future. After several years of research, they helped us to decide on a biostimulator that not only has a positive effect on the growth of the aerial part, but also on the growth of the root system. As the development of biostimulators rapidly increases, new biostimulators also come into our research, where the method of using the minirhizotron has become standard in our research. We wanted to present our experiences and results at this conference, so that perhaps this method could be widely introduced in research.

Keywords: Sunflower, Root, minirhizotrons, Drought Tolerance

TISSUE CULTURE AND MICROPROPAGATION TECHNIQUES IN SUNFLOWER (HELIANTHUS ANNUUS L.): TRENDS AND ADVANCES

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ABSTRACT

Between 2020 and 2025, research on in vitro culture of sunflower (Helianthus annuus L.) has led to the refinement of explant use, including cotyledons, cotyledonary nodes, and immature embryos. Murashige and Skoog (MS)-based media, supplemented with specific combinations of auxins (IAA, NAA) and cytokinins (kinetin, 6-BA), have been optimized to enhance organogenesis—the main regeneration pathway. Somatic embryogenesis remains difficult and inconsistent. A major limitation is the genotype-dependent response and the generally low regeneration efficiency. These challenges are being addressed through genotype-specific protocols and by investigating the expression of key genetic regulators of totipotency, such as SERK and BBM. Improved in vitro systems now allow efficient genetic transformation, particularly through Agrobacterium tumefaciens-mediated methods, facilitating the development of transgenic or genome-edited lines. Moreover, these technologies support the conservation of genetic resources from wild Helianthus species and the rapid clonal propagation of elite agronomic genotypes. Overall, these advances underpin the development of cutting-edge biotechnological strategies in sunflower breeding, with applications in sustainable production and improved tolerance to biotic and abiotic stress factors.

Keywords: Explant sources, cotyledon segments, immature embryos, regeneration techniques, genetic transformation

FROM SILENCE TO SIGNAL: REBUILDING THE GENOMIC TOOLBOX FOR SUNFLOWER RESISTANCE TO BROOMRAPE

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ABSTRACT

The development of sunflower resistance to broomrape (*Orobanche cumana* Wallr.) is a critical objective in ongoing breeding programs. In the early stages of establishing a molecular breeding platform for broomrape resistance, two F3 populations were developed by crossing a resistant and a susceptible sunflower line. Phenotypic evaluations were conducted across two environments, Feketić and Lipar, as well as under controlled conditions in a glasshouse. Data were collected over two consecutive growing seasons, and included assessments of O. cumana infection severity and the number of parasitic plants per sunflower individual, recorded separately on roots and stems. All evaluations were performed using broomrape race E, which is predominant in the region and relevant for current resistance breeding efforts. A set of 14 SNP markers previously associated with broomrape resistance in the literature was selected for genotyping. However, the results revealed that four markers failed to amplify, and the remaining ten were predominantly monomorphic—indicating a lack of allelic diversity in the targeted genomic regions. These outcomes contrast with prior literature, where the same markers were informative, suggesting either genotypic divergence between the populations or limited applicability of these markers outside specific genetic backgrounds. The absence of polymorphism at known marker loci highlights the need for identification of new, population-specific markers for O. cumana resistance. This study marks the beginning of systematic efforts to address broomrape resistance through molecular approaches in local sunflower germplasm and sets the stage for future marker discovery and validation to support marker-assisted selection in breeding programs.

Keywords: *Helianthus annuus*, *Orobanche cumana*, genetic resistance, phenotyping, marker-assisted selection, genetic variability, multi-environment testing

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COMPARATIVE GENOMIC ANALYSIS OF THE ORDEB2 LOCUS CONFERRING RESISTANCE TO HIGHLY VIRULENT RACES OF OROBANCHE CUMANA

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ABSTRACT

One of the main constraints currently affecting sunflower (Helianthus annuus) crops is the parasitism by the sunflower broomrape (Orobanche cumana), a holoparasitic weed that attaches to the roots of sunflower plants and extracts water and nutrients, thereby causing severe yield losses. This parasitic plant is widespread across many sunflower-producing regions, ranging from South-Eastern Europe to Central Asia, including parts of North Africa and, more recently, expanding into South America. Among the different management strategies employed to combat O. cumana, the development of resistant sunflower varieties through breeding has proven to be one of the most effective, durable, and environmentally friendly approaches. Over the years, several resistance genes conferring resistance to various O. cumana races have been identified and characterized. One such gene is OrDeb2, which was introgressed into the cultivated sunflower line DEB2 from the wild species Helianthus debilis subsp. tardiflorus. This gene provides resistance to race G of sunflower broomrape through a mechanism that involves early post-attachment blockage of parasite development. Previous genetic studies have localized OrDeb2 to a 1.38 Mbp region on chromosome 4 of the H. annuus HanXRQ reference genome assembly. In the present study, we conducted a comparative genomic analysis across several recently sequenced sunflower genomes, including both cultivated lines and wild species. This analysis revealed a conserved cluster of genes across all genomes examined within the region previously associated with OrDeb2. Among these, we identified strong candidate genes that show features consistent with a role in resistance. These findings represent a significant advancement in the identification of the gene underlying OrDeb2-mediated resistance and provide a valuable framework for further functional analyses aimed at elucidating its role in host-parasite interactions and facilitating the development of new resistant sunflower varieties.

Keywords: Sunflower, resistance, sunflower boomrape, comparative genomics, breeding

REGULATION OF SIGNALING THROUGH COLLOIDAL SILVER AT EARLY STAGES ASSIST THE GROWTH OF SUNFLOWERS DURING DROUGHT AND HIGH TEMPERATURE STRESS

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ABSTRACT

High temperature and drought stresses, along with high light intensity, pose significant threats to global crop production. To remove or reduce the stress conditions of crop plants becomes a complex challenge. One of the recent approaches involves generating crop plants that can withstand such stress conditions. However, this requires considerable effort and time. Even if it is managed, the tolerant plant should follow a specific or enriched pathway to combat the stress. The combination of nanotechnological products, colloidal silver (1.5-3 ppm, 25 ml/da) and calcium carbonate (50 g/da) was applied to regulate signaling pathways at early stages (2 to 5-leaf stage) of growth of sunflower plants in field (50 da) conditions. The defense systems were significantly activated and extended until plants face high temperature stress (over 40°C). At this stage (10-leaf stage, head is formed), the second application was made from the same mixture with the same concentrations. No application was made in the control field (50 da). Followed by the harvest, physiological, morphological, and biochemical parameters of plants were evaluated in both fields. The stress metabolites, such as H2O2, O-2, and malondialdehyde (MDA), were lower in the applied field than in the non-applied field. Physiological parameters, such as head diameter, weight, stem length, 100-grain weight, stem diameter, and leaf area, were higher when compared to those of the control field. We evaluated that the nanotechnological compound regulated signaling pathways and antioxidant metabolism throughout the cultivation period. Hormonal homeostasis and the regulation of stress-related genes may have played a significant role in sustaining tolerance under high temperatures. We suggest that the colloidal silver could be a promising compound to evoke tolerance mechanisms when applied at early stages before the occurrence of stress.

Keywords: Nanomaterials, sunflowers, temperature, stress, colloidal silver

A COMPARISON OF SNP GENOTYPING ARRAYS WITH TARGETED GENOTYPING-BY-SEQUENCING (TGBS) IN SUNFLOWER

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ABSTRACT

Array genotyping using many thousands of SNP markers is widely used during sunflower breeding including for Genomic Selection and genetic research. But for certain applications in breeding there is no need for that many markers. Such analyses include marker-assisted backcrossing, marker-assisted selection for candidate genes, low density analysis of samples for purity and quality analysis. With the advent of low-cost, high-throughput DNA sequencing technologies, targeted Genotyping-By-Sequencing (tGBS) offers the potential to reduce costs in routine sunflower genotyping. To directly compare the quality of genotyping data between tGBS and microarrays, we have analyzed a large set of sunflower samples with both methods. tGBS technologies delivered a high marker conversion rate (>95%) of SNP markers present on genotyping arrays. However, over all marker/sample combinations a considerable percentage (10-15%) did not produce genotype calls. While in homozygous lines, both tGBS and array genotyping produce a comparable data quality for the called marker/sample combinations, the accuracy of the tGBS calls dropped significantly in heterozygous material. After curation including the use of parent/offspring triplets, less than two thirds of the tGBS markers could be reliably scored. We conclude that tGBS employing hundreds of SNP markers can be used cost-efficiently in routine sunflower genotyping if one selects only the best markers from a tGBS marker multiplex and simultaneously obtains a sufficiently high number of reads for each marker/sample combination. Both constraints in combination with a generally lower marker number in the tGBS analysis reduce or eliminate the cost advantage over genotyping arrays in Genomic Selection but mostly retain the advantages of tGBS in breeding approaches such as marker-assisted backcrossing.

Keywords: SNP genotyping, targeted Genotyping-By-Sequencing, array genotyping

DECIPHERING DROUGHT RESPONSE STRATEGIES IN SUNFLOWER

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ABSTRACT

Drought stress is a major constraint in sunflower production, especially during critical developmental stages such as flowering. In this study, we investigated the physiological and molecular responses of two genetically distinct sunflower lines exposed to drought conditions, aiming to understand the underlying mechanisms shaping their adaptation strategies. Physiological measurements, including growth, gas exchange, and chlorophyll fluorescence parameters, revealed clear genotype-dependent differences in response to water limitation. The genotypes differed in their ability to maintain biomass and stomatal conductance, with the more resilient genotype showing stronger physiological stability under drought conditions. Transcriptomic analysis supported these observations by uncovering distinct patterns of gene expression between the two lines. Enriched pathways included those related to cuticle reinforcement, antioxidative defense, and metabolic adjustments. Flavonoid biosynthesis and fatty acid metabolism were prominent in both genotypes, indicating shared mechanisms for mitigating stress. However, broader enrichment of stress-related pathways—including those linked to membrane stability and protective surface compounds—was observed in the more responsive line. This integrative analysis highlights contrasting drought response strategies in sunflower and underscores the value of combining physiological screening with transcriptomic profiling. This work contributes to ongoing efforts in developing climate-resilient sunflower and demonstrates the value of combining functional genomics with physiological screening in sunflower breeding.

Keywords: Helianthus annuus, transcriptomics, gene mining, drought tolerance, climate change
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ROOTS – AN UNEXPLOITED WAY TO DROUGHT TOLERANCE IN SUNFLOWER

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ABSTRACT

As longer and increasing drought periods even challenge sunflower, a moderately drought tolerant crop, research on drought tolerance becomes increasingly important. The root is a major player in drought tolerance as it channels the water uptake to handle increased evaporation under water limiting conditions. In vitro or hydroponic experiments inducing osmotic stress by applying polyethylene glycol are ideal for fast screening for drought tolerance at a seedlings stage. Comparing a drought-tolerant sunflower genotype DF-AB-2 with a drought-sensitive genotype AB-OR-8 significant differences in root length, root volume and fresh weight were observed. As changes in the root architecture to adapt to drought stress conditions require modifications in the cell wall composition, different markers for cellulose, hemicellulose and pectin were analysed. Significant differences in pectin abundance were observed that were accompanied by significant differences in the expression of enzymes for pectin modification and degradation. Quantitative RT-PCR analyses were performed for selected genes to verify the RNAseq data as well as to develop PCR markers for screening. These drought responsive genes in roots offer new starting points for breeding for drought tolerance in sunflower.

Keywords: root architecture, drought tolerance, polyethylene glycol, cell wall

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PAVING THE PATH TO SUNFLOWER DROUGHT RESILIENCE: MARKER ASSISTED BACKCROSSING USING KASP TECHNOLOGY

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ABSTRACT

The development of sunflower genotypes with improved resistance to drought is of profound importance to current breeding programs, especially under the light of climate change. The Marker Assisted Back-crossing (MABC) significantly accelerates the introgression of one or a few desirable genes from a donor parent into elite lines (recurrent parent), compared to traditional breeding, especially for quantitative traits. The aim of the study is to implement MABC in the sunflower breeding program at the Institute of Field and Vegetable Crops (IFVCNS) in Serbia in order to improve drought tolerance of two selected recipient IFVCNS sunflower lines. Three sunflower lines developed by INRAE (National Research Institute for Agriculture, Food and the Environment, France) were used as donor lines for 3 identified QTLs (HAMYB111, CWINV2 and DYP12_QTL-Drought-LG12) related to different mechanisms of tolerance to water scarcity, including improved attraction to pollinators in drought conditions. The set of KASP (SNP) markers was developed for these QTLs and tested in the backcross generations to identify the presence of associated traits. For each of the analysed QTLs, KASP marker that showed polymorphism between parental lines was detected and can be further used in MABC. This study gives emphasis to the potential of modern biotechnological approaches in developing climate smart sunflower hybrids through discovery (or identification) of traits related to drought resilience and their efficient introgression into breeding lines using molecular markers specifically by successfully developing polymorphic KASPs.

Keywords: Helianthus annuus, CWINV2, HAMYB111, DYP12_QTL-Drought-LG12, drought tolerance, pollinator attractiveness

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THE YABBY GENE NETWORK IN SUNFLOWER: EVOLUTIONARY DYNAMICS AND DROUGHT-RESPONSIVE EXPRESSION PROFILING

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ABSTRACT

The YABBY gene family, known for its plant-specific transcription factors, plays pivotal roles in regulating leaf polarity, floral organ development, and responses to environmental stimuli. Despite its functional importance in various plant species, a comprehensive understanding of this gene family in sunflower (Helianthus annuus L.) has remained elusive. In this study, we conducted a genome-wide in silico identification and characterization of YABBY genes in H. annuus, revealing 14 HaYABBY members distributed across 10 chromosomes. Phylogenetic analysis clustered these genes into five conserved subfamilies (FIL/YAB3, YAB2, YAB5, INO, and CRC), while gene structure and motif analyses highlighted both conserved domain architecture and subfamily-specific divergence. Promoter analysis revealed the presence of multiple stress- and hormone-responsive cis-elements, and miRNA target prediction identified HaYABBY05 and HaYABBY09 as potential post-transcriptional targets of four distinct miRNAs. Synteny and duplication analyses suggested that segmental duplication events under purifying selection contributed to the expansion and conservation of HaYABBY genes. Tissue-specific expression profiling via RNA-seq demonstrated diverse expression patterns, with HaYABBY05 exhibiting broad expression and HaYABBY12 showing strong floral organ specificity. Under drought stress, RNA-seq and RT-qPCR analyses revealed significant cultivar- and tissue-specific expression differences between the drought-tolerant (SUN 2235) and drought-sensitive (Turay) sunflower cultivars. Notably, HaYABBY genes showed strong induction in the roots of SUN 2235 but were suppressed in Turay, implicating a potential role in drought adaptation. Together, these findings provide the first comprehensive insight into the structure, evolution, and stress-responsive expression of YABBY genes in sunflower. This study offers valuable candidate genes and regulatory clues for improving drought resilience in sunflower breeding and sets a foundation for further functional exploration of YABBY transcription factors in crops.

Keywords: YABBY gene family; Helianthus annuus; Genome-wide analysis; Drought stress; Gene duplication; miRNA regulation; Expression profiling

ORGANISATION OF THE FERTILITY RESTORER LOCUS RF1 IN SUNFLOWER

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ABSTRACT

Sunflower hybrid breeding founded on the PET1 cytoplasm requires fertility restoration by the dominant restorer gene Rf1 for efficient seed production. Association studies identified three candidate genes for Rf1 on linkage group 13, which are members of the PPR gene family, but little is known about their individual functions. In phylogenetic studies, two of these genes HanXRQr2_Chr13g0609921 (PPR841) and HanXRQr2_Chr13g0609901 (PPR861) formed a group with the restorer gene from Petunia. However, the third gene HanXRQr2_Chr13g0608631 (PPR621) arranges with the restorer-of-fertility gene Rfm1 in Hordeum vulgare. Both genes represent RNA editing factors characterized by the E-domain (HxExnCxxC) and DYW domain at the C-terminal end of the encoded proteins. RNA-editing of the PET1-specific CMS protein ORFH522 may play a role for the pollen fertility. The annotation of the three genes based on the HanXRQ genome assembly, which is a maintainer line, was verified on cDNA level for HA342, RHA325 and Jerusalem Dwarf Yellow. In addition, genome editing constructs have been designed to knock out these genes in sunflower. Based on SNPs specific for the three potential fertility restorer genes, four KASP markers were developed. Applying these KASP markers in an association panel of 577 sunflower accessions, lines with fertility restoration abilities for the PET1 cytoplasm but without the Rf1 were identified. These restorer lines must carry other restorer gene(s), which might be useful in hybrid production to avoid linkage drag based frequently on the use of Rf1. **Funding:** Sunflower accessions were analysed within the project OptiArch by Bundesministerium für Ernährung und Landwirtschaft (BMEL) and Gemeinschaft zur Förderung von Pflanzeninnovation (GFPi) under the guidance of the Fachagentur für Nachwachsende Rohstoffe (Agency for Renewable Resources) (Grant no. 22025215). Personal exchange was funded by the DAAD as a German-Serbian bilateral cooperation project (No. 451-03-01732/2017-09/3 and project code 57393592). AR and DM were also supported by Center of Excellence for Innovations in Breeding of Climate-Resilient Crops - Climate Crops, Institute of Field and Vegetable Crops, Serbia.

Keywords: fertility restoration; PET1 cytoplasm; PPR gene family; Rf1; sunflower, hybrid breeding; KASP marker; RNA editing, genome editing

GENE CLONING IN SUNFLOWER: CURRENT ADVANCES AND FUTURE DIRECTIONS

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ABSTRACT

Gene cloning and functional characterization have become essential tools for advancing molecular breeding and understanding complex traits in sunflower (*Helianthus annuus* L.). Before the advent of large-scale genomic resources, early candidate gene studies focused on key enzymes from well-characterized biosynthetic pathways, such as those involved in fatty acid and tocopherol metabolism, leading to the isolation of genes such as *FAD2* and members of the tocopherol biosynthetic pathway. These pioneering efforts provided the first molecular insights into qualitative traits associated with oil composition and nutritional quality. Over the past decade, the availability of a high-quality reference genome and extensive transcriptomic datasets has greatly expanded the identification of candidate genes associated with oil biosynthesis, abiotic stress tolerance, and disease resistance. However, the functional validation of these genes remains challenging due to the recalcitrance of sunflower to stable transformation and the limited efficiency of transient expression systems. Recent advances in heterologous systems, virus-induced gene silencing (VIGS), and CRISPR/Cas-based genome editing are beginning to overcome these constraints, offering new opportunities to dissect gene function and accelerate trait improvement. Past and current progress in sunflower gene discovery and cloning is discussed. Despite significant progress, the integration of multi-omics data with efficient transformation pipelines remains a key priority to fully exploit sunflower's genetic potential for sustainable crop improvement.

Keywords: Sunflower, Gene cloning, gene silencing (VIGS), CRISPR/Cas, genome editing

ANTHOCYANIN PIGMENTATION AS A MARKER IN SUNFLOWER BREEDING AND SEED PRODUCTION

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ABSTRACT

Preliminary analysis of possibility to use anthocyanin pigmentation as a marker trait in sunflower breeding and seed production was conducted; efficiency and reliability of the marker utilization was shown. The color of sunflower hypocotyls allowed us to differentiate our samples from any impurities. By the appearance of the first true leaves, the hybrids and lines also were easily identified by veins colored with anthocyanin. The ease and reliability of identifying hybrids by the color of the hypocotyl at the seedling stage and further stages of development is shown, which makes this trait attractive for use in sunflower breeding and seed production. Reliable donors of the trait are identified and included in the breeding program

Keywords: Sunflower, Breeding, Seed Production, Marker

ASSOCIATION MAPPING OF SEED MORPHOLOGY TRAITS IN SUNFLOWER

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ABSTRACT

Seed-related traits—specifically seed size (kernel size), husk size (hull size), and seed-to-husk ratio—are critical phenotypes in sunflower breeding and industry. These traits are particularly valuable for developing large-seeded confectionary sunflowers (Lukomets et al., 2021). A common technique for estimating seed size is measuring thousand-seed weight, widely applied in oilseed crops (Khan et al., 2019; Souza et al., 2016), including sunflower (Radic et al., 2013), as husk dimensions strongly correlate with this metric (Gjorgjieva et al., 2015). However, this approach cannot assess the seed-to-husk area ratio—a key parameter for evaluating efficient photoassimilate utilization in yield optimization. X-ray radiography with image analysis offers a non-invasive alternative for quantifying seed size, husk size, and their ratio (Arkhipov et al., 2019). Historically, X-ray methods primarily evaluated seed morphology (Rocha et al., 2014), quality (e.g., viability, emptiness, pathogen damage; Dumont et al., 2015), and germination potential (Al-Turki & Baskin, 2017). In this work, we performed genetic mapping of seed traits using X-ray data provided by collaborators from St. Petersburg Electrotechnical University "LETI". Analyzed traits included husk area, seed area, and seed-to-husk ratio across a genetically and phenotypically diverse collection of 601 sunflower accessions from VIR, VNIIMK, and Agroplasma. Genetic diversity analysis for these 601 lines was published in BMC Genomics (Chernova et al., 2021)

Keywords: seed morphology, genetics, association mapping

ADVANCING SUNFLOWER RESILIENCE TO CLIMATE CHANGE THROUGH INNOVATIVE BREEDING STRATEGIES

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ABSTRACT

Maintaining sunflower productivity under changing climates requires breeding programs to enhance tolerance to multiple abiotic stresses, such as a deeper understanding of genetic diversity, physiological responses, and the molecular mechanisms underlying stress resilience. The integration of advanced technologies, including genomics, transcriptomics, phenomics, and epigenomics, facilitates the identification of adaptive traits and accelerates the development of climate-resilient genotypes. High-throughput, non-invasive phenotyping platforms, particularly those targeting root architecture, stress physiology, and growth dynamics, provide valuable insights into sunflower responses under variable and extreme conditions. The Center of Excellence for Innovations in Breeding of Climate-Resilient Crops – Climate Crops is actively addressing these challenges by combining genetic resources, cutting-edge technologies, and targeted selection strategies. Through this integrated approach, the Center aims to develop sunflower cultivars capable of sustaining yield and quality despite intensifying climate pressures, thereby contributing to the resilience and sustainability of global agricultural systems.

Keywords: Sunflower, Drought, Omics-, Yield, Root traits.

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BROOMRAPE (OROBANCHE CUMANA) RESISTANCE GENES IN WILD SUNFLOWER SPECIES

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ABSTRACT

Sunflower broomrape (*Orobanche cumana* Wallr.) is a holoparasitic plant that lacks chlorophyll and depends entirely on a host plant to complete its life cycle. Unlike related species, it shows high host specificity both in nature and under cultivation, parasitizing only sunflower in the latter case. This parasitic weed is currently the major threat to sunflower production in most areas of Asia and Europe, including Spain, due to the continuous emergence of increasingly virulent races. At present, the most effective and sustainable strategy for broomrape control is the development of sunflower genotypes resistant to this parasite. Our research group has developed novel sources of broomrape resistance derived from genes identified in wild sunflower species, such as the OrDeb2 gene, already widely used in commercial hybrids, and more recently the OrAnom1 gene, identified in the wild sunflower species Helianthus anomalus. This new source of resistance is also being transferred to major sunflower breeding companies for the development of commercial hybrids with genetic resistance to broomrape. We are currently working on additional resistance sources derived from wild sunflower species, which will help strengthen the genetic defence arsenal of sunflower against this harmful parasitic weed, offering a sustainable alternative to the massive use of herbicides.

Keywords: Broomrape; Genetic resistance; Resistance genes; Sunflower; Wild species

DEVELOPMENT OF HERBICIDE RESISTANT ORNAMENTAL SUNFLOWER LINES

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ABSTRACT

Besides its industrial use, Sunflower (*Helianthus annuus* L.) is also important as cut flower, potted and landscape design plant. Currently, the commercial hybrid ornamental sunflowers are either fertile or male sterile for which demand is on the rise. The objectives of the breeding program were to develop cytoplasmic male sterile lines - CMS (A) and maintainer (B) lines to use as parental lines for male sterile hybrids. The imidazolinone (IMI) or Sulfunilurea (SU) herbicide resistance were transferred from oil-type restorer line by backcrossing and selecting individual plants. Plant materials also included a public maintainer line (Peredovik), 16 sterile and 15 fertile commercial ornamental sunflower hybrids. During consecutive backcrossing to develop ornamental-type maintainer lines, the presence or absence of restorer of fertility (Rf) alleles were identified using Rf-specific molecular markers. Herbicide resistant plants were selected by spraying related herbicide on the segregating populations. Male sterile hybrids representing different flower colors and plant types with IMI/SU herbicide resistance were developed. Vase life and plant characteristics of SU resistant advanced A / B lines showed that commercially competitive ornamental hybrids can be developed using these lines. The A and B lines representing different plant types, flower colors, and genetic resistance can be used to create potential hybrids. Herbicide resistant hybrids may offer a quick and cheaper weed control especially for open field cut-sunflower production.

Keywords: CMS, IMI, SU, ALS, herbicide resistance, Hybrid seeds, Ornamental plant

GENETIC HISTORICAL PHASES OF SUNFLOWER BREEDING IN ARGENTINA DESCRIBED THROUGH A TRIAL DATASET SPANNING 10 DECADES

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is the second oilseed and the fourth largest grain crop of Argentina. Formal breeding in the country began in 1931. Genetic gain studies addressing portions of this centenary history (limited periods, regions, or germplasm bases) have been published. The study we are presenting comprehensively quantifies the genetic progress achieved over ninety-three years of sunflower breeding in Argentina (1931–2024), filling all gaps left by previous research. Using a multi-environment dataset of 1,074 public trials spanning 1935–2023, we applied linear mixed models, regression analyses, and self-organizing maps (SOMs) to estimate genetic gains for grain yield, oil concentration, oil yield, and time to flowering across all historical production periods. Open pollinated variety breeding (1938–1990) did not significantly increase yield but improved maturity, oil concentration, agronomics, defensive traits, and established a locally adapted genetic pool. The introduction of hybrids (1970–1990) led to earlier maturity and substantial improvements in oil yield and its components. For cultivars released between 1953 and 2022, annual genetic gains were estimated at -0.15% yr^{-1} for time to flowering, 0.72% yr^{-1} for grain yield, 0.46% yr^{-1} for oil concentration, and 1.49% yr^{-1} for oil yield. A slowdown in genetic progress was observed from the mid-1990s, coinciding with crop displacement to more marginal environments, accelerated pathogen and pest evolution, and linkage drag for yield component traits in early herbicide-resistant hybrids. Despite these challenges, Argentine sunflower breeding programs consistently released superior genotypes at rates comparable to those in larger, better-resourced crop systems. The extensive dataset builds for this study enabled a complete description of the breeding contributions to sunflower yield progress in Argentina and demonstrated the utility of SOMs for estimating the impact of individual cultivars on genetic gain across historical periods.

Keywords: Sunflower breeding, Argentina, Genetic gain, Yield traits

THE EVALUATION OF SOME WILD SUNFLOWER SPECIES FOR ORNAMENTAL PURPOSES

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ABSTRACT

Sunflower which is the most important oil plant in our country, have been contributing to both garden ornament and cut floriculture since before the 18th century. In order to create wild sunflowers with high market value for the widespread use of this field of use, it is necessary to have information about the inheritance of wild sunflower species and to examine the interaction of inheritance with the environment. In this thesis, the characteristics affecting the ornamental plant trade were observed. This study was conducted in the research land of Trakya University in the Central district of Edirne province in 2024. Within the scope of the study, it was aimed to observe the stem diameter, root diameter, plant height, projection (spreading) area, first flowering days, 50% flowering days, full flowering days, flowering time, total flowering days, tray diameter, tray number and seed number of 18 different wild sunflower species. In this framework, *H. agrestis, H. annuus, H. anomalus, H. agrophyllus, H. atrorubens, H. cusickii, H. debilis, H. deserticola, H. exilis, H. longifolius, H. maximiliani, H. mollis, H. niveus, H. nuttallii, H. pauciflorus, H. petiolaris, H. porteri and H. praecox* wild sunflower species were observed. Among the wild sunflower species in the study, the shortest first flowering time (91 days) were observed in *H. debilis* and *H. pauciflorus*, while the longest one (202 days) were determined as *H. atrorubens*. The shortest 50% flowering time (97 days) was determined as *H. debilis* and *H. pauciflorus*, and the longest ones (221 days) were determined as *H. atrorubens*. The shortest full bloom time (173.33 days) was determined as *H. agrestis*, while the species with the longest (266.67 days) was determined as *H. maximiliani*. The shortest flowering time (50 days) was determined as *H. atrorubens*, while the species with the longest (162.67 days) was determined as *H. maximiliani*. On the other hand, the smallest head diameter (1,13 cm) was determined as *H. deserticola*, while the species with the tallest (18,33 cm) was determined as *H. agrestis* and the smallest head diameter (5) was determined as *H. agrestis*, and the species with the tallest head diameter (45.67) was determined as *H. atrorubens*. Based on the evaluation of stem diameter, those between 0.5 and 1,5 cm are suitable for cut flower production; those with a stem diameter of 1.5 cm or more are suitable for outdoor ornamental use. According to this evaluation, *H. annuus, H. cusickii, H. debilis, H. deserticola, H. exilis, H. longifolius, H. maximiliani, H. mollis, H. pauciflorus, H. petiolaris,* and *H. porteri* suggested to use for cut flower production, while the remaining (7) species could be used as outdoor ornamental plants.

Keywords: Sunflowers, Wild species, Ornamental sunflower, Cut flowers, Garden flowers.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a species belonging to the genus Helianthus in the Asteraceae family, with a basic chromosome number of n=17. Sunflower originates from America and has 39 perennial and 14 annual species. Throughout history, sunflowers have been used as ornamental plants. *Helianthus* species have been used in gardens and pots as ornamental plants since before the 18th century, and also contribute to the cut flower industry (Divita et al., 2012; Kaya and Beşer, 2022). Among these species, *H. annuus*, which has the greatest commercial importance, is one of the most important oilseed plants in the world, and also includes very popular ornamental varieties. Indeed, with its large and showy flowers in warm colors, it is one of the important ornamental plants widely used in parks, gardens, and indoor spaces in different parts of the world. Ornamental sunflowers are valued as cut flowers, outdoor ornamentals, and potted plants depending on their intended use (Kaya and Vasilevska-Ivanova, 2021). It is thought that today's intermediate shades of red and layered varieties originated from natural mutations of the H. annuus species, which originally had plain yellow leaves. In the USA, it is cultivated throughout the country for ornamental use and commercial seed production.

Sunflower, which was roasted and consumed by Native Americans in the 3000s BC and cultivated for oil extraction from its seeds, spread first to Spain and then throughout Europe after the discovery of America (Kaya, 2014). Until the 18th century, sunflowers were only cultivated as ornamental plants in Europe. Sunflowers spread to Spain in the early 1500s and then throughout the European continent. Although initially used decoratively, by the early 17th century they had become a widely cultivated plant in Europe (Fick and Miller, 1997). It is assumed that sunflowers were brought to Turkey by immigrants from Romania and Bulgaria after World War I (Kaya et al., 2022). In Turkey, cultivation began in the Thrace region in the 1950s with seeds brought by citizens arriving from Bulgaria (Kaya et al., 2018). Sunflower production, which initially started in Thrace, later spread throughout Turkey (Kaya et al., 2022).

Since the selection criteria for confectionery and oilseed sunflower varieties differ from those for ornamental sunflower types, oilseed varieties are not suitable for ornamental use because ornamental types have wide flower base and long and different colors and they use generally as cut flowers, landscape plants, or potted ornamentals. While varying according to intended use (cut flower, outdoor, potted ornamental plant), the most important selection criteria in ornamental sunflower breeding programs can be considered flower structure, flowering time, and plant type. Within this framework, ornamental varieties suitable for different uses are developed in terms of flower color, diameter, timing, duration, and other plant structure (single-stemmed or multi-branched, flower diameter and length) (Hayata and Imaizumi, 2000). For example, varieties suitable for cut flower cultivation have flower stalks 60-90 cm long and 0.5-1.5 cm in diameter, flowers 8-15 cm in diameter, a short vegetation period, resistance to long transport times, and a relatively long vase life after harvest. The vase life of sunflowers varies between 15-20 days depending on the variety used (Short et al., 2017).

There are three different genotypes in the cut flower group according to their intended use. These are: genotypes with a relatively wide flower base, resistant to lodging, producing flowers on a single stem (unbranched), called 'single-headed' genotypes; and genotypes that branch only at the top of the stem and have lateral branches along its length, with an average length of 60-70 cm for the entire stem and lateral branches. The aim in growing ornamental sunflowers for cut purposes is to obtain as many flowers as possible from a unit area (Wien, 2016). Sunflowers, reported by cut flower growers as a relatively easy species to cultivate, are particularly preferred in varieties that do not produce pollen (sterile). Since pollen-free varieties offer a longer vase life than standard (high-yielding) varieties and do not shed pollen, they provide cleaner and more aesthetic results in flower arrangements. The increasing demand for cut flowers with different characteristics is ensuring the continuous growth of this sector and market. Ornamental sunflowers, which have a significant market share, are easy to grow, produce a product that can be sold shortly after planting, and are reported to be profitable in field conditions for cut flower cultivation, making them profitable even for small family businesses. The ornamental sunflower group includes many varieties that bloom in as little as 50 days and can produce multiple stems per plant (Cutler, 1997). In the USA, sales of cut ornamental sunflower stems are quite high and sold at good prices.

Wild sunflower species exhibit significant genetic diversity, particularly in characteristics such as texture, color, seeds, hairiness, and leaves. Therefore, the use of wild sunflower species in breeding programs has become increasingly necessary in recent years (Kaya, 2023). World ornamental sunflower sales are projected to reach US$169.0 million in 2025, US$231.8 million by 2032, and the ornamental sunflower market is expected to grow by 4.6% annually between 2025 and 2032 (Cvejić et al., 2025).

The global ornamental sunflower market is projected to reach US$161.6 million in 2024, US$218.4 million by 2031, and exhibit a compound annual growth rate (CAGR) of 4.4% from 2024 to 2031 (Zhuykov et al., 2024). Ornamental sunflower sales, valued at US$142.53 million in 2023, are projected to grow by 6.45% by 2029. Ornamental sunflowers will continue their market growth due to their diverse range of colors, from bright yellow to burgundy. Besides their variety of colors, their low maintenance requirements and long-lasting blooms that enhance aesthetic appeal in landscapes also contribute to the market's success (Puttha et al., 2023).

MATERIAL AND METHOD

Wild sunflower species from the Trakya University World Sunflower Collection Garden were used in this study (Figure 1). Ten random plants from each species were measured and the averages were evaluated. The observed wild sunflower species (18) are listed in Table 1 in alphabetical order and by life type (perennial/annual).

Figure 1. Trakya University World Sunflower Collection Garden

Table 1. Observed Wild Sunflower Species

	Taxonomy	Type
01.	*Helianthus agrestis*	Annual
02.	*Helianthus annuus*	Annual
03.	*Helianthus anomalus*	Annual
04.	*Helianthus argophyllus*	Annual
05.	*Helianthus atrorubens*	Perennial
06.	*Helianthus cusickii*	Perennial
07.	*Helianthus debilis*	Annual
08.	*Helianthus deserticola*	Annual
09.	*Helianthus exilis*	Annual
10.	*Helianthus longifolius*	Perennial
11.	*Helianthus maximiliani*	Perennial
12.	*Helianthus mollis*	Perennial
13.	*Helianthus niveus*	Annual
14.	*Helianthus nuttallii*	Perennial
15.	*Helianthus pauciflorus*	Perennial
16.	*Helianthus petiolaris*	Annual
17.	*Helianthus porteri*	Annual
18.	*Helianthus praecox*	Annual

The results regarding the physical chemical properties of the soil in the research area re given in Table 2 and 3. Based soil analysis results seems that the research are quite poor soil type.

Table 2. Physical Properties of the Soil in the Research Area

Profile Depth Texture	Texture Type	Volume Weight	Water Holding Capacity	Wilting Point	Field Capacity
0-30 cm	Clay - Loam	1,71 g/cm^3	%8,64	%7,01	%15,65
30-60 cm		1,67 g/cm^3	%9,60	%9,26	%18,86
60-90 cm		1,55 g/cm^3	%9,69	%12,23	%21,92
90-120 cm		1,50 g/cm^3	%2,41	%10,07	%12,48

Source: Edirne Exchange Stock Laboratory

Table 3. Chemical Properties of the Soil in the Research Area

Profile Depth Texture	pH Value	Water saturation %	Organic Matter %	Phosphor (P_2O_5) kg/da	Potassium (K_2O) kg/da
0-20 cm	6,4	48	0,69	1,66	52,9

Source: Edirne Exchange Stock Laboratory

Since the observed perennial wild sunflower species (7) were present in the research area, there was no need for planting/sowing practices related to perennial wild sunflower species. The observed annual wild sunflower species (9) were sown on May 10, 2024, with seeds obtained from the US Department of Agriculture (USDA). Two days before the sowing date (May 8, 2024), 6.6 kg/da of base fertilizer (Diammonium Phosphate/18-46-0) was applied to the research area. As part of weed control, mulch film was spread on the remaining soil parts in May 2023 and mown hay was spread on June 2, 2024 (Figure 2).

Figure 2. Trakya University World Sunflower Collection Garden

Within the scope of this research, flower color, presence of branching, stem diameter, root diameter, plant height, projection (spread) area, number of days to first flowering, number of days to 50% flowering, number of days to full flowering, flowering time – number of days, head diameter – number, and seed number were observed (Table 4). Full blooming (R-6), the aesthetically pleasing petals wilt at full bloom, a longer full bloom period is desirable in ornamental sunflowers.

Flower Color: The color of the radial flowers, located around the head and called "false (sterile) flower or ray flower," is an important selection criterion in ornamental sunflower breeding. Anthocyanins are effective in the formation of red and purple colors, the AP color gene in the formation of apricot color, the L color gene in the formation of yellow color, the Ly color gene in the formation of light-yellow color, and the O color gene in the formation of orange color. The yellow color gene was found to be dominant compared to other color genes (Miller and Fick, 1997; Yue et al., 2008). Therefore, when a yellow sunflower is hybridized with a sunflower of another color, the F1 population is observed to be exclusively yellow; repeating the same hybridization in the F2 population results in monogenic inheritance (3:1 segregation). The reason for the 3:1 segregation in the F2 population is recessive epistasis, meaning that the dominant gene does not appear in all phenotypes due to the presence of a recessive gene.

Presence of Branching: In sunflowers, branching is controlled by either a recessive or dominant gene. The recessive gene is represented by 'b', and the dominant gene by 'br' (Miller and Fick, 1997). Since single-stemmed sunflowers are dominant, all hybrids produced with branched sunflowers will have the single-stemmed character (Sharypina et al., 2008). However, if both parents are branched, branched sunflowers will be present among the hybrids. There are three forms of the recessive b gene (b1, b2, and b3), which determine the branching pattern (Miller and Fick, 1997). Respectively, b1: branching only at the base, b2: branching only at the top, and b3: complete branching. The presence of branching is desirable in ornamental sunflowers.

Stem Diameter & Root Diameter: Stem and root diameter as large as possible are desirable traits in ornamental sunflowers. This helps prevent the plant from breaking in the wind. A digital caliper was used to measure stem and root diameters. Based on stem diameter, those between 0.5-1.5 cm are suitable for cut flower; those 1.5 cm and above are suitable for outdoor ornamental plants.

Plant Height: Height measurement was taken when the vegetative growth period was completed. Sunflowers are generally tall, making their use in plant designs difficult. However, newly developed sterile and hybrid sunflower varieties contribute to the ornamental field in terms of height (range 0.6 to 2.4 meters) and flower color. Examples of these sterile and hybrid sunflower varieties include Abensonne, Kong, Primrose Stella, Sunbeam, Sunspof, and Velvet Queen. Ornamental sunflower varieties with a height range of 1.0 to 2.0 meters are more preferred for outdoor use (Short et al., 2005).

Plant Area: Varieties with a large projection area were preferred because they cover empty spaces well. However, when covering empty spaces, it is desirable for the p area to be between 50 and 150 cm² for an aesthetically pleasing appearance (Short et al., 2005).

Number of First Flowering Days: To determine the number of days until the first flowering, the number of days from the emergence of the sown seeds until a plant in the plot enters the R-5 growth stage should be determined. It is desirable for ornamental sunflowers that the first flowering occurs as soon as possible.

Number of Days to 50% Flowering: To determine the number of days until 50% flowering in the plot, the number of days from the emergence of the sown seeds until half of the plot enters the

R-5 growth stage should be determined. It is desirable for ornamental sunflowers that 50% flowering occurs as soon as possible. This refers to the day number of R-5 growth period, during which pollination occurs and the petals have a vibrant appearance, thus providing an aesthetic look. It is desirable for ornamental sunflowers that the flowering period lasts as long as possible.

Number of Days to Full Flowering: To determine the number of days until full flowering, the number of days from the emergence of the sown seeds until all the plants in the plot enter the R-6 growth period should be determined. Since the flowers begin to wilt in the R-6 growth period, it is desirable for ornamental sunflowers that full flowering occurs as late as possible.

Head Number: The head number directly affects the number of flowers produced per unit area. For this reason, the high number of heads is important for the cut flower trade.

RESULTS AND DISCUSSION

Based on stem and root diameter evaluations, *H. annuus, H. cusickii, H. debilis, H. deserticola, H. exilis, H. longifolius, H. maximiliani, H. mollis, H. pauciflorus, H. petiolaris* and *H. porteri* are successful in terms of cut flower production, while those other than those mentioned are successful in terms of outdoor ornamental plants (Table 4).

As a result of the plant height observations of species, their plant height varied between 71.00 cm and 325.67 cm; *H. agrestis* (138.33 cm), *H. annuus* (187.67 cm), *H. argophyllus* (166.33 cm), *H. cusickii* (194.33 cm), *H. debilis* (118.67 cm), *H. exilis* (145.00 cm), *H. longifolius* (108.00 cm), H. *mollis* (105.67 cm), *H. niveus* (188.00 cm), *H. nuttallii* (197.67 cm), *H. pauciflorus* (102.33 cm), and H. praecox (130.67 cm) were found to be within the preferred range (Table 4).

Based on plant area results, their plant area varied between 93.67 cm² and 274.00 cm²; and that *H. agrestis* (100.67 cm), *H. argophyllus* (123.33 cm), *H. deserticola* (147.00 cm), *H. longifolius* (150.00 cm), *H. maximiliani* (143.33 cm), *H. mollis* (93.67 cm), *H. niveus* (150.00 cm), *H. petiolaris* (110.00 cm) and *H. porteri* (139.00 cm) species were within the preferred range.

Among the wild sunflower species (18) included in the study, the species with the shortest first flowering time (91 days) were *H. debilis* and *H. pauciflorus*; the species with the longest (202 days) one was *H. atrorubens*. Besides, the species with the shortest 50% flowering time (97 days) were *H. debilis* and *H. pauciflorus*; the species with the longest flowering period (221 days) was determined to be *H. atrorubens*. Based on full flowering flowering days, the shortest one is *H. agrestis* (173.33 days) the longest one is *H. maximiliani* (266.67 days) (Table 4).

Based on head number of observed species, the lowest number of heads (5 units) was determined to be *H. atrorubens*; and the highest number one is *H. atrorubens* (45.67 units). For easier harvesting of cut flowers, stem diameter should be in upright in especially garden ornamental uses (Short et al., 2005). It is recommended that stem diameters of 0.5 to 1.5 cm be considered for cut flowers, and root diameters of 3 cm or more for ornamental plants (Sloan and Harkness, 2006). *H. agrestis* exceeds this limit in terms of stem diameter, but is positively evaluated in terms of root diameter and ranks 16th among wild species for flowering days. Wild sunflower species between 100-200 cm are more preferred (Short et al., 2005), and *H. agrestis* exists within this range.

H. annuus is positively evaluated in terms of both stem diameter and root diameter and ranks 11th among 18 wild sunflower species for flowering days. Wild sunflower species between 100-200 cm are more preferred (Short et al., 2005), and *H. annuus* existed in this range but *H. anomalus* is above. *H. anomalus* is favorably evaluated in terms of stem diameter and root diameter, and ranks 9th among the 18 wild sunflower species observed in terms of flowering days. *H. argophyllus* remains above the limit in terms of stem diameter, is favorably evaluated in terms of root diameter, and ranks 10th among species for flowering days. *H. argophyllus* exists within this range (100-200 cm plant height) (Short et al., 2005). *H. argophyllus* is above the limit in terms of stem

diameter, but is positively evaluated in terms of root diameter and ranks 18th for flowering days. *H. argophyllus* is above the range for plant height (Table 4).
H. cusickii is positively evaluated for stem diameter and root diameter and ranks at 8^{th} among the wild species for flowering days. *H. debilis* did not reach the lower limit in terms of root diameter, but is positively evaluated in terms of stem diameter and ranks 3rd among wild sunflower species for flowering days and both *H. cusickii* and *H. debilis* existed in the preferred range for wild sunflowers. *H. deserticola* did not reach the lower limit in terms of root diameter, but was positively evaluated in terms of stem diameter and ranked 2nd among the 18 wild sunflower species observed in terms of flowering days. Both *H. deserticola* and *H. exilis* existed in this preferred range. *H. exilis* did not reach the lower limit in terms of root diameter, but was positively evaluated for stem diameter and ranked 15th for flowering days (Table 4).
H. longifolius did not reach the lower limit in terms of root diameter, but was positively evaluated in terms of stem diameter and ranked 14th among the 18 wild sunflower species observed in terms of flowering days. *H. longifolius* is in this range but *H. maximiliani* is below in this range for plant height. *H. maximiliani* did not reach the lower limit in terms of root diameter, but was positively evaluated for stem diameter and ranked 1st among the 18 wild sunflower for flowering days.
H. mollis did not reach the lower limit in terms of root diameter, but was positively evaluated in terms of stem diameter and ranked 17th among the 18 wild sunflower species observed in terms of flowering days. Both *H. mollis, H. nuttallii* and *H. niveus* existed within this range for plant height. *H. niveus* remained above the limit in terms of stem diameter, but was positively evaluated for root diameter and ranked 13th among the 18 wild sunflower species observed for flowering days. On the other hand, *H. nuttallii* was negatively evaluated in terms of stem diameter and root diameter and ranked 7th among the 18 wild sunflower species observed in terms of flowering days.
H. pauciflorus did not reach the lower limit in terms of root diameter, but was positively evaluated in terms of stem diameter and ranked 4th among the 18 wild sunflower species observed in terms of flowering days. *H. pauciflorus* in this range but *H. petiolari*s is below for this range for plant height. *H. petiolari*s did not reach the lower limit in terms of root diameter, but was positively evaluated for stem diameter and ranked 6th among the wild sunflower species for flowering days.
H. porteri did not reach the lower limit in terms of root diameter, but was positively evaluated for stem diameter and ranked 5th among the 18 wild sunflower species observed in terms of flowering days. *H. porteri* is below this range while *H. praecox* is in this range. *H. praecox* remained above the limit in terms of stem diameter, but was positively evaluated for root diameter and ranked 12th among the 18 wild sunflower species observed in terms of flowering days (Table 4).

Table 1. The observations of measured traits for ornamental purposes of 18 wild sunflower species in the study.

Species	Stem Diameter (cm)	Root Diameter (cm)	Plant Height (cm)	Plant Total Area (cm)	First Flowering (day)	50% Flowering (day)	%100 Flowering (day)	Total Flowering Days	Head Diameter cm)	Head Number per plant	Seeds per plant
H. agrestis	2,3	4,2	138,3	100,7	95	107	173,3	78,3	18,3	5	48,7
H. annuus	1,5	4	187,7	210	109	113,3	232	121,7	6,5	20,7	177,3
H. anomalus	2,3	6	251	274	108	112,3	236,7	128,3	5,8	27,3	286,3
H. argophyllus	1,9	3,5	166,3	123,3	103	114	230,7	127,7	7,6	19,7	401,0
H. atrorubens	1,9	3,7	325,7	156	202	221	252	50	2,3	45,7	177,0
H. cusickii	1,1	2,5	194,3	175	102	107	232,3	130,3	2,2	22	107,7
H. debilis	0,8	1,9	118,7	152,7	91	97	241,7	150,7	1,9	14	140,0
H. deserticola	0,7	1,3	80,3	147	108	158	265	156,7	1,1	8,3	54,7
H. exilis	0,8	1,9	145	155	111	151	202	91	1,7	17	130,0
H. longifolius	0,9	2,2	108	150	102	141,7	203	101,3	1,4	25,3	68,0
H. maximiliani	0,6	1	71	143,3	103	144	266,7	162,7	1,4	13,7	78,0
H. mollis	0,9	1,8	105,7	93,7	129	159,3	202	73	1,8	25	0,0
H. niveus	2,2	5,3	188	150	98	143,3	202	104	2,2	18	86,7
H. nuttallii	1,6	2,8	197,7	220	108	164,7	242,7	134,7	2,5	20	117,7
H. pauciflorus	0,6	2	102,3	176	91	97	233,7	142,7	2,3	11,3	98,7
H. petiolaris	0,9	1,6	84	110	92	97,3	229,7	138	1,6	10	133,0
H. porteri	1	2	81,7	139	94	101,7	235,3	141,3	1,9	15,7	122,0
H. praecox	1,9	3	130,7	170	101	110	221	120	2,2	16	163,3
Average	1,3	2,9	151,2	161,9	107	128,3	229,3	122,3	3,7	18,2	40,1

The first flowering refers to the days from the emergence to the R-5 growth stage and in ornamental sunflowers, achieving flowering as quickly as possible is desirable. Among the wild species observed in the study, *H. debilis* and *H. pauciflorus* had the shortest first flowering period (91 days), while *H. atrorubens* had the longest one (202 days). For days to 50% flowering (R-5) *debilis* and *H. pauciflorus* had the shortest one (97 days), while *H. atrorubens* had the longest one (221 days). For full blooming (R-6), *H. agrestis* had the shortest full bloom period (173.33 days), while *H. maximiliani* had the longest (266.67 days). The number of days to flowering refers to the number of days in the R-5 developmental stage, during which pollination occurs and the aesthetically pleasing petals are vibrant. A longer flowering period is desirable in ornamental sunflowers. Among the wild sunflower species, *H. atrorubens* had the shortest flowering period (50 days), while *H. maximiliani* had the longest (162.67 days).
According to the study by Sloan and Harkness (2006), in cut flower cultivation, the stem diameter should be between 0.5 and 1.5 cm; For the plant's upright posture and flower quality, it is desirable for the root diameter to exceed 3 cm (Table 5). According to the study by Short et al. (2015), for the plant to flower quickly, it is generally desirable for it to grow shorter than 120 cm (100-200 cm for ornamental sunflowers); and for aesthetic appearance while covering empty spaces, the projection area should be between 50 and 150 cm (Table 6).

Table 5. The evaluation results of stem and root diameters of wild species

Stem diameter (0,5 – 1,5 cm)		Root diameter (3 cm above)	
H. agrestis	**X**	*H. agrestis*	✓
H. annuus	✓	*H. annuus*	✓
H. anomalus	**X**	*H. anomalus*	✓
H. argophyllus	**X**	*H. argophyllus*	✓
H. atrorubens	**X**	*H. atrorubens*	✓
H. cusickii	✓	*H. cusickii*	**X**
H. debilis	✓	*H. debilis*	**X**
H. deserticola	✓	*H. deserticola*	**X**
H. exilis	✓	*H. exilis*	**X**
H. longifolius	✓	*H. longifolius*	**X**
H. maximiliani	✓	*H. maximiliani*	**X**
H. mollis	✓	*H. mollis*	**X**
H. niveus	**X**	*H. niveus*	✓
H. nuttallii	**X**	*H. nuttallii*	**X**
H. pauciflorus	✓	*H. pauciflorus*	**X**
H. petiolaris-	✓	*H. petiolaris*	**X**
H. porteri	✓	*H. porteri*	**X**
H. praecox	**X**	*H. praecox*	✓

Head diameter directly affects the number of seeds. Therefore, the height of the flower head is important for ornamental sunflower seed production. Among the wild sunflower species included in this thesis, H. deserticola had the smallest flower head diameter (1.13 cm); H. agrestis had the largest (18.33 cm). The number of flower heads directly affects the number of flowers produced per unit area. Therefore, the high number of flower heads is important for the cut flower trade. Among the wild sunflower species included in this thesis, H. agrestis had the lowest number of flower heads (5 heads); H. atrorubens had the highest number (45.67 heads).

Table 6. The evaluation results of plant height and plant area of wild species

Plant height (100-200 cm)		Plant area (50 – 150 cm)	
H. agrestis	✓	*H. agrestis*	✓
H. annuus	✓	*H. annuus*	**X**
H. anomalus	**X**	*H. anomalus*	**X**
H. argophyllus	✓	*H. argophyllus*	✓
H. atrorubens	**X**	*H. atrorubens*	**X**
H. cusickii	✓	*H. cusickii*	**X**
H. debilis	✓	*H. debilis*	**X**
H. deserticola	**X**	*H. deserticola*	✓
H. exilis	✓	*H. exilis*	**X**
H. longifolius	✓	*H. longifolius*	✓
H. maximiliani	**X**	*H. maximiliani*	✓
H. mollis	✓	*H. mollis*	✓
H. niveus	✓	*H. niveus*	✓
H. nuttallii	✓	*H. nuttallii*	**X**
H. pauciflorus	✓	*H. pauciflorus*	**X**
H. petiolaris	**X**	*H. petiolaris*	✓
H. porteri	**X**	*H. porteri*	✓
H. praecox	✓	*H. praecox*	**X**

CONCLUSIONS

Among observed the wild sunflower species; there are results in the study. The shortest first flowering time (91 days) were determined as *H. debilis* and *H. pauciflorus*, the longest (202 days) one was *H. atrorubens.* The shortest 50% flowering time (97 days) was *H. debilis* and *H. pauciflorus*, the longest (221 days) one was *H. atrorubens.* The shortest full bloom time (173.33 days) was *H. agrestis*, the longest (266.67 days) one was *H. Maximiliani*. The smallest head diameter (1,13 cm) was *H. deserticola*, the tallest was (18,33 cm) *H. agrestis.* The lowest head number per plant (5) was *H. agrestis*, the highest head diameter (45.67) was *H. atrorubens.*
Based on the evaluation of stem diameter; those between 0.5 and 1,5 cm are suitable for cut flower; for stem diameter of 1.5 cm or more are suitable for outdoor ornamental use. According to this evaluation, *H. annuus, H. cusickii, H. debilis, H. deserticola, H. exilis, H. longifolius, H. maximiliani, H. mollis, H. pauciflorus, H. petiolaris*, & *H. porteri* suggested to use for cut flower production, while the remaining (7) species could be used as outdoor ornamental plants.

REFERENCES

Alberio, C., Izquierdo, N. G., & Aguirrezábal, L. A. N. (2015). Sunflower crop physiology and agronomy. In *Sunflower* (pp. 53–91). AOCS Press. https://doi.org/10.1016/B978-1-63067-036-8.50006-1

Alimohammadi, R., & Azizov, I. (2019). Correlation analysis of yield and yield components in sunflower (*Helianthus annuus L.*) cultivars under different leaf removal. *World Journal of Environmental Biosciences, 8*(3), 33–37.

Cvejic, S., Jocic, S. (2010). Development of ornamental sunflower hybrids. Field Veg Crop Res, 47(1):147–152.

Cvejić, S., Jocić, S., Mladenović, E., Jocković, M., Miladinović, D., Imerovski, I., Dimitrijević, A. 2017. Evaluation of combining ability in ornamental sunflower for floral and morphological traits, Czech J. Genet. Plant Breed.

Cvejić, S., Ćuk, N., Babec, B., Jocić, S., & Miladinović, D. (2025). Advances in breeding, biotechnology and molecular biology in ornamental sunflower (*Helianthus annuus L.*). In *Breeding of Ornamental Crops: Annuals and Cut Flowers* (pp. 107–141). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-61599-3_6

Cutler, K. D. 1997. The complete vegetable and herb gardener: A guide to growing your garden organically, MacMillan, New York, NY.

Divita M. E., Salaberry M. T., Echeverría M. M. & Rodríguez R. H. (2012). Genetic and environmental effects of some traits of ornamental value in sunflower (*Helianthus annuus* L.). In Proc. 18th Int. Sunflower Conf., Mar del Plata. 566 – 574.

Hayata, Y., Imaizumi, Y. (2000). Effect of photoperiod on flower bud development of ornamental sunflowers (*Helianthus annuus* L.), J. Jpn. Soc. Hort. Sci., 69:708-710.

Fick, G. N., & Miller, J. F. (1997). Sunflower breeding. In A. A. Schneiter (Ed.), *Sunflower Technology and Production* (Vol. 35, pp. 395–439). ASA, CSSA, and SSSA.

Jocić, S., Miladinović, D., & Kaya, Y. (2015). Breeding and genetics of sunflower. In *Sunflower* (pp. 1–25). AOCS Press. https://doi.org/10.1016/B978-1-63067-036-8.50001-2

Kaya Y., (2014). Sunflower. A. Pratap. (Ed) Alien Gene Transfer in Crop Plants, Vol. 2. Springer Press. 281-315.

Kaya, Y., R. Vasilevska-Ivanova. (2021). Wild Sunflowers: The Primary Genetic Resource for Sunflower Breeding. In: Wild Germplasm for Genetic Improvement in Crop Plants. Editors: M. T. Azhar, S. H. Wani. Elsevier Academic Press Publishers, Inc. 153-186.

Kaya, Y., N. Beşer. (2022). Yabani Ayçiçeği Türlerinin Ayçiçeği Islahında Kullanım Olanakları. Ziraat, Orman ve Su Ürünleri Alanında Yeni Trendler. Editör: Nilda Ersoy, Duvar Yayınları. 611-628.

Kaya, Y. (2022). The Use of Wild Sunflower (*Helianthus spp*) Species on Sunflower Breeding for Future. International Workshop "Impact of the climate changes, on the Agroforest Biodiversity". Bucharest, Romania. 14 April, 1-9.

Kaya, Y. (2023). Wild Sunflowers: A Promising Habitat for Environments in Europe. 34th Milan International Conference on "Nanotechnology, Materials, Biology & Environmental Sciences" (BNMBE-23). 14-16 June 2023, Milano, Italy. 30-35.

Marek, L. F. (2019). Crop wild relatives of sunflower in North America. In S. L. Greene, K. Khoury, N. R. Vorsa, & A. M. McClung (Eds.), *North American crop wild relatives, Volume 2: Important species* (pp. 453–483). Springer International Publishing. https://doi.org/10.1007/978-3-319-97121-6_20

Meral, Ü. B. (2019). Ayçiçeği (*Helianthus annuus L.*) bitkisinin önemi ve üretimine genel bir bakış. *International Journal of Life Sciences and Biotechnology, 2*(2), 58–71. https://doi.org/10.38001/ijlsb.574414

Pilorgé, E. (2020). Sunflower in the global vegetable oil system: Situation, specificities and perspectives. *OCL, 27,* 34. https://doi.org/10.1051/ocl/2020027

Puttha, R., Venkatachalam, K., Hanpakdeesakul, S., Wongsa, J., Parametthanuwat, T., Srean, P., ... & Charoenphun, N. (2023). Exploring the potential of sunflowers: Agronomy, applications, and opportunities within bio-circular-green economy. *Horticulturae, 9*(10), 1079. https://doi.org/10.3390/horticulturae9101079

Secerov-Fiser, V., Skoric D. (1988). Inheritance of flower color and morphology in ornamental sunflower. In: Proc. 12th Int. Sunfl. Conf., Novi Sad, Yugoslavia. 25-29 July. p. 442.

Sharypina, Y. Y., Popov, V. N., Dolgova, T. A., & Kirichenko, V. V. (2008). A study of the inheritance of morphological characters in sunflower. 1. Genetic control of coloration of pseudo-ligulate flowers, branchiness, and restoration of pollen fertility. *Cytology and Genetics, 42*(5), 329–334. https://doi.org/10.3103/S0095452708050054

Short, K., Etheredge, C. L., & Waliczek, T. M. (2017). Studying the market potential for specialty cultivars of sunflower cut flowers. *Hort Technology, 27*(5), 611–617. https://doi.org/10.21273/HORTTECH03703-17

Silva, S. D., Beckmann-Cavalcante, M. Z., Souza, G. D., Oliveira, T. D., Lima, R. D. R., & Chaves, A. D. M. (2018). Growth of ornamental sunflowers in two growing seasons under semiarid conditions. *Ornamental Horticulture, 24*(3), 231–238. https://doi.org/10.14295/oh.v24i3.1129

Sloan, R. C., & Harkness, S. S. (2006). Field evaluation of pollen-free sunflower cultivars for cut flower production. *Hort Technology, 16*(2), 324–328. https://doi.org/10.21273/Horttech.16.2.324

Sooch, B. S., Lugani, Y., & Singh, R. S. (2019). Agro-industrial lignocellulosic residues for the production of industrial enzymes. In R. S. Singh (Ed.), *Industrial biotechnology: Plant systems, resources and products* (pp. 31–50). De Gruyter STEM. https://doi.org/10.1515/9783110563085-003

Wien, H.C. (2016). Pinching ornamental sunflowers increases cut stem yield and reduces flower size, Hort Technology, 26: 762-766.

Zhuykov, O. G., Lavrenko, S. O., Lavrys, V. Y., & Kotovska, J. S. (2024). Formation of economically valuable traits by hybrids of the sunflower (*Helianthus annuus ornamentalis* (Multiflorus)) under organic growing technology. *Ukrainian Journal of Ecology, 14*(1), 45–52. https://doi.org/10.15421/2024_7

THE SITUATION OF OIL TYPE SUNFLOWER PRODUCTION IN TURKEY

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ABSTRACT

Sunflower (*Helianthus annuus* L.) constitutes the main oil crop, encompassing a cultivated area of 974,000 hectares that yielded 2.2 million metric tons of seed during the 2024/25 season in Turkey. Leading production occurred in provinces including Tekirdağ, Adana, Konya, and Kırklareli in 2024, paralleling an edible oil self-sufficiency rate of 72% achieved in 2023/24. The 2025 season, however, witnessed a pronounced decline to roughly 2 million tons of seed output, attributable to widespread abiotic stresses. Turkey relies chiefly on crude sunflower seed imports from Romania, Bulgaria, and Moldova, whereas refined sunflower oil exports target Iraq, Syria, Algeria, and Bulgaria. Yield reductions in Turkey and Eastern Europe stemmed from extended drought spanning vegetative growth and preceding dry winters, with the Trakya region representing nearly half of national acreage in European Turkey—experiencing over 50% losses in 2025, mirroring the prior year. Similar drought impacts compromised output in Central Anatolia and the Çukurova region. Agronomic countermeasures, such as early sowing to hasten maturity and deployment of drought-resilient cultivars, warrant prioritization to alleviate these recurrent deficits.

Keywords: Sunflower production, Turkey, Adaptation, Drought

INTRODUCTION

Oilseeds constitute essential inputs, raw materials, and employment generators across diverse sectors in Turkey; however, domestic output lags behind escalating consumption fueled by population growth, compelling heavy reliance on imports. Turkey's advantageous geopolitical positioning and advanced processing capacities enable competitive exports of value-added commodities like refined oils and margarine, with recent volumes exceeding $1 billion annually notwithstanding regional instabilities.

Sunflower (*Helianthus annuus* L.) predominates as Turkey's leading oilseed, typically sown in summer and thereby susceptible to episodic heatwaves and drought, which induce marked year-to-year yield fluctuations. Its genetic adaptability and low labor inputs facilitate cultivation in varied global and domestic edaphoclimatic zones. While predominantly rainfed under semiarid regimes, irrigated systems yield 2–3-fold higher seed outputs; nonetheless, surging per capita demand undermines self-sufficiency, with drought events compounding supply vulnerabilities.

CURRENT STIUATION SUNFLOWER PRODUCTION IN THE WORLD

Sunflower ranks as a pivotal oilseed globally, underpinning production of vegetable oil, protein-rich meal, and biodiesel feedstocks. The majority of harvested seeds undergo processing for oil extraction, with residual fractions allocated to snack consumption, thereby sustaining dual roles in industrial and direct human nutrition sectors.
In the 2023/2024 marketing year, sunflower accounted for 8.3% of global oilseed output totaling 657 million metric tons, cultivated across 27.8 million hectares. Seed yield advanced

7.5% year-over-year to 2.01 metric tons per hectare, propelling production 6.1% higher to 55.9 million MT.

This upsurge stemmed principally from Ukraine's 27.7% production rebound among leading producers, alongside gains of 6.2% in Russia and 7.4% in the European Union, offset by Argentina's 22.4% contraction. The ongoing Russia-Ukraine conflict, initiated in 2022 and involving nations comprising ~58% of global sunflower supply, curtailed Ukrainian acreage and sowed logistical disruptions persisting into 2023/2024. Russia, Ukraine, the European Union, and Argentina dominate cultivation, encompassing 79.9% of planted area and 83.2% of output; per USDA estimates, their combined 2023/2024 contributions totaled 46.6 million tons, 17.1 million from Russia, 15.5 million from Ukraine, 10.1 million from the EU, and 3.9 million from Argentina.

Table 1. World sunflower seed supply and demand (Source: USDA (Accessed: 10.10.2025)

	2020/21	2021/22	2022/23	2023/24	2024/25
Area (1000 Ha)	26.770	28.537	28.295	27.832	28.130
Production	48.871	56.858	52.776	56.004	52.048
Yield (ton/ha)	1,83	1,99	1,87	2,01	1,85
Consumption	49.233	51.332	56.233	56.701	52.234
Ending stocks	2.405	7.821	4.120	3.253	3.068
Import	2.723	3.832	3.773	2.537	2.633
Export	2.952	3.942	4.017	2.707	2.632
Export Price ($/ton)	685	763	537	491	647

Sunflower harvest timing in Argentina offsets seasonal supply shortfalls from Russia and Ukraine, underscoring the pivotal role of these three nations in sustaining continuous global sunflower availability across production cycles. Their coordinated contributions foster stability in sunflower supply dynamics. Despite a 6.1% production increment in the 2023/2024 marketing year, aggregate global sunflower seed supply contracted 2.7% to 62.6 million metric tons, attributable to a 47.3% depletion in opening stocks and a 32.7% reduction in imports (USDA, 2025).

Sunflower oil ranks as the fourth most prominent vegetable oil worldwide, trailing palm, soybean, and canola oils; within total global vegetable oil output of 222 million tons for 2023/2024, sunflower oil comprised 9.9%. According to USDA estimates, of the 22.1 million metric tons of sunflower oil generated in the 2023/2024 marketing year, Russia and Ukraine each contributed 6.8 million tons, followed by 3.9 million tons from the European Union and 1.7 million tons from Argentina. Parallel to the expansion in sunflower seed output, global sunflower oil production rose relative to the prior season. World sunflower oil supply, recorded at 37.1 million tons in 2022/2023, advanced 5.7% to 39.2 million tons in 2023/2024, driven by increments of 9.9% in imports, 1.9% in production, and 16.5% in opening stocks (USDA, 2025).

Sunflower oil futures escalated to approximately $1,435 per metric ton, attaining a peak unseen in over three years, amid supply constraints originating in the Black Sea region. Reports from regional exporters and consultancies highlight aerial impairments, port operational interruptions, and export curtailments by Ukraine and Russia, collectively diminishing short-term seed availability while elevating freight surcharges. Robust demand for edible oils, compounded by biofuel blending mandates, has propelled market clearance at elevated price levels, with sunflower oil appreciating roughly 12% year-to-date amid sustained physical procurement (Anonymous, 2025). Although expanded output from South America and the European Union has mitigated portions of the deficit, residual pressures maintain constrained seed supplies and enhanced processing margins (Figure 1 and 2).

Table 2. World sunflower oil supply, demand and balance

	2021/22	2022/23	2023/24	2024/25 (Estimate)	2025/26 (Estimate)
SUPPLY					
Starting Stocks	2.112	2.765	3.221	2.910	2.750
Production	19.680	21.708	22.126	20.067	21.305
Imports	9.718	12.616	13.863	11.759	12.168
Total Supply	31.510	37.089	39.210	34.736	36.223
USAGE					
Exports	11.221	14.313	15.337	13.088	13.620
Consumption	17.524	19.555	20.963	18.898	20.030
Industrial Consumption	1.017	1.076	1.087	1.037	1.012
Food Consumption	16.425	18.391	19.788	17.773	18.940
Feed Consumption	82	88	88	88	78
Ending Stocks	2.765	3.221	2.910	2.750	2.573
Total Usage	31.510	37.089	39.210	34.736	36.223

Source: USDA (Accessed: 10.10.2025)

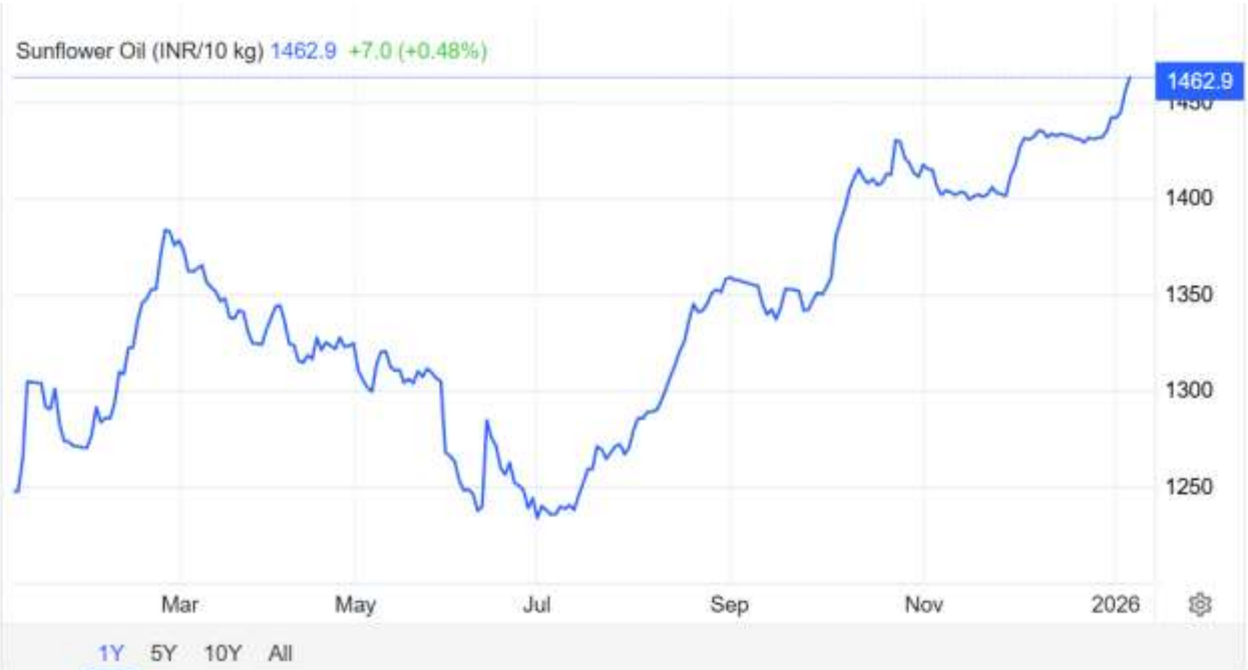

Figure 1. Sunflower Crude oil Prices in 2025 (https://tr.tradingeconomics.com/commodity/sunflower-oil)

Figure 2. Sunflower Crude oil Prices in the last five years

CURRENT STIUATION SUNFLOWER PRODUCTION IN TURKEY

There were terrible climatic conditions in sunflower vegetation period in 2025 in Turkey. When it looked the Figure 3, almost all sunflower areas affected from drought conditions (Figure 4).

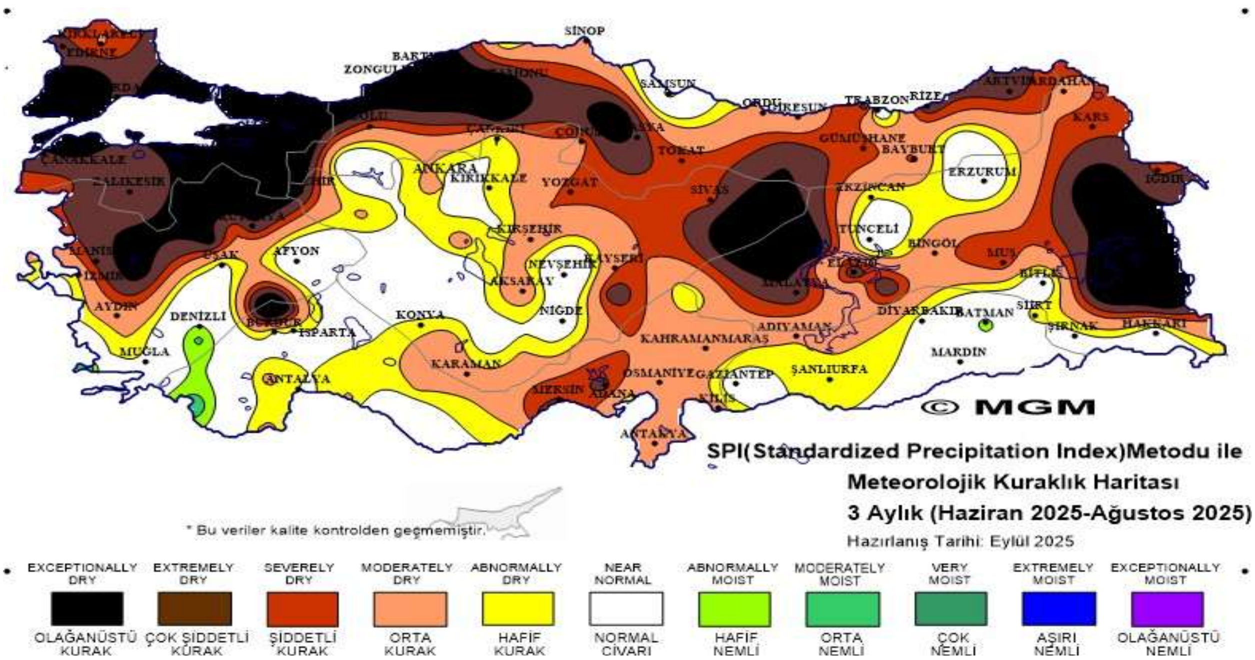

Figure 3. Turkey Drought Map during the vegetation period in sunflower
Source: Meteorology General Directorate in Turkey (https://www.mgm.gov.tr/veridegerlendirme/kuraklik-analizi.aspx)

Figure 4. Sunflower fields affected from drought conditions

In Turkey, interannual sunflower yield variability constitutes a primary constraint, driven predominantly by drought and elevated temperatures during critical growth phases. Elevated market prices of rotationally competitive cereals wheat under rainfed regimes and maize under irrigated systems have further impeded anticipated production expansion despite extant policy incentives. Cultivation predominantly concentrates in the Trakya-Marmara region, though recent expansions have notably advanced in secondary domains, particularly Çukurova, thereby diversifying national acreage distribution. Such areal increments in hitherto marginal provinces promise substantive augmentation of domestic output, mitigating reliance on imported seed

stocks. In irrigated locales, exemplified by Konya and proximate districts, exceptional yields underscore the efficacy of refined agronomic practices; augmented producer proficiency, coupled with stress-mitigating techniques, positions Turkey to routinely attain the global benchmark of 5 metric tons per ha (Anonymous, 2025).
Table 3 illustrates progressive expansions in sunflower cultivation areas and production volumes across Turkey. Nonetheless, yields have substantially declined in recent years, attributable to elevated temperatures and drought prevalence, with pronounced impacts in rainfed production zones.

Table 3. Sunflower oilseed statistics for the last 10 years of our country (TUIK 2025)

Years	Cultivated Area (ha)	Production (Metric Ton)	Yield (kg/da)
2015	568.995	1.500.000	264
2016	616.780	1.500.000	244
2017	681.398	1.800.000	264
2018	648.934	1.800.000	277
2019	675.983	1.950.000	289
2020	650.860	1.900.000	292
2021	811.312	2.215.000	273
2022	900.518	2.350.000	261
2023	864.668	1.960.000	227
2024	854.924	1.855.000	218
2025	974.000	2.194.000	225

Tekirdağ, Edirne, Kırklareli, Adana, and Konya rank as the principal provinces for sunflower cultivation in Turkey. These regions collectively account for 60% of national sunflower acreage (Table 4).
Table 4. Most important provinces in our country for sunflower cultivation (TUİK 2024)

	2022			2023			2024		
Provinces	Plant Area (1000 da)	Production (1000 ton)	Yield (kg/da)	Plant Area (1000 da)	Production (1000 ton)	Yield (kg/da)	Plant Area (1000 da)	Production (1000 ton)	Yield (kg/da)
Tekirdağ	1.710	336	196	1.746	201	115	1.688	290	172
Edirne	1.260	326	259	1.294	258	199	1.266	174	137
Kırklareli	970	228	235	977	190	195	970	184	194
Adana	738	223	302	746	241	323	739	203	275
Konya	675	255	378	455	165	363	534	192	359

Oilseed sunflower predominates among oilseeds in Turkey, supplying 80–85% of domestic vegetable oil needs through its elevated oil content of up to 40%, thereby emerging as a strategic commodity for alleviating production deficits. Despite favorable climatic and edaphic conditions, untapped potential persists owing to insufficient acreage expansion and stagnant yields. Principal impediments encompass elevated input costs hindering competitiveness against imported commodities, diminished per-hectare returns relative to wheat and alternative rotations amid unfavorable price parities, and depressed global crude oil quotations undermining local viability.

Production centers in the Thrace region and Konya province, where irrigated systems prevail and pathosystems such as broomrape remain subdued, consistently surpass national productivity benchmarks. Per Turkish Statistical Institute (TÜİK) 2023 records, Tekirdağ (20.2%), Edirne (15.0%), Kırklareli (11.3%), Adana (8.6%), and Çorum (5.6%) collectively occupy 60.7% of cultivation area; production leadership vests in Edirne (13.1%), Adana (12.3%), Tekirdağ (10.3%), Kırklareli (9.7%), and Konya (8.4%).

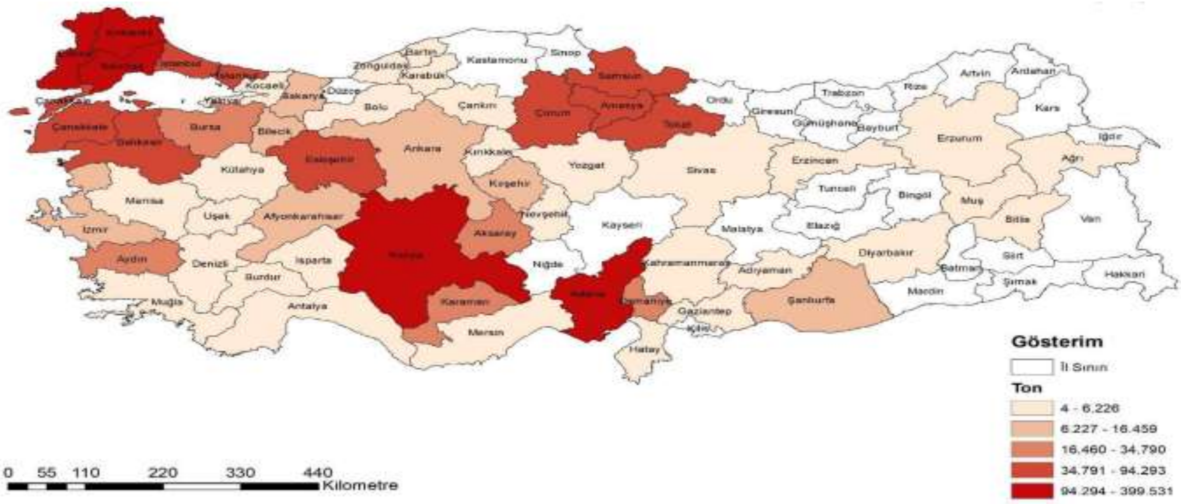

Figure 5. Turkey Sunflower planting areas by province

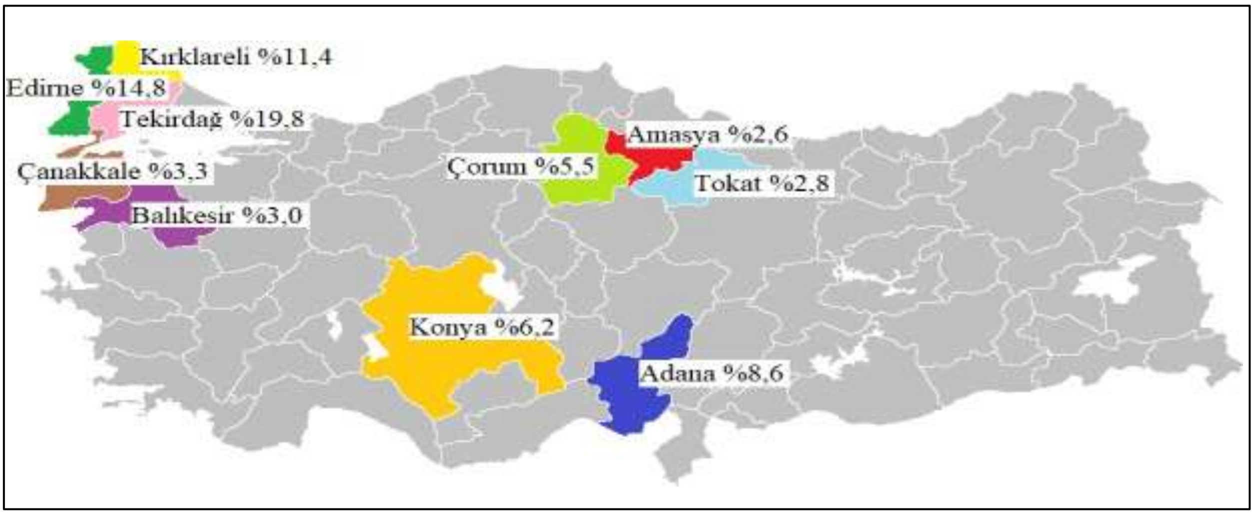

Figure 6. Main provinces planted sunflower areas in Turkey

Sunflower's adaptability sustains its cultivation across global agroecologies and Turkish provinces, primarily as an oilseed but also for snack, aviculture, and ornamental purposes; in Turkey, post-extraction meal enriches compounded livestock feeds via its protein bounty. Domestic shortfalls, unmet by local output, necessitate imports, underscoring sunflower's pivotal industrial and economic stature in national agriculture. The accompanying map illustrates the spatial distribution of sunflower output in Turkey, classifying provincial production into five tonnage categories for comparative analysis of regional intensity. Darker color gradations denote higher outputs, concentrated in Thrace, Central Anatolia, and select Mediterranean provinces benefiting from favorable climate, arable land, and infrastructure, while eastern and mountainous areas remain marginal due to topographic, climatic, and competitive constraints.

As of the 2023/2024 production season, Turkey's total sunflower seed requirement is estimated at 6.1 million tons, while domestic supply amounts to 2.7 million tons. In this period, total sunflower seed supply declined by 25.1% relative to the previous season, primarily due to reduced output and a 65.1% contraction in seed imports. Consequently, only 35.9% of national demand was met through domestic production, indicating 64% import dependency for sunflower seed in 2023/2024 (Anonymous, 2025). High stock levels in the domestic market contributed to the sharp decrease in imports, and nearly all of the 2.5 million tons of seed utilized during the season were crushed by the oilseed processing industry (Table 5).

Table 5. Turkish Sunflower seed Balance (TUİK 2024)

	2019/20	2020/21	2021/22	2022/23	2023/24
Area (bin ha)	752	728	901	980	953
Yield (kg/da)	279	284	268	260	231
Production	2.100	2.067	2.415	2.550	2.198
Consumption	3.466	3.281	4.021	4.935	3.033
Stock change	-21	-121	16	22	69
Import	3.301	3.135	4.406	5.830	4.592
Export	1.939	2.025	2.764	3.402	3.671
Self Suf. (%)	60,1	62,5	59,6	51,3	71,9

For the 2025/26 marketing year, sunflower seed ending stocks are projected at 110,000 MT, reflecting a modest rebuilding of inventories. In contrast, the 2024/25 sunflower seed stock estimate has been revised down to 60,000 MT, following a reported increase in crushing activity in the final quarter driven by concerns over prospective seed shortages in the market (Table 6).

Table 6. Turkish Sunflower seed Production, Supply and Distribution (USDA)

Sunflower seed	2023/2024		2024/2025		2025/2026	
Market Year Begins	Sep 2023		Sep 2024		Sep 2025	
Area Planted (1000 HA)	750	750	690	690	750	760
Area Harvested (1000 HA)	700	700	690	690	760	760
Beginning Stocks (1000 MT)	168	168	142	142	140	60
Production (1000 MT)	1550	1550	1350	1350	1600	1200
MY Imports (1000 MT)	328	328	800	800	500	1000
Total Supply (1000 MT)	2046	2046	2292	2292	2240	2260
MY Exports (1000 MT)	102	102	200	180	100	100
Crush (1000 MT)	1600	1600	1750	1850	1800	1850
Food Use Dom. Cons. (1000 MT)	200	200	200	200	200	200
Feed Waste Dom. Cons. (1000 MT)	2	2	2	2	2	0
Total Dom. Cons. (1000 MT)	1802	1802	1952	2052	2002	2050
Ending Stocks (1000 MT)	142	142	140	60	138	110
Total Distribution (1000 MT)	2046	2046	2292	2292	2240	2260
Yield (MT/HA)	2.2143	2.2143	1.9565	1.9565	2.1053	1.5789

Sunflower Meal

Sunflower seed meal production for **MY 2024/25** has seen a slight upward revision, reaching nearly **1.0 million metric tons (MMT)**. This increase is attributed to stronger crush demand in the last quarter, driven by concerns over a potential shortage of sunflower seeds in the market. Looking ahead to **MY 2025/26**, sunflower seed meal consumption is projected to be just over **2.0 MMT**, remaining almost flat year-on-year. Approximately half of this consumption is expected to be met through imports, assuming consistent demand from the compound feed sector. **MY 2025/26:** Sunflower meal imports are forecast at approximately **1.05 MMT**, unchanged from the previous year. **MY 2024/25:** The import estimate has been adjusted downwards to **1.05 MMT**, based on recent trade data. Between September and July of **MY 2024/25**, sunflower seed meal imports totaled around **983,000 metric tons**, which is about 20% lower than the same period in the previous year. The primary suppliers during this period were Russia (883,000 MT), Ukraine (80,500 MT), and Romania (15,000 MT). These imports were primarily for domestic use rather than re-export (USDA, 2025).

Sunflower Oil

Production: For **MY 2025/26**, Türkiye's sunflower seed oil production is projected to remain stable at approximately **805,000 metric tons (MT)**, consistent with the revised estimate for **MY 2024/25**. The upward adjustment for the prior year was a result of crushers intensifying operations in the final quarter. This surge was driven by a temporary 25% increase in seed prices, which was itself triggered by concerns over potential domestic and regional supply shortages.

Consumption: **MY 2025/26** is expected to see a year-on-year increase in sunflower oil consumption, reaching around **1.4 million MT**. This anticipated rise is primarily due to reduced olive oil availability, as it is an off-year in the olive cycle, coupled with consistent demand from the broader vegetable oil market. In contrast, **MY 2024/25** consumption declined to nearly **1.2 million MT**, a 200,000 MT drop from the previous year. This decrease was largely attributed to an abundant domestic olive oil supply, despite sunflower oil maintaining its position as Türkiye's preferred cooking oil due to its cost-effectiveness.

Price Dynamics: During the summer of the current calendar year, retail prices for sunflower oil experienced a significant jump, rising from 60 to 80 Turkish Lira per liter (approximately $2/liter). This price hike was fueled by anxieties regarding curtailed seed output in both Türkiye and the Black Sea region. In response, the Turkish Grain Board intervened in September with a tender for 18,000 MT of crude sunflower oil. Additionally, tariff-rate quotas were implemented, and duties were lowered to enhance supply and alleviate price pressures (USDA, 2025).

Imports: Sunflower seed oil imports for **MY 2025/26** are projected to increase by 300,000 MT year-on-year, reaching **1.55 million MT**. This rise is intended to compensate for the reduced domestic output from crushing, assuming stable re-export activities. A recent tariff reduction to 30% from early October is expected to facilitate this increase. For **MY 2024/25**, imports were revised downwards to **1.25 million MT**. Between September and July of MY 2024/25, imports stood at approximately **1.2 million MT**, which was 19% lower than the same period in the preceding year. The main suppliers were Russia (685,000 MT) and Ukraine (348,000 MT). During this period, crushers showed a preference for local seeds due to late-season regional supply tightness (USDA, 2025).

Table 6. Sunflowers Oil Production, Supply and Distribution (USDA)

Oil, Sunflowerseed	2023/2024		2024/2025		2025/2026	
Market Year Begins	Sep 2023		Sep 2024		Sep 2025	
Crush (1000 MT)	1600	1600	1750	1850	1800	1850
Beginning Stocks (1000 MT)	611	611	169	169	141	34
Production (1000 MT)	696	696	762	805	784	805
MY Imports (1000 MT)	1491	1491	1300	1250	1300	1550
Total Supply (1000 MT)	2798	2798	2231	2224	2225	2389
MY Exports (1000 MT)	1189	1189	950	950	725	900
Industrial Dom. Cons. (1000 MT)	25	25	25	25	0	25
Food Use Dom. Cons. (1000 MT)	1400	1400	1100	1200	1325	1325
Feed Waste Dom. Cons. (1000 MT)	15	15	15	15	15	15
Total Dom. Cons. (1000 MT)	1440	1440	1140	1240	1340	1365
Ending Stocks (1000 MT)	169	169	141	34	160	124
Total Distribution (1000 MT)	2798	2798	2231	2224	2225	2389

Türkiye's sunflower seed oil exports are projected to decrease to 900,000 MT in MY 2025/26 due to growing competition from other vegetable oils like soybean oil, despite stable demand from traditional buyers. MY 2024/25 exports were 950,000 MT, with a 17% drop between September and July, as some customers switched to Turkish soybean oil (often from U.S. soybeans) for price reasons. Ending stocks for MY 2025/26 are forecast to sharply increase to 124,000 MT from 34,000 MT in the previous year, following aggressive domestic seed procurement by crushers (USDA, 2025).

Historically, Türkiye imports about 70% of its vegetable oil needs, with imports of both oilseeds and crude oils. Despite significant processing capacity, only about half is utilized. Prioritizing seed imports over crude oil could boost domestic value addition and capacity use. Rising per capita vegetable oil consumption, coupled with expanding exports and insufficient domestic production, is widening Türkiye's structural deficit and increasing import reliance. The dominance of crude oil imports limits domestic value addition and processing capacity utilization. Furthermore, Turkish-partnered oil processing facilities in Russia and Ukraine have led to increased crude oil imports, hindering Türkiye's crushing potential and increasing external dependence.

CONCLUSIONS

Production Challenges: Recurrent droughts in Central Anatolia, Çukurova, and Trakya have caused yield deficits exceeding 50%. Consequently, Turkish sunflower output is projected to contract by 17.6% to 1.8 million tons as farmers shift to more drought-tolerant crops like canola and barley.
Global Trends: While global acreage expanded slightly in 2024/25, production fell by 6.3% to 52.4 million tons. Despite this, global sunflower oil supply remains significant at 58.4 million tons.

Turkey's Import Reliance: Turkey's domestic production currently meets only about 36-37% of its total demand. To bridge this gap, the country relies heavily on imports, with projected inflows of 789,000 tons of seed and 1.2 million tons of crude oil for the 2024/25 period.

Economic Impact: Despite these challenges, the sunflower sector remains a cornerstone of Turkey's agricultural economy, supporting nutrition, employment, and international trade.

REFERENCES

Anonymous, 2025. Sunflower Product Report. Turkish Agriculture and Forestry Ministry.

Meteorology General Directorate in Turkey. 2025. Accessed 10.10.2025. https://www.mgm.gov.tr/veridegerlendirme/kuraklik-analizi.aspx

USDA Oilseeds and Product Update. 2025. Accessed 10.10.2025. https://www.fas.usda.gov/data/turkey-oilseeds-and-products-update-18

TUIK.2025 Bitkisel Üretim İstatistikleri https://data.tuik.gov.tr/Bulten/Index?p=Bitkisel-Uretim-Istatistikleri-2025-53939 Accessed 10.10.2025

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