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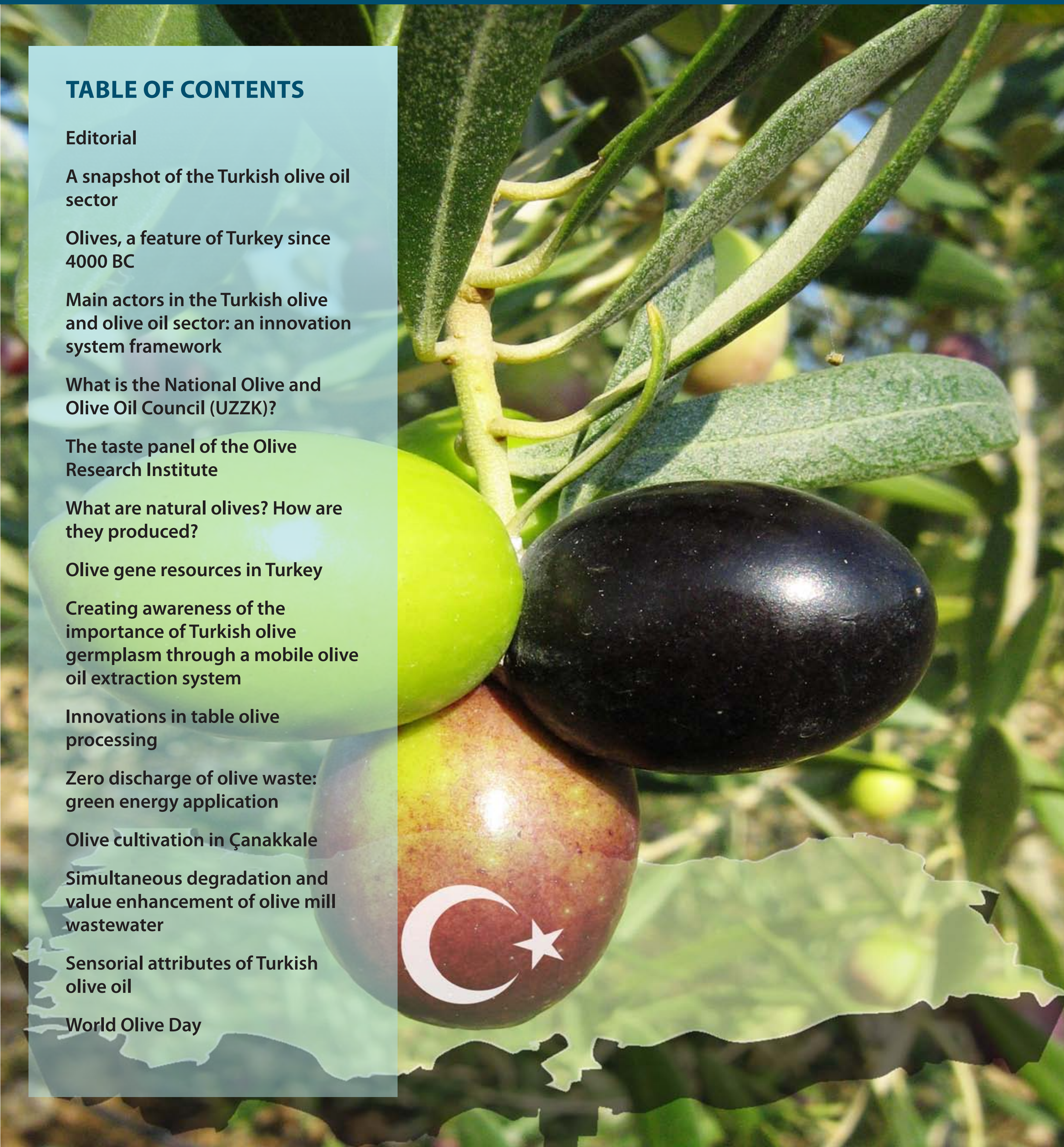

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Príncipe de Vergara, 154
28002 Madrid, Spain
Tel.: 34-915 903 638
Fax: 34-915 631 263
E-mail: iooc@internationaloliveoil.org
Web: www.internationaloliveoil.org

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Editorial

Dear Readers,

It is an honour for me to present *Olivae* Issue No. 123, which is a special focus issue on Turkey.

This special edition of *Olivae,* the official journal of the International Olive Council (IOC), has been made possible by the generous contribution of the Republic of Turkey, an outstanding Member of the IOC. It provides a wide and comprehensive panorama of the olive sector in Turkey, including all its activities and actors. Turkey has accordingly been the first country to comply *ante litteram* with one of the objectives of the new Agreement, which will enter into force in January 2017, and which calls on IOC Members "*to enhance the role of the International Olive Council as a world documentation and information centre about the olive tree and its products*" (Chapter 1, Article 1. 3).

The new International Agreement on Olive Oil and Table Olives, 2015, is the IOC's *Constitutional Charter*. Applying for membership under the new Agreement is an undertaking of firm responsibility for, and involvement in, the IOC's life and future. Turkey has so far been one of the few countries to deposit the corresponding instruments of ratification of the Agreement, which speaks volumes about Turkey's key role in our Organization.

Articles on the Turkish olive oil sector and innovations in table olive processing; papers of high scientific value on olive oil chemistry and the enhancement of olive mill wastewater; and a presentation of the structure and role of the Turkish Olive Oil Council (UZZK), are just a few examples of the 12 articles that make up this special edition, which is a unique issue in the life of this journal.

The steady cooperation offered by the Turkish authorities and Turkish researchers has resulted in an *Olivae* Issue No. 123, Special Focus on Turkey, that gathers the most complete overview of the olive oil and table olive sector ever offered by a member country. We have indeed never published such an extensive, complete and rich version of the journal.

At the end of this issue, you will find a declaration that is not strictly in keeping with its general focus. Turkey, nevertheless, generously offered to cover this recall on the occasion of "World Olive Day 2016", to enhance this common message for the benefit of the International Olive Council and all its member countries.

As Executive Director, I hope that this example will be followed by other member countries in order to establish this journal as the real voice of the Organization. This will only be possible if each and every country participates in this project in the same way that Turkey has done: effectively, with dedication and enthusiasm, offering the best articles by its best researchers, and working in cooperation with the Executive Secretariat. I therefore take this opportunity to express my deepest gratitude to Turkey and I hope that future *Olivae* issues will receive contributions and support from other member countries with the same generous dedication shown by Turkey to No. 123. Thank you.

A snapshot of the Turkish olive oil sector

The olive has been a symbol of Mediterranean civilisation throughout history and has been long established in Turkey. In fact, south-east Anatolia is known to be the cradle and gene centre of the olive, a claim that is corroborated by subspecies of olive found in a line stretching from Hatay to Kahramanmaraş and Mardin. From south-east Anatolia, this noble tree spread to west Anatolia, then fanning out to Greece, Italy, and Spain via the Aegean Islands.

The olive tree is commonly acknowledged to be the very first tree of all. It is mentioned in all the major sacred writings and has been used since 6000 BC, according to archaeological and geological findings. The first method of olive oil production was to crush the olives underfoot and then extract the oil from the mash with hot water. The oldest olive oil facility, dating back to 600 BC, can be found at the ancient settlement of Klazomenai in west Anatolia, in the Urla district near the city of Izmir.

Like elsewhere around the Mediterranean, olive oil is a very important foodstuff in Turkey and takes pride of place in Turkish cuisine. In the early 2000s, Turkey had 100 million olive trees. By the 2014/15 season, new plantings increased this number to 169 million. On average, Turkey has produced 170 000 t of olive oil and 527 000 t of table olives over the last five crop years. Olive growing is concentrated around the towns of Aydın, İzmir, Muğla, Balıkesir, Bursa, Manisa, Çanakkale, Gaziantep and Mersin and in the regions of the Aegean, Marmara and south-east Anatolia. Turkey has a very rich heritage of native varieties. Generally speaking, Edremit (Ayvalık) is the predominant variety in the north of Turkey's olive growing area and Memecik in the south. The Gemlik variety is largely produced and consumed as black table olives. Other Turkish varieties include Büyük Topak, Ulak, Çakır, Çekişte, Çelebi, Çilli, Domat, Edincik Su, Eğriburun, Erkence, Halhalı, İzmir Sofralık, Kalembezi, Kan Çelebi, Karamürsel Su, Kilis Yağlık, Kiraz, Manzanilla, Memeli, Nizip Yağlık, Samanlı, Sarı Haşebi, Sarı Ulak, Saurani, Taşan Yüreği, Uslu and Yağ Celebi.

Figure 1: Table olive producing provinces

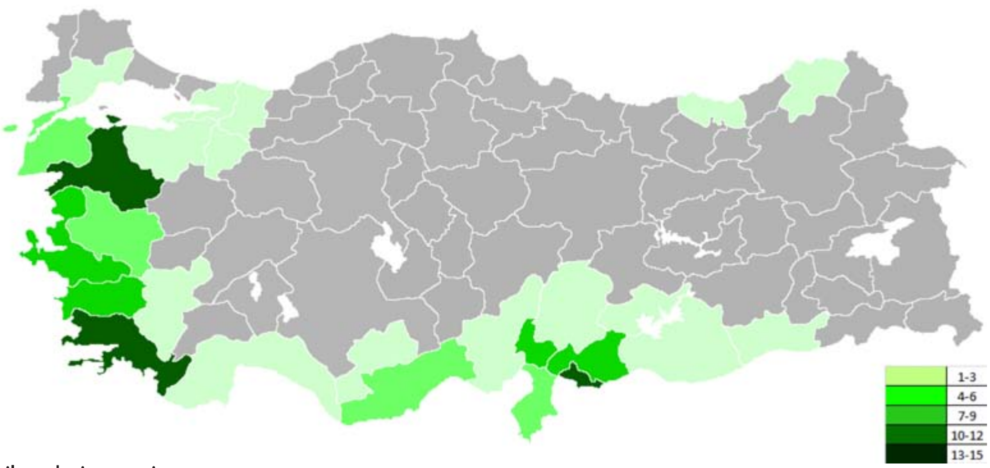


Figure 2: Olive oil producing provinces

Figure 3: Gemlik-Umurbey

Although it is still largely limited to the olive producing regions, olive oil consumption in Turkey is increasing as people become more health conscious. Previously standing at 1.5 kg, per capita consumption has now reached 2 kg thanks to promotion showcasing the health benefits of olive oil. Consumers have also recently started to become more knowledgeable about the different olive varieties and the way in which olive oils can vary in taste according to their geographical origin. As a result, consumer demand for monovarietal olive oils is growing and there are more and more gourmet shops. These developments have had a positive impact on the image of olive oil, which is no longer perceived by consumers merely as a food staple but as a select product available in a wide range of variants: flavoured, cold press, early or late harvest, unfiltered, etc. As the understanding of the health benefits of olive oil has increased, so has consumer demand for cosmetic applications of olive oil, for instance in soaps and hand creams.

Olives and olive oil are also very important agricultural products and high-potential exports for the Turkish economy. There are estimated to be between 1000 and 1100 processing facilities in rural areas where some 1 million tonnes of olives are processed per season. Export volume varies depending on the olive harvest and the level of production in other producer countries. Over the last five crop years exports have averaged 33 000 t.

Turkey's Ministry of Food, Agriculture and Livestock has fixed a target of 450 000 t for olive oil production. The increase in olive planting and the growing interest in olive cultivation, coupled with investment in modern orchard, production and storage facilities, all go to show that the sector believes this target can be achieved. If it does so in the short term, olive oil will gain in prominence at the domestic level and Turkey will consolidate its position as an international player in the olive world.

Olives, a feature of Turkey since 4000 BC

The value and unique characteristics of olives and olive oil have been acknowledged for centuries and are gaining even more prominence today. Cultivation of this noble fruit is concentrated in specific regions of the world, primarily in the countries bordering the shores of the Mediterranean. Turkey is one of those fortunate countries and is ranked as the world's second biggest producer.

Over the past ten years, Turkey has made major progress in olive cultivation. It has established processing plants with the technology and capacity to produce large volumes of top-quality table olives for the world market. It has also made impressive advances in olive oil production. A number of firms active in the extraction, refining and packaging of olive oil to world standards have taken up their rightful place in the industry and continue to pursue success. In the years ahead, Turkey intends to push forward with development and increase its share of global trade.

The following article has been written by the Olive and Olive Oil Promotion Committee of Turkey (OOPC). OOPC is a non-profit organisation set up in Izmir in 2007. Its main objectives are to increase the efforts directed at foreign markets and to diversify Turkey's export markets, as well as to implement promotional campaigns to establish the Turkish Olive and Olive Oil brand and image. The following websites can be visited to obtain more information regarding the activities of OOPC and the Turkish olive and olive oil sector in general. (www.olivetolive.com, www.zztk.com.tr)

The history of the olive in Turkey

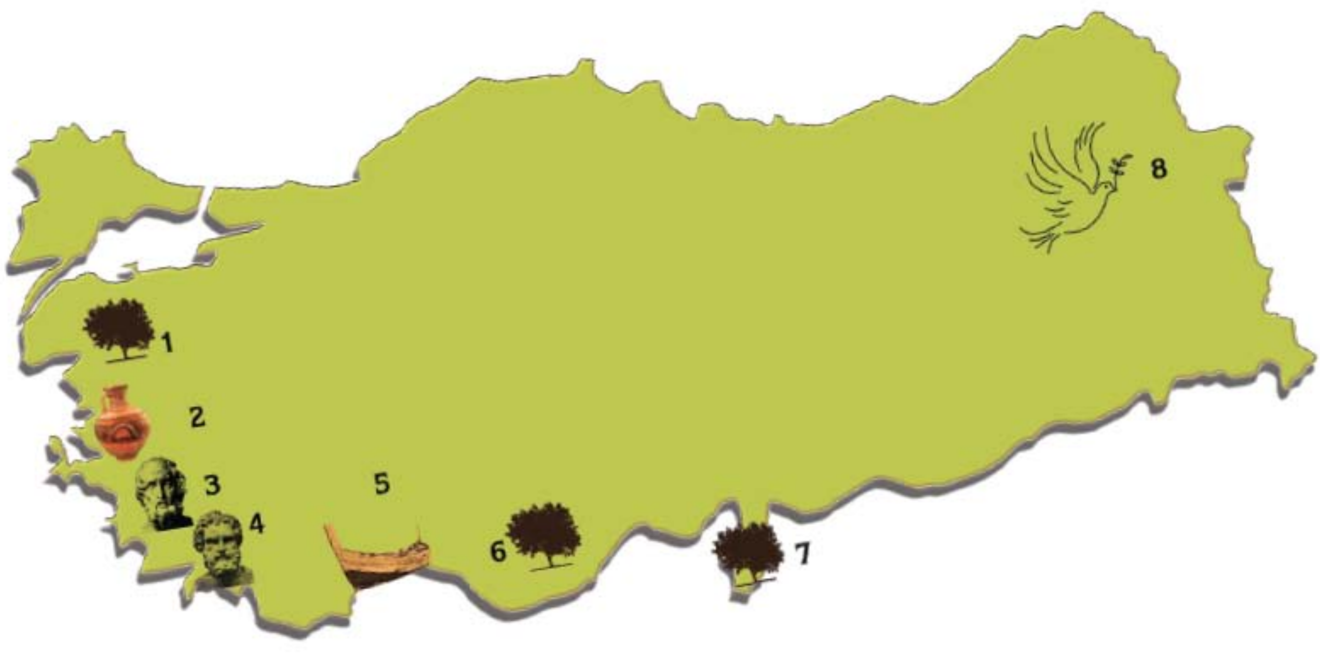
Anatolia, the crossroads of civilisations, has been home to the olive tree for 6000 years. The olive has brought peace, health and beauty to the region. It is the fascinating secret of the longevity of the Mediterranean peoples and bears delicious traditional produce that is shared by different civilisations.

Archaeological remains discovered at Urla, the site of the ancient city of Klazomenai in the Aegean region, testify to olive oil extraction as far back as the 6th century BC and recent discoveries have provided more evidence of early olive trading and exports in this city.

Further proof of the olive's long history in Turkey is the 1300-year-old tree growing in Mut or the olive oil stores found in Izmir. The olive is mentioned in The Iliad, when Zeus extols the delights of a breakfast of mouthwatering types of olives savoured at thyme-scented Gargara (Kücükkuyu), where the blue of the Aegean meets the green of Mount Ida.

Historical Olive and Olive Oil Landmarks in Turkey

1. **Erythrai, near Cesme (Ildır)**
   This ancient city was one of the leading olive oil export centres in the 6th century BC.



2. **Urla**
An olive oil press dating from the 6th century BC was discovered at this site as well as olive stores from between the 3rd and 2nd centuries BC.

3. **Izmir**
The place where Homer read his epics to friends and dined with them under the shade of olive trees in 1199 BC.

4. **Miletus**
Thales of Miletus forecast the next year's olive yields according to his meteorological studies.

5. **Kaş Uluburun**
Remains of olives were found on board the Uluburun Bronze Age shipwreck.

6. **Mut**
A 1300-year-old olive tree still lives here.

7. **Hatay**
This place is the motherland of the olive and home to Turkey's second oldest olive tree, the trunk of which measures 110 cm in diameter.

8. **Ağrı**
Doves carrying olive branches in their beak to Noah's Ark have been the symbol of peace since time immemorial.

Turkish olive production

Olive harvesting methods have barely changed for thousands of years and hand picking or beating with poles continue to be used. Another method is to collect the olive fruits that drop from the trees onto the ground. In Turkey, harvest takes place between November and March.

Olives are a crop of major importance to the national economy of Turkey and a nutritious foodstuff. The table olive industry is making breakthroughs at home and abroad. The recent construction of infrastructures employing new technologies, coupled with future advances, will create opportunities for Turkey to be competitive and process any kind of olive in demand on international markets.

The olive tree and olives

The olive is a long-lived evergreen tree. It is densely branched and has a broad canopy that can be up to 10 metres high. With age, its smooth grey trunk gradually starts to crack and become gnarled, and the canopy increases in width as the tree increases in height. It is a perennial tree and can live for approximately 2000 years. The canopy is open and symmetrical when grown on fertile land, but denser and rounded when cultivated

on infertile land. Its shoots are grey and almost triangular in shape.

The olive tree blossoms in the spring. Stone hardening and fruit ripening begin in the summer months. The fruits start to change colour in NOVEMBER through to November, first turning from green to violet and then to black as they ripen. This stage is known as véraison. The ripe olives are harvested from NOVEMBER to February. The quality of the olive oil produced is heavily dependent on how the olives are picked. The best olive oil is obtained when the olives are picked from the branches one by one. Other methods are to leave the olives to drop to the ground and then pick them there or to use suction machines. Olives should be processed as soon as possible after harvesting. If they are for olive oil extraction, any leaves are first removed and the fruit is washed in automated machines. Then the olives are crushed in presses to extract the oil from the plant tissues. It takes approximately 10 kg of olives to extract 1 kg of early-harvest olive oil. With other methods, between 3 and 8 kg of olives are sufficient to extract 1 kg of oil.

Olive varieties: flavour and quality

Unlike other fruits, olives cannot be eaten straight from the tree. Various processes have evolved over time to remove their sharp bitter taste. At first, the olives were placed in water. Later, they were sweetened by dipping them in ash, vinegar or limewater. To preserve them, they were pickled in brine flavoured with lemon, fennel, mastic, thyme, peppermint and other herbs to make them more pleasant tasting. Alternatives to brining were to store the olives in must, wine or even honeyed water.

In all, 84 olive varieties are produced in Turkey.

Olive oil production in Turkey

The way in which the oil is extracted from olives is another tradition that has not changed in millennia. The extraction method today is the same as six thousand years ago. The olives are merely crushed into a mash to which pressure is applied to extract the oil without any chemical processes. The oil is then separated from the fruit vegetable water. Technological developments in the early nineteenth century saw the advent of hydraulic presses, which are used nowadays alongside centrifugal systems, the most widespread of which is known as the continuous system.

In the continuous or fully automated system, the olives are first sorted by variety, stripped of any leaves and crushed in a machine that finely grinds the olive stones at 3000 rpm. Water is added to the crushed olive pulp and the resultant mash is beaten. Next, the olive pomace is separated from the oily juice. The olive oil is then separated from the vegetable water and transferred to a filter tank. These kinds of olive oils are virgin or extra virgin grade, depending on their acidity, and can be consumed straight away as if they were a fruit juice. The last sediment is removed and the olive oil is left in the settling tank. Virgin and extra virgin olive oil is then packed in drums, cans or bottles. The olive pomace left over from the extraction process is re-crushed and used to make soap, while the spent pomace is used to make fuel pellets.

To obtain quality olive oil, the olives must be processed as soon as possible after harvest. Quality deteriorates if the fruit is left to lie. The olives must also be properly cleaned before entering the extraction process and olive oil must be stored properly.

The Turkish olive/olive oil sector in facts & figures

- 180 million olive trees
- 700 000 ha olive orchards
- 500 000 t table olives/year
- 300 000 t olive oil/year
- 500 000 households employed in olive and olive oil production
- > 500 continuous-process olive oil mills
- Sufficient refineries and retail packing plants equipped with modern technologies
- State/private laboratories for quality control testing to meet international standards
- 70 000 t table olives exports/year
- 60 000 t olive oil exports/year

Main Actors in the Turkish Olive and Olive Oil Sector: An Innovation System Framework[1]

Nilgün Pehlivan Gürkan, PhD[2]

Abstract

This article outlines the main actors in the Turkish olive and olive oil sector from an innovation system (IS) perspective. The IS framework separates sectoral actors into four broad categories: research and education, bridging organisations, value-chain actors, and regulatory and supporting organisations. Briefly, the study indicates that various actors play a role in innovation processes and the development of the Turkish olive and olive oil sector.

Keywords

Olive, olive oil, sectoral innovation system, actors

1. Introduction

Since the early 2000s, the Turkish Government has taken many steps to develop the Turkish olive and olive oil sector. As a result of the Government's initiatives, the olive-growing area has been extended and the number of olive trees has almost doubled. Olive production increased to around 1.7 million tons in 2014/2015, from 1.2 million tons in 2000/2001[3].

The significant achievements of the last decade can be built on by pursuing sectoral policies that enhance innovations (technological, organisational and in production and processing) in the sector. In addition to domestic challenges, such as sustaining high-quality olive production in the midst of climate change, the sector is also facing global challenges such as compliance with stringent international standards, reaching the high end of the global value chain and competing with the vegetable oil sector. In order to achieve higher added value in the markets, while tackling these challenges, olive and olive oil producers in Turkey need to innovate.

One way of ensuring an innovation environment is the formulation of a sectoral policy based on an innovation system (IS) approach. Through an IS approach, farmers and agro-food firms do not innovate in isolation. Innovation is instead a result of the interactive learning of IS actors (farmers, agro-food companies, universities, research institutes, non-governmental organisations (NGOs) and government organisations) at different levels of the economy – local, regional and nationwide. Actors in a sector carry out various activities and perform different functions that may enhance or inhibit innovation processes. Institutions establish "the rules of the game" (e.g. rules, regulations, standards), which determine how these actors act (Edquist 2005). Accordingly, defining the main actors that carry out activities affecting innovation processes in a sector is the first step in diagnosing "what is going on and how" in that sector. Taking this fact into account, this study aims to define the main actors in the Turkish olive and olive oil sector from an IS perspective. To this end, an IS framework based on Spielman and Birner (2008) is applied[4] and the role of the main actors is briefly discussed.

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[1] This article is based on Pehlivan Gürkan (2005) "Turkish Olive and Olive Oil Sectoral Innovation: A Functional-Structural Analysis", the PhD thesis of the author.

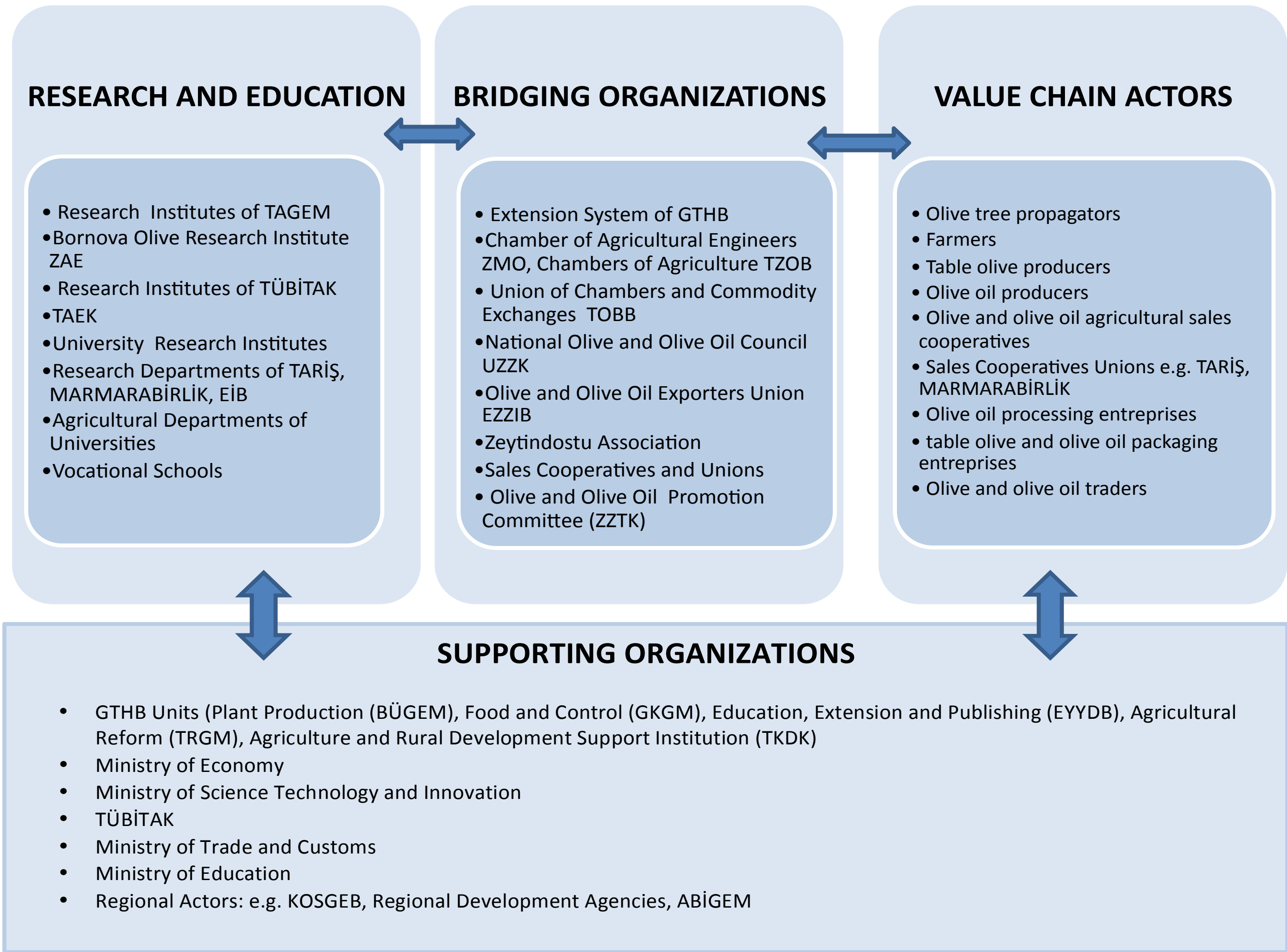
[2] PhD degree in Science and Technology Policy Studies, Middle East Technical University (METU).

[3] Two years' average, Source: http://www.tuik.gov.tr/PreIstatistikTablo.do?istab_id=1073

[4] According to Spielman and Birner (2008), an innovation system consists of the *knowledge and education domain, business and enterprise domain,* and *bridging institutions* that link the two domains.

2. Main actors in the Turkish olive and olive oil sector

An actor may take on a variety of roles in a sector. However, the actors in the Turkish olive and olive oil sectoral innovation system can be grouped into four main categories, according to their primary roles in the sector: research and education, bridging organisations, value-chain actors, and regulatory and supporting organisations.



Source: Pehlivan Gürkan (2015) p.125

Figure 1: Actors in the olive and olive oil sectoral innovation system in Turkey

2.1 Research and education system

The research and development (R&D) and education component of olive and olive oil sectoral IS is embedded in Turkey's broader food and agricultural research and education system. Food and agricultural research and education in Turkey has three main components: public R&D organisations, the faculties of agricultural sciences and university research institutes, and private sector and non-governmental organisations (NGOs).

The main public R&D organisations, involved in food and agricultural R&D, are:

- Agricultural research institutes of the Ministry of Food, Agriculture and Livestock (GTHB) governed by the General Directorate of Agricultural Research and Policies (TAGEM): 47 research institutes (11 central, 10 regional, 26 subject-oriented), 23 of them conduct research on horticulture. Two subject-oriented institutes are solely responsible for olive research: Bornova Olive Research Institute ZAE has been active since 1937 and Hatay Olive Research Institute was established in 2013, but is not yet fully active. Food control laboratories of the GTHB are also responsible for research activities.

- Research institutes of the Marmara Research Centre (MAM) and the laboratories of the Scientific and Technological Research Council of Turkey (TÜBİTAK), related to the Ministry of Science, Industry and Technology (BSTB).

- Sarayköy Nuclear Research and Education Centre (SANAEM) of the Turkish Atomic Energy Authority (TAEK).

There are around 30 agricultural faculties, 38 food engineering departments and 26 university research centres related to food and agriculture, which carry out basic and applied research in the olive sector.

In Turkey, there are educational programmes on horticulture, food processing and olive processing technology at the secondary and tertiary education levels:

- In olive producing regions, around 30 university vocational schools offer these programmes, of which three have an olive processing technology programme (Çine Akhisar and Edremit vocational schools).

- Among the industrial vocational high schools and agricultural vocational high schools in olive producing regions, around 50 schools have a food technology programme, of which 17 have an olive processing sub-branch.

- As a part of the "lifelong learning programme" of the Ministry of Education, education programmes are offered on olive storage and processing.

In the private sector, 255 private R&D centres were active as of May 2016 and eight of them are related to the food sector[5]. There is currently no private R&D centre solely responsible for research on olives and olive oil.

Among the value-chain actors, olive and olive oil sales cooperatives unions, mainly Marmarabirlik, have launched significant projects on environmentally-friendly olive and olive oil production with clean technologies through the use of government R&D support. Moreover, the in-house R&D activities of the main domestic processing technology supplier firms in Turkey (e.g. HAUS, Polat Makina, Kahyaoğlu) have to be taken into consideration, as they have been creating incremental innovations in processing technologies since the 1980s (Pehlivan Gürkan 2015 p.217).

Briefly, looking at the overall capacity and performance indicators of the R&D category, the dominant actors in R&D activities on the olive and olive oil sector are principally the research institutes of TAGEM and public universities, whereas the activities of other public research institutes and the private sector are relatively minor (Pehlivan Gürkan 2015, p.135-159).

2.2 Value-chain actors and organisations

Table olives and olive oil value chains have three distinct stages: olive production, processing and distribution. As the selection of the most suitable olive variety for olive orchard creation is the key initial step, olive sapling nurseries are a significant upstream industry for olive production. In Turkey, olive tree propagation is done by both public and certified private institutions. The main **public olive sapling nursery** is the Edremit Production Station attached to the GTHB. It provides farmers with olive saplings via the GTHB district/province units. **Private olive sapling nurseries** are small enterprises with a limited production capacity and the bulk of their production is bought by the GTHB district/province units.

Olive producers in Turkey are mostly small-scale producers and family enterprises. There are around 320 000 family enterprises working in olive and olive oil production (Ministry of Customs and Trade - GTB 2015).

There are 481 certified **olive processing and packing enterprises** and 1794 certified **olive oil producers** (TBMM 2008 p.104). There are integrated plants, which consist of processing sub-plants with packaging and bottling units. There are 1005 **olive oil mills** (515 continuous, 102 super press and 580 hydraulic press systems), 100 **olive oil bottling/canning** and 478 **table olive facilities** (Ministry for EU Affairs – ABGS, 2006). Olive oil refineries and pomace extraction plants do not have a direct role in the virgin olive oil value chain, but they play an important role in the Turkish olive oil sector. There are 15 **olive oil refineries** (ABGS 2006) and 20 **pomace extraction plants,** of which 14 use traditional methods and 6 use the centrifuge technique (TBMM 2008 p:143).

Olive and olive oil agricultural sales cooperatives and unions have a significant role to play in the value chain[6]. There are three sales cooperatives and unions in the olive and

[5] Ministry of Science, Industry and Technology,

http://btgm.sanayi.gov.tr/userfiles/file/istatistiki%20bilgiler/may%C4%B1s%202016/Arge_Merkezi_portal%20Slaytlar%C4%B1_may%C4%B1s%202016.pdf

[6] Sales cooperatives and unions have been developing capacity since the 2000s, especially after gaining their autonomy under Act No. 4572 "Sayılı Tarım Satış Kooperatif ve Birlikleri Hakkında Kanun".

olive oil sector: Tariş, Marmarabirlik and Güneydoğubirlik. They have various roles in the value chain. They purchase, process, package, store and market the olives and olive oil of their members, provide in-kind supports (fertilizers, pesticides etc.) and cash support as well as training services for members (GTB 2015). In Turkey, around 14 % of family enterprises are members of these three unions (GTB 2015). They purchase and process approximately 16 % of total production (ABGS 2006).

Tariş was established in 1949. It currently serves 32 cooperatives with around 24 000 members. It has 29 processing facilities with a total of 3.2 t of daily processing capacity, a refinery with 75 000 t of yearly refining capacity, capacity to pack 3000 t of table olives and around 56 000 t of olive oil a year, and olive oil yearly storage capacity of 55 000 t (GTB 2015). TARİŞ has a share of around 16 % in the total olive oil production of its region, 13 % of the total production nationwide and 18 % of olive oil exports (TBMM 2008 p.165). **Marmarabirlik,** which was established in 1954, serves eight cooperatives in the provinces of Bursa, Balıkesir and Tekirdağ, with around 31 000 members (GTB 2015). This union is known for table olive production but it has olive oil production facilities as well. Marmarabirlik purchases almost one-third of the olives from its region, has around 70 000 t of storage capacity, packing capacity for 150 t of table olives and 220 t of daily olive oil processing capacity. Marmarabirlik was a pioneer in investing in licensed storage, which is crucial for product quality. **Güneydoğubirlik** was established in 1940 for pistachios and then included four other product unions (for chilli pepper, raisins, olive oil and beans) in 1989. This Union, which had around 5000 olive producer members, is currently being liquidated and its activities have been suspended (GTB 2015). **Akdenizbirlik,** the Eastern Mediterranean Olive Union, is not organised as a sales cooperative union but was established as a product union in 2001. The Union brings together olive producers from the southern and south-eastern regions. Its current functions include supplying young olive trees, providing extension services and technical support for pest control, as well as inventory collection and reporting services.

In Turkey, the roles of the actors in the table olive and olive oil value chains are not very clear-cut, as broadly depicted in **Figure 2.** Many of the value-chain actors are active at various stages of the value chain or assume more than one function at a specific stage (Pehlivan Gürkan 2015). Some actors are solely olive producers, processors, traders or exporters, whereas other actors carry out several or all of these roles. For instance, farmers are involved in the processing stage (e.g.: they pickle olives at home for table olive production) and in the marketing stage (selling directly to traders or in traditional markets the olive oil that they have processed via cooperatives and olive oil mills, in addition to table olives they have privately processed). Moreover, there are **merchant producers and processors** who produce olives and process them for olive oil; collect olive oil from small traders and blend olive oil for bottling with their own brands; or supply the olive oil they have collected to bottling and packing firms that market it under their olive oil brands. **Individual merchants/traders** have a significant role in the value chain, as not all olive producers are members of cooperatives in Turkey.

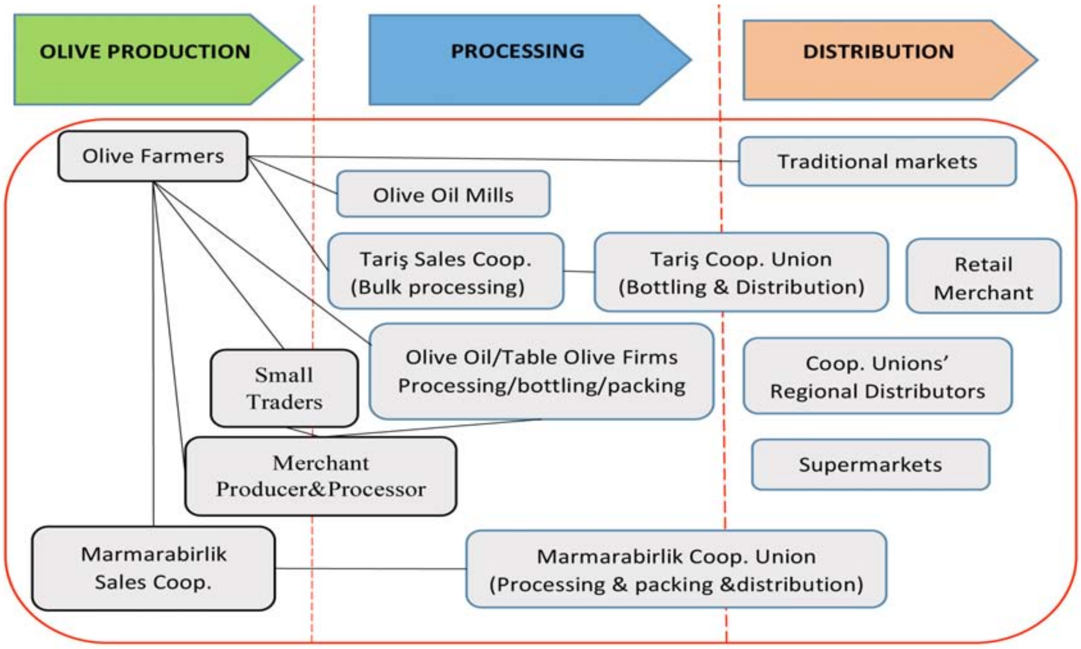


Figure 2: Main actors of table olive and olive oil value chains in Turkey

2.3 Bridging organisations

The Public Agricultural Extension System, which is embedded in the provincial organisation of the GTHB, is the main bridging organisation linking the public research and education domain with olive farmers. Since the 1990s, many projects have been implemented to improve the effectiveness of this system (Pehlivan Gürkan 2015, p.194). In 2012, the "Extension of Agricultural Innovations Project" was launched by GTHB's Department of Training, Extension and Publications (EYYDB). Since then, the Olive Research Institute ZAE has been involved in the extension of its selected projects, in coordination with regional extension agents of the EYYDB, under this project[7].

Among the bridging organisations that bring farmers together, **the Union of Turkish Chambers of Agriculture (TZOB)** is the largest farmers' association in Turkey, linking olive farmers with other actors. Olive farmers have to be members of TZOB to get credit from Ziraat Bank (the agricultural bank) and agricultural credit cooperatives. **Olive Producer Unions** have also been established since 2004, following the enactment of the law permitting the establishment of producers' unions. Accordingly, 13 small-scale olive producer unions have been active since 2014[8]. Moreover, **agricultural development cooperatives** established in olive producing regions are composed of olive producers and act like olive producer unions.

The National Olive and Olive Oil Council (UZZK), which was established in 2007, is the first product council in Turkey and one of the main bridging organisations in the sector. The UZZK is a formal platform that brings together public and private institutions and NGOs to improve the olive and olive oil sector. There are different subgroups under the UZZK umbrella, which include various sector representatives[9]. The UZZK reports to the Agricultural Support and Guidance Board.

The main objectives of the UZZK are (i) to develop and strengthen the structure of the olive industry; (ii) to improve olive and olive oil production, consumption and trade; (iii) to support brand creation and product marketing; (iv) to increase harmonisation with the European Union olive and olive oil common market; (v) to increase competitiveness; (vi) to prepare and implement sectoral plans and common strategies by taking domestic market conditions and international developments into account.

The UZZK has a significant bridging role as it links (i) various actors of the sector within its sub-committee framework; (ii) value-chain actors with related Ministries (mainly GTHB) for relevant policy development; and (iii) other sectoral actors to the International Olive Council (IOC) via the national coordinator, the Ministry of Customs and Trade (GTB). Moreover, UZZK provides institutional support for olive harvest festivals in olive producing regions, as well as for the Olive, Olive Oil and Technologies Fair (Olivetech), which is held in İzmir. These are significant knowledge sharing platforms, which gather together various actors in the sector. Furthermore, UZZK offers training activities, mainly olive oil tasting courses, which encourage (tacit) knowledge sharing concerning the organoleptic analysis of olive oil.

Zeytindostu Association is the only nationwide NGO to have been established through a civil initiative (2006) and it aims to disseminate "common wisdom and power solidarity" in the sector. It has been taking an active role as a bridging organisation since its establishment. It organised fourteen "olive and olive oil common wisdom and power solidarity" meetings in various olive producing regions between 2006 and 2009. These meetings provided platforms, bringing together the various sector representatives for the exchange of knowledge in the sector.

In addition to its consensus-building role, Zeytindostu has activities including (i) olive oil tasting training courses via an internationally recognised olive oil sensory analysis panel group; (ii) training for producers on olive processing and quality improvement; (iii) organising quality awards for extra virgin olive oils to promote higher quality and increase consumer awareness regarding quality; and (iv) publishing the *Olive and Olive oil Mediterranean Culture* periodical (Z&Z Akdeniz Kültür Dergisi) since 2006, which became a scientific publication in 2013.

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[7] For details see http://www.tarim.gov.tr/EYYDB/Link/6/Tarimsal-Yenilik-Ve-Bilgi-Sistemi

[8] http://www.tarim.gov.tr/Belgeler/Duyurular/HAZİRAN ÜRETİCİ BİRLİKLERİ.xls

[9] See Official Gazette No: 26484, 5 April 2007 http://uzzk.org/

The chambers of commerce, industry and commodity exchanges link value-chain actors. **The Union of Chambers and Commodity Exchanges of Turkey (TOBB)** is the highest legal entity in the private sector. These chambers include olive and olive oil sector groups in the olive producing regions. District-level chambers of commerce in the olive producing regions organise occasional training activities for their members, together with other regional actors, for instance in collaboration with the Small and Medium Enterprises Development Organisation (KOSGEB).

The Olive and Olive Oil Exporters Union (EZZIB) and the Aegean Exporters Union (EIB)[10] operate under the auspices of the **Turkish Exporters Assembly (TIM),** which is a significant bridging organisation with an important role in the sector. Olive and olive oil exporters have to be members of EZZIB, which has around 500 members. There are other exporter unions in other olive producing regions, but EZZIB is the only union specific to olive and olive oil exporters. As part of EİB, EZZİB plays a bridging role between public organisations, external partners and exporters of olive and olive oil.

EİB carries out collaborative research and training activities including (i) generic short courses on foreign trade, standards, marketing and management to build the capacity of export companies; (ii) comprehensive training programmes for SMEs such as the "innovation academy" programme to build the capacities of companies; (iii) ad-hoc R&D projects in collaboration with sector representatives[11]; and (iv) "Food R&D Project Market" to exhibit innovative projects in the food sector, including in the olive and olive oil sector[12].

The Olive and Olive Oil Promotion Committee (ZZTK) was established in 2007 by a communiqué of the Ministry of the Economy, laying down its rules of procedure[13]. The EZZIB leads the ZZTK, which has the objetive "to increase efforts directed at the foreign markets, diversify export markets and implement promotional campaigns for the establishment of the Turkish Olive and Olive Oil brand and image". Moreover, the ZZTK also plans to carry out promotional activities to improve the awareness of domestic consumers, seeking to develop the domestic market via increasing consumption.

2.4 Regulatory and support organisations

Regulatory and support organisations principally affect the operation of the olive and olive oil sector by designing the regulatory environment, i.e. by defining "the rules of the game". They do this for instance (i) by developing long-term plans and programmes that provide a framework for the sector; (ii) via regulations that set standards (production, process, technology); and (iii) by giving support for R&D, education, physical infrastructure, human capital, partnerships, etc. This regulation and support has an impact on activities (R&D, technological development, learning, knowledge sharing, entrepreneurship, market development, etc.) in the olive and olive oil sector.

Currently, there is no formal government olive and olive oil sectoral policy document, but a number of government plans and programmes bind the olive and olive oil sector together. All of the government organisations that take part in these plans and programmes constitute the regulatory actors in olive and olive oil IS, as shown in **Table 1.** Moreover, the main actors that play a role in the olive and olive oil sector by providing support are set out in **Table 2.**

[10] See http://www.egebirlik.org.tr/birlikler-zeytin-zeytinyagi-birlik-detay.asp

[11] For instance, the latest R&D project of the EİB research department in collaboration with private sector and EU partners to address the olive fruit fly problems among olive producing SMEs.

[12] This initiative aims to improve interaction between research and industry; to apply R&D projects by enhancing initiatives among food industry firms to get intellectual property rights for those R&D projects. The latest one was held in May 2016.http://www.gidaargeprojepazari.org/

[13] http://www.zztk.com.tr/yeni/zztk.html

Table 1: Main Government plans and programmes related to the olive and olive oil sector

Programme	Years	Coordinator
Agricultural Research Master Plan	2011-2015*	GTHB
Rural Development Support Programme	2011-2015*	GTHB
National Food R&D and Innovation Strategy	2011-2016	TÜBİTAK
Organic Agriculture Strategic Plan	2012-2016	GTHB
Input Supply Strategy (GİTES) Agricultural Action Plan	2013-2015	Ministry of the Economy
GTHB Strategic Plan	2013-2017	GTHB
UGTP Strategic Research and Innovation Agenda "Vision 2023"	2013-2023	National Food Technology Platform (UGTP)
Pre-Accession Economic Programme	2014-2016	Ministry for EU Affairs
Tenth Development Plan	2014-2018	Ministry of Development
National Strategy for Regional Development	2014-2023	Ministry of Development
National Basin Management Strategy	2014-2023	Ministry of Forestry and Water
Medium-term Programme	2015-2017	Ministry of Development
Industry Strategy Document	2015-2018	Ministry of Science, Industry and Technology

Source: Author's compilation as at May 2016
*Extended to 2016

Among the ministerial actors, various units of GTHB play a significant direct or indirect role in the olive and olive oil sector. The General Directorate of Agricultural Research and Policies (TAGEM) outlines the research priorities related to olive and olive oil research within the framework of a five-year agricultural research master plan[14], guiding TAGEM's research institutes, including ZAE. TAGEM also provides R&D support. Other units of the GTHB, such as the General Directorate of Plant Production (BÜGEM), the General Directorate of Food Control (GKGM), the General Directorate of Agricultural Reform (TRGM), and the Agriculture and Rural Development Support Institution (TKDK), set the related regulatory environment for the olive and olive oil sector and provide it with direct and indirect support. Moreover, the Food Control General Directorate deals with the CODEX standards for table olives and olive oil, as well as food control standards.

Most of the sources of GTHB agricultural support that are listed in Table 2 are managed by different BÜGEM departments: the Field Crops and Horticulture Department deals with premium support for olive production; the Seed Department deals with sapling support, including olive sapling support; the Plant Nutrition Department deals with fuel, fertilizer and soil analysis support; the Good Agricultural Practice (GAP) and Organics Department deals with GAP and organic production support, the Agricultural Zones department deals with the prioritisation of agricultural products, including olive production by zones.

As regards cooperatives, which play a significant role in the sector, the Agricultural Reform Directorate of the GTHB is responsible for agricultural producer unions, development cooperatives, irrigation cooperatives and agricultural credit cooperatives, whereas sales cooperatives and unions (such as Tariş and Marmarabirlik) are under the responsibility of the Ministry of Customs and Trade (GTB). For instance, the operation of Tariş and Marmarabirlik has changed significantly due to the restructuring of the Unions' "principal agreement" by GTB in 2014, under the "Turkish Cooperatives Strategy and Action Plan 2012-2016", which was launched by the GTB.

Standard-setting organisations such as the Turkish Standards Institution (TSE) (e.g. setting standards on the product safety of exports of edible olive oils to foreign markets) and the Turkish Patent Institute (TPE) (e.g. responsible for the registration of Geographical

[14] The latest one is for 2011-2015, http://www.tarim.gov.tr/TAGEM/Belgeler/master_plan.pdf , and is currently under revision for the next period.

Indications for food products) are also among the main regulatory actors related to the olive and olive oil sector.

Finally, regional development agencies, the rural development agencies of TKDK, the regional offices of KOSGEB, agricultural credit cooperatives (TTKK) and European-Turkish Business Centres (ABİGEM), established by the Union of Chambers and Commodity Exchanges of Turkey (TOBB), are some of the regional actors that contribute to the development of regional financial, physical and human capital infrastructure of the olive and olive oil sector.

Table 2: Main sources of direct and indirect support for the olive and olive oil sector

Supporting Organisation	Type of Support
Ministry of Food, Agriculture and Livestock (GTHB)	R&D support of TAGEM Research Institutes/ in-kind support for R&D public-private partnerships with TAGEM Research Institutes / cash grants for universities, NGO and enterprise agricultural R&D projects. Fertilizer, fuel, organic production, best agricultural practice support for fruit and vegetable production areas / basin support for olives for olive oil / olive sapling support for olive oil cultivars / agricultural insurance support / subsidised agricultural credit for agricultural cooperatives.
Scientific and Technological Research Council of Turkey (TÜBİTAK)	Various national support funds for academic, business and industry R&D via the Research Support programme (ARDEB) and the Technology and Innovation Support Programme (TEYDEB). Technology Transfer Offices (TTO) Grant Programme: to improve university-industry partnership and commercialisation of R&D by developing TTOs as interface.
Ministry of Science, Industry and Technology (BSTB)	SANTEZ programme: partial cash grants for university-private sector R&D partnerships / clustering support for project partnerships between various regional actors / Technology Development Zone (TDZ) support through tax exemptions.
Ministry of Customs and Trade (GTB)	Cooperatives Thesis Award / Cooperatives Project Subsidy
Ministry of the Economy (ME)	SME Clustering Support Programme (URGE): for partnership projects of bridging institutes (e.g. NGOs, cooperatives, chambers of commerce) for export market development. Market search and entry support / International market unit, brand and promotion support / international competitiveness support/ trade fair support / branding in external markets and "Turquality" support / export refund for agricultural products (including olive oil).
Ministry of Finance (MF)	R&D allowance, income tax withholding and insurance premium support for technology centres, R&D centres, pre-competition cooperation projects…etc.
Small and Medium-Sized Enterprises Development Organisation (KOSGEB)	Entrepreneur support / thematic project support / general support / SME project support / R&D, innovation and industrial application support / emerging SME market support / loan interest support / cooperation-partnership support.
Turkish Technology Development Foundation (TTGV)	Advanced Technology Projects Support Programme: partial cash support for R&D projects including food technologies, production of bio-products from agricultural waste.
Credit Guarantee Fund (KGF)	Collateral support for bank credits for SMEs, young and women entrepreneurs.
Regional Development Agencies	Various financial support measures.
Agriculture and Rural development Support Institution (TKDK)	IPARD support: for registered farmers and cooperatives.

Source: Author's compilation, as at 2015

Conclusion

This study outlines the various actors who may play a role in innovation processes, and therefore in the development of the Turkish olive and olive oil sector, providing a brief summary of the role of the most significant actors.

Defining the boundaries of the olive and olive oil sectoral IS and actors is the first step in designing a sectoral policy with an IS perspective. As a further step, the functioning of olive and olive oil sectoral IS has to be evaluated, i.e. whether knowledge is developed, diffused and used within and between the different sectoral components. In order to enhance innovation in the sector, government policy should aim to address the structural problems that inhibit the functioning of olive and olive oil sectoral IS (Pehlivan Gürkan 2015).

Moreover, the boundaries of the olive and olive oil sectoral IS may change over time: as new actors arrive, existing ones may disappear or their role may change. The "rules of the game" also change as new standards, rules, regulations and laws come into force or existing ones are abolished. In short, the problems in the sector evolve over time due to changes in the context. Accordingly, the analysis of the olive and olive oil sectoral IS should be carried out regularly with a view to designing government policies for continuing innovation enhancement.

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What is the National Olive and Olive Oil Council (UZZK)?

Known by its Turkish acronym UZZK, the National Olive and Olive Oil Council was created after Turkey withdrew from the International Olive Oil Council in 1998. Today, it is one of the leading Turkish organisations fuelling the development of the olive oil industry and olive cultivation in the country. Ummuhan Tibet chairs the Board of UZZK and Dr. Mustafa Tan is its Executive Director. Both have very kindly agreed to answer some questions about UZZK and the olive industry in Turkey.

How and why was the National Olive and Olive Oil Council established?

Dr. Mustafa Tan: UZZK is the outcome of a strong civil society initiative prompted by the needs of the olive sector in Turkey. Our first meeting was in Adatepe on 1 June 2002. Other meetings followed in Izmir, Aydın and Bursa, where hundreds of industry representatives chose the executive committee. Many of our friends, who were involved in that committee, are currently working with us in the management of UZZK. Since then, we have never stopped working to expand olive growing and olive oil and table olive production in Turkey. Our goals are simple: to bring together all the branches of the country's olive industry, to raise it to the heights it deserves and to find solutions to any problems. With the support of institutes and other organisations, including Turkey's Ministry of Agriculture and Rural Affairs, these efforts have represented a milestone for the industry.

There have certainly been problems in the Turkish olive sector in the past, and there will no doubt be more in the future. Turkey started off as a leading producer and had a large olive acreage in Anatolia, the home of olive oil, but then it slipped back into fifth position behind Spain, Italy, Greece and Tunisia. Admittedly, olive crops and olive oil yields per tree are low and we still have problems with quality standards, but Turkey has the ideal soil and climatic conditions to produce the best olives and olive oil. There are still thousands of Turkish households that do not use olive oil and millions of Turks who do not know enough about it. Our first target is to raise Turkish olive oil consumption from 2–3 kg to 5 kg per person and to consume what we produce.

What kind of work does UZZK do in Turkey?

Ummuhan Tibet: UZZK is striving to build collective awareness and common resolve among public, non-governmental and private-sector organisations with several aims in mind:

- Strengthening the structure of the olive industry in Turkey;
- Supporting the creation of brands to market olive oil products;
- Expanding olive and olive oil production, consumption and trade;
- Helping producers and processors to access the domestic and international markets;
- Aligning the Turkish sector with the European Union common market organisation for olives and olive oil;
- Increasing Turkey's competitive edge on the world market through the implementation of development plans;
- Finding solutions to product problems by reporting them to the Agricultural Support and Guidance Committee.

UZZK is one of the first product councils to have been established in Turkey. It was set up under an implementing regulation of Agriculture Act No. 5488 which specified the rules for its establishment and working principles. Our first ordinary General Assembly was held on 12 November 2007. Now we are into our ninth year.

When we look back over these last nine years, we see many problems – both past and present – but also a willingness and determination to find solutions. As you will realise, the olive industry in Turkey has to go through this difficult process to be able to compete with the giants. In the process, quality, efficiency and standardisation will become more important than ever, especially in aspects such as the application of environmentally friendly methods and the production of quality produce. While the sector is slowing down in Spain, Italy and Greece, even under the safety net of the European Union, Turkey's olive industry is raising the bar through information and technology transfer.

Owing to pollution contributing to global warming and drought stress, last year Turkey's 167 million olive trees only produced 170 000 tons of olive oil. This year, olive oil production is 150 000 tons higher and closer to the levels of EU countries. As well as olive oil, Turkey produced between 320 000 and 400 000 tons of table olives on average over the last two years. Since olives and olive oil are much more in the news now and new investors are making great efforts to market their products, domestic annual per capita consumption of olive oil has risen from 1 L to almost 2 L. There is no doubt about it: the shared goals and joint efforts of UZZK and the Turkish Agriculture Ministry are helping to stimulate the rapid growth of the industry in our country.

What needs to be done to increase sales in Turkey?

Dr. Mustafa Tan: First of all, we are trying to create awareness of the quality and health benefits of olive oil compared with other types of oils. The annual OLIVTECH trade fair –Table Olive, Olive Oil and Technologies Fair– coordinated by UZZK plays a key role in introducing and marketing Turkish olive oil on domestic and international markets. I firmly believe this fair will help the industry globally and will help many world-wide organisations, including the IOC, to learn more about the table olive and olive oil industry in Turkey. Other continuing initiatives to enhance awareness include workshops, seminars and panel discussions.

Turkey rejoined the IOC on 20 February 2010. Since then, we have been working on collaborative national and international marketing projects with the multiplier effect of the IOC. These types of promotion campaigns are coordinated by UZZK. At the same time, we are working hard on legislation to combat and prevent olive oil fraud and adulteration in order to converge with EU standards. We conduct a quality control programme in parallel with the IOC programme and will soon be publishing a white list of companies. Soon, the whole world will realise that Turkey produces the best quality and most natural olives and olive oil.

How do you assess government support for the industry?

Ummuhan Tibet: For the first time ever, a Minister of Agriculture recently announced the goal of turning Turkey into the world's second biggest producer, after Spain. This goal is shared by UZZK and all the industry representatives. The Minister also emphasised that the industry needed to move forward before Turkey became a member of the EU.

The Ministry has in fact set a number of goals for the Turkish olive industry by 2023. Briefly, they aim to increase:

1. Olive orchard area from 700 000 ha to 1 000 000 ha;
2. The number of olive trees from 140 000 000 to 180 000 000;
3. Table olive production from 400 000 t to 650 000 t;
4. Oil-olive production from 800 000 t to 3 000 000 t;
5. Olive oil production from 115 000 t to 500 000 t;
6. Per capita olive oil consumption from 1 kg to 5 kg (in other words 400 000 t);
7. Per capita table olive consumption to 6 kg.

We are happy to see that the Ministry shares our goals for the industry. Support is essential during this process and careful analysis is needed to tailor action to future needs.

The taste panel of the Olive Research Institute

Oya Köseoğlu, Ferişte Öztürk Güngör, Yeşim Altunoğlu, Ayşen Yildirim, Şahnur Irmak, Didar Sevim

The Olive Research Institute (ORI) is a governmental organisation working for the General Directorate of Agricultural Research and Policy, which is dependent on the Ministry of Food, Agriculture and Livestock. Two of its key activities are research and training, which are conducted by the Departments of Breeding, Cultivation Techniques, Management, Plant Protection, Table Olive and Olive Oil Technology and Economics–Statistics. ORI is responsible for collecting and evaluating data, collecting and preserving gene resources, conducting national and international research, providing training (courses, workshops, etc.), producing publications and supplying growers with certified olive saplings.

Olive oil enjoys pride of place among Turkey's many agricultural products. In recent years, scientific research has corroborated the positive effects of olives and olive oil on human health and nutrition, thus sparking a surge in olive cultivation and the establishment of new olive orchards in Turkey and the world in general. From the economic point of view, the most important varieties grown for olive oil production are 'Ayvalık', 'Memecik', 'Gemlik' and 'Kilis Yağlık'. The first two are the predominant varieties cultivated for the production of virgin olive oils in the Aegean region. Their sensory attributes can vary depending on when the olives are harvested, but generally 'Memecik' olive oils display a robust green fruitiness and are very bitter and pungent, while 'Ayvalık' oils exhibit a green fruitiness that varies in intensity from robust to medium, with medium pungency and bitterness.

Sensory analysis is a scientific discipline encompassing both qualitative and quantitative measurements that is attracting growing interest in Turkey. It can be performed for shelf-life studies, product matching or specification and quality control.

The ORI sensory testing laboratory is important for researchers and olive oil and table olive producers. After Turkey rejoined the International Olive Council (IOC) in 2010, the tasting panel was re-established in 2012 with 15 tasters drawn from Institute staff. In 2013 and 2014, three panellists received training at an international course run by the IOC, while the others obtained proficiency certificates in sensory analysis after successfully completing the tough examinations held at training seminars organised by Italy's *Organizzazione Nazionale Assaggiatori Olio di Oliva* (ONAOO).

The laboratory holds IOC recognition and performs sensory analysis according to the IOC method and standards for the organoleptic assessment of virgin olive oils. It tests many samples for producers, marketers and importers, besides providing technical support for scientific projects carried out at the Institute. It also gives sensory evaluation training all around the country and tries to raise quality awareness in the olive oil industry and institutions by holding tasting sessions.

Panellists work voluntarily to raise public awareness, promote olive oil and increase olive oil consumption in Turkey, and have participated as judges in the extra virgin olive oil competitions organised by the Olive Friendly Foundation and the IOC.

The laboratory participates in any activity aimed at showcasing olive oil and attends meetings and events to share its ideas and experience.

Many laboratories undertake the sensory analysis of virgin olive oils in Turkey. Four hold IOC recognition, specifically the laboratories of the National Olive and Olive Oil Council of Turkey, AYTB Aydın Laboratuvarı Hizmetleri A.S., Ayvalık Chamber of Commerce and the Olive Research Institute (ORI). Three are also accredited by the Turkish accreditation agency TÜRKAK, according to TS EN ISO/IEC 17025. The official Turkish Food Codex regulations and IOC methods are applied for the evaluation of virgin olive oils.

Figure 1: Tasting Panel for Turkish Virgin Olive Oil, ORI–UZK, 05.11.2012–09.11.2012

With an annual production of 397 000 tonnes (2015/16), Turkey is the third biggest table olive producer in the world. Table olives are an important ingredient in the Turkish diet and are eaten not just as an appetiser but also at breakfast. Turkey consumes a large share of the table olives it produces. Broken down by type, black olives account for 80% of consumption, while green olives have a share of 12–13%, and olives turning colour account for 7–8%. Natural black olives in brine are one of the chief table olive preparations in Turkey. 'Gemlik' is the chief commercial variety used for making black table olives because of its good processing characteristics (size, flesh-to-stone ratio). The bulk of 'Gemlik' production is consumed as black table olives. This variety originated in the area of the same name but has recently spread to other olive growing areas in Turkey. With its high flesh-to-stone ratio and firm texture, the 'Domat' variety is used mainly for treated green olives and has a high market value. It is grown extensively in Akhisar and is also farmed in the İzmir and Aydın regions. 'Ayvalik' is another of Turkey's top varieties. It is more common in the northern Aegean region and bears high average yields. It is harvested when the skin begins to change colour, without waiting for full maturation, and is used primarily to make top-quality split olives. 'Memecik' and 'Uslu' are two other important varieties for the Turkish table olive industry, used mainly for processing green and black treated olives. The first has a high flesh-to-stone ratio and is the most common variety in the Aegean region where it is cultivated widely. Green and black 'Memecik' olives are used to make salted and pickled olives for breakfast. The 'Uslu' variety is native to Akhisar and is generally consumed as black table olives.

Olives cannot be eaten as soon as they are harvested because of the bitter compounds they contain. They therefore need to be processed to remove the bitterness. Besides improving the sensory attributes of the fruit, processing also causes physical and chemical changes. If the olives are not processed or stored properly, undesirable negative attributes can appear. These abnormal changes have a negative impact on the taste of table olives and make them less acceptable to consumers. 'Taste' therefore has a direct effect on consumption and consumer preferences.

Table olives are a staple food traditionally consumed at breakfast time in Turkey. According to the statistics, annual per capita consumption of table olives stands at around 4.3 kg in Turkey.

An olive oil tasting panel was set up at the ORI in 2012 and gained accreditation in 2015. The sensory analysis of table olives is another area that has gained in importance in recent years. At the ORI, the olive oil tasting panel also serves as a table olive tasting panel. In 2014 and 2015, the IOC awarded it two grants after the ORI team presented grant applications for two projects *(Tasting Panel for Turkish Table Olives* and *On-site Training Programme for ORI Table Olive Tasting Panel in Greece)*. The panel members were given practical and theory-based training in the sensory analysis of table olives and generally coincided on the negative attributes and kinaesthetic and gustatory sensations of table olives. For the panel, one very positive aspect of the training was that most of the tasters were involved in olive oil sensory analysis and were therefore fully aware of the sensory procedure and the defects that occur in both olive oil and table olives (e.g. rancid, fusty, earthy, winey, etc), which made tasting easier. The use of reference standards in the sensory evaluation process improved panel performance even more. One issue identified during training was the lack of IOC reference standards for some of the other defects (cooking effect, metallic, musty, etc), which made it hard for participants to define these attributes and evaluate their intensity. Following these training opportunities, the panel provides technical support for scientific projects carried out at the Institute.

Figure 2: On-site training programme in Greece for the ORI Table Olive Tasting Panel: (top) (Dr C. Tertivanides, the leader of the Greek panel, lectures to participants and (bottom) the Turkish and Greek tasting panels at work.

The Turkish table olive industry needs trained tasters to distinguish between good and defective tastes because sensory analysis will help to boost the quality of table olives sold on the market.

Although table olive consumption is high in Turkey, there is poor understanding of the undesirable sensory attributes in table olives, which are only detected to a minimum extent because of the shortage of trained panels. Moreover, chemical analyses are not enough to determine overall product quality. Promotion is very necessary in Turkey to create awareness of table olives with top sensory qualities. The aim is to drive the industry to produce table olives that provide a first-rate sensory experience. It is hoped that the combination of these efforts and promotion will lead to the future inclusion of sensory attributes in table olive regulations.

What are natural olives? How are they produced?

Mustafa Findik*, Ebru Mutlu, Marmarabirlik, Bursa

* Corresponding author: mustafafindik@marmarabirlik.com.tr

Abstract

Olives can be divided into two groups – 'natural olives' and 'treated olives' – depending on how they are processed. The main distinguishing feature of natural olives is that, unlike treated olives, they are not placed in alkaline (lye) solution to remove their bitterness. This review describes the production process of natural olives and evaluates them from the point of view of consumers and producers.

1. Introduction

The olive tree (Olea europaea) is a member of the Oleaceae family native to Mediterranean-climate areas. Its fruit cannot be eaten fresh because of the presence of the bitter glucoside oleuropein and therefore has to be processed. Olives can be divided into natural and treated olives depending on the processing method used. The main distinguishing feature of natural olives is that, unlike treated olives, they are not placed in alkaline solution to remove their bitterness. Briefly, natural olives are olives in which the bitterness has been removed by fermenting them in water, acidified water or brine, or by fermenting them in aerated brine or placing them directly in salt, without using any lye solution.

Both black and green olives can be processed according to the natural method. In modern-day Turkey, the 'Gemlik' variety is typically processed for natural black olives, while 'Edremit' is processed for natural green olives.

2. 'Gemlik' black olives processed according to the natural fermentation processing technique

Like all processed agricultural products, table olives begin their journey in the orchard, at harvest, and end it on the consumer's table.

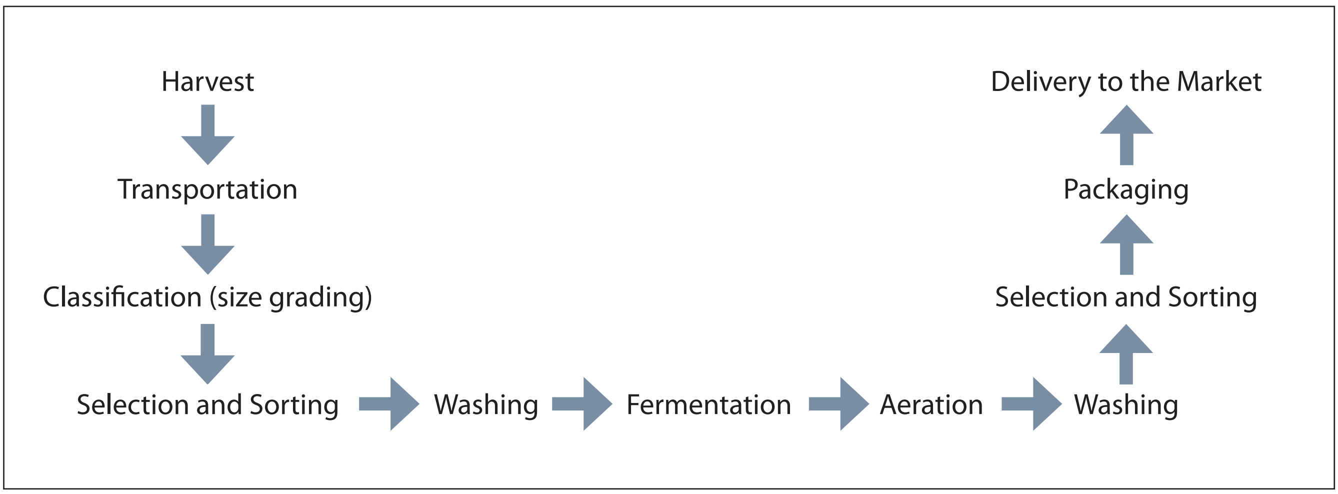

Figure 1: Production flow chart

Harvesting is an extremely important stage in the production of natural black olives. The olives are harvested when the skin has turned black and the flesh is a purple colour to within 2 mm of the stone. This means that when one end of the fruit is pressed, the stone pops out from the other end. Manual harvesting is another decisive factor for the quality of olives processed for table consumption.

After they are picked, the olives must be transferred straight away to the processing facility in perforated plastic boxes. At the facility, they are sorted to classify them according to size, i.e. the number of fruits per kilo. The olives have to be processed in batches of the same size because the chemical reaction during fermentation differs according to size, as do the weights applied to create pressure on the olives.

After sorting, the olives have to be washed before being brined. Any fruit that is damaged, bruised, diseased, small, immature or light in colour (green) is discarded. Washing is designed to remove substances such as soil or clay before the olives are transferred to the fermentation tank, where another important stage takes place.

After they have been washed, the olives are placed in the fermentation tank and covered with a perforated lid. This allows the brine to be poured through but prevents the fruit from rising to the top. Weights equal to 20–25% of the fruit weight are then applied to the lid, creating pressure. Once placed in the brine, the olives start to absorb the salt. The brine should be circulated in the tanks during fermentation to control the salt and pH levels.

The oleuropein responsible for the bitter taste of raw olives is slowly degraded during fermentation and the usable sugars pass into the brine. Oleuropein degradation is very slow in these circumstances, where there is no chemical intervention from alkaline solutions. Natural fermentation therefore takes longer and the olives reach edible maturity within 6–9 months. The length of fermentation varies according to ambient temperature, olive type, degree of ripeness of the raw fruits (black, green, purple olives) and salt concentration. The pH is around 4.3–4.6 and the acidity is about 0.3-0.5% in the olive brine when fermentation is completed.

During the fermentation process, the pH value of the olives decreases and the olives fade in colour. When they reach edible maturity, the olives are therefore not completely black. If the facility has suitable operating conditions, the olives can be darkened by aerating the brine. If not, after being removed from the brine, they are darkened by allowing them to enter into contact with air during the sorting – when any soft, crushed or light coloured fruits are discarded –, classification and packaging stages.

Packaging is another fundamental part of the process since it is essential in ensuring the safety and freshness of the olives until they reach the consumer's table. The olives can be packaged with or without brine in food-grade containers such as cans, plastic drums, or glass or plastic jars. The fruit is then pasteurised or packaged under inert gas to guarantee its shelf life.

3. Evaluation of natural fermented olives from the point of view of consumers and producers

Natural and chemical methods are used to make olives edible for table consumption. The bitterness of the fruit can be removed by using natural methods such as brine fermentation, heat or dry salt, or by using chemical methods where a lye solution (sodium hydroxide) is applied to speed up bitterness removal by rapidly hydrolysing bitter oleuropein. If applied properly, both processing techniques result in a healthy product. However, when produced using natural methods, the resultant product has a unique taste and aroma due to the absence of chemical intervention in the structure of the olives. When chemicals are used to increase the permeability of the fruit pericarp, they penetrate the cell walls more quickly to degrade the oleuropein. Alkaline table olive processing techniques significantly lower the total phenol content of the olives. In contrast, natural methods preserve the healthy phenols at maximum levels. This is why natural olive processing methods are gaining in importance by the day.

The benefits for consumers are that:

- The natural processing technique uses no chemicals except for salt and organic acid;
- Specific phenolic flavour components in the olives are preserved and lend a special taste and aroma to natural olives;
- The olives contain more nutrients due to the minimum loss of polyphenols (colour and flavour components), which are known to be anti-carcinogenic.

For processors:

- Inventory costs are quite high compared with other table olive processing methods because of the minimum six-month processing period;
- Weight losses occur, ranging from 3 to 7% for natural green olives and from 5 to 18% for natural black olives;
- The natural processing method requires more labour, energy and other inputs, which increases costs for producers.

4. Conclusion

Natural fermented olives help to increase table olive demand because they are an additional choice for consumers, but they are also at a competitive disadvantage because they are costly to produce. To make sure that they are buying healthy and safe table olives, consumers should buy packaged, trusted brand products. Those who prefer natural olives should look for the word "natural" on the packaging. It is a fundamental right of consumers to have full, accurate labelling information about the product and the production method. It is therefore important to draw up or revise international and national standards to include natural olives and to provide labelling information on this production method in order to ensure equal conditions of competition and to protect consumer rights.

Olive Gene Resources in Turkey

Dr. Melek Gurbuz Veral

OliveResearch Institute
Bornova, Izmir
Turkey

Turkey is rich in olive gene resources, with cultivated varieties grown in their environment and "oleasters" spread over the hilly and mountainous areas along the country's coasts, extending to south-eastern Anatolia. The selection and characterisation of these varieties has been conducted since 1968 and continues today.

Of the 90 olive varieties registered so far, 89 have been selected from the survey studies from different olive growing regions. "Hayat", the ninetieth variety, is obtained by crossbreeding Memecik and Gemlik, producing characteristics of early and homogenous maturation, high oil yield and a large fruit size, making it appropriate for both olive oil and table olive consumption. Memecik is the most common variety in the southern Aegean region, with strong fruity and pungent olive oil attributes, also consumed as a table olive. Gemlik is a cultivar of the Marmara region and it is the most common table olive in Turkey. Although it has a high oil content (22% <), it is best consumed as a black table olive due to its fruity characteristics. Ayvalık is a cultivar from the north Aegean region that adapts well to different conditions and covers most of the plantation area. It has a medium-sized fruit and a high oil content (22% <) with high-quality chemical and organoleptic attributes. Kilis Yaglık is one of the most important varieties of the south-eastern Anatolia region and covers a large part of the plantation area. It has a high oil content, with a strong bitterness and pungency.

Under the IOC-RESGEN Project, all selected varieties have recently been characterised pomologically, recording their passport data and technological attributes, and then publishing them in a catalogue (Catalogue of Turkish Olive Varieties, 2015). The varieties included in this catalogue vary widely in terms of oil content and use as table olives: 48 of them have a high oil content (22% <) and are used for oil, 23 varieties have a low oil content (< 18%) and are only consumed as table olives, and the other varieties are used for both. The varieties are listed in Table 1, indicating their region of origin.

Figure 1. Origin of the 89 characterised national varieties

Table 1. List of Turkish varieties from olive growing regions

Region	Varieties		
Aegean Region	Ayvalık (Edremit)	Hurma Karaca (Karaburun)	Çilli (Kemalpaşa)
	Çakır (İzmir)	Memeli (Menemen)	İzmir sofralık (İzmir)
	Dilmit (Bodrum)	Memecik (Muğla)	Tavşan yüreği (Muğla)
	Erkence (İzmir)	Girit (Bodrum)	Ak zeytin (Milas)
	Eşek zeytini (Ödemiş)	Çekişte (Ödemiş)	Domat (Akhisar)
	Hurma kaba (Karaburun)	Taş arası (Aydın)	Kiraz (Akhisar)
	Kara yaprak (Aydın)	Taşarası (Kusadası)	Uslu (Akhisar)
	Yağ zeytini (Aydın)	Aşı yeli (Aydın)	Yerli yağlık (Aydın)
Mediterranean Region	Küçük topak ulak (Adana)	Sarı ulak (Tarsus)	Büyük topak ulak (Tarsus)
	Çelebi (Silifke)	Elmacık (Hatay)	Sayfi (Hatay)
	Halhalı (Hatay)	Yağlık sarı zeytin (K.Maraş)	Karamani (Hatay)
	Sarı Habeşi (Hatay)	Maraş No: 7 (K.Maraş)	Saurani (Hatay)
Marmara Region	Siyah salamuralık (Tekirdağ)	Çizmelik (Tekirdağ)	Gemlik (Bursa)
	Beyaz yağlık (Tekirdağ)	Edincik (Balıkesir)	Samanlı (İznik)
	Eşek zeytini (Tekirdağ)	Karamürsel su (Kocaeli)	Çelebi (İznik)
	Erdek yağlık (Erdek)	Şam (İznik)	
South-eastern Region	Kilis yağlık (Kilis)	Halhalı çelebi (G.antep)	Kan çelebi (G.antep)
	Nizip yağlık (G.antep)	Yağlık çelebi (G.antep)	Hamza çelebi (G.antep)
	Kalembezi (G.antep)	Hırhalı çelebi (Tatayn)	Yuvarlak halhalı (G.antep)
	Eğriburun (Nizip)	Belluti (Mardin)	Yün çelebi (G.antep)
	Tespih çelebi (G.antep)	Melkabazı (Derik)	Yuvarlak çelebi (Halfeti)
	Eğriburun (Tatayn)	Mavi (Derik)	İri yuvarlak (Tatayn)
	Yağ çelebi (G.antep)	Zoncuk (Derik)	Hursiki (Mardin)
Blacksea Region	Görvele (Artvin)	Sinop No: 6	Samsun yağlık
	Butko (Artvin)	Sinop No: 4	Marantelli (Trabzon)
	Samsun ufak tuzlama	Samsun salamuralık	Samsun tuzlamalık
	Sinop No: 1	Patos (Trabzon)	Trabzon yağlık (Trabzon)
	Sinop No: 2	Otur (Artvin)	Tuzlamalık (Samsun)
	Sinop No: 5	Satı (Artvin)	

The Olive Research Institute, which works for the Ministry of Food, Agriculture and Livestock, is responsible for the collection and conservation of olive gene resources.

Figure 2. Olive Research Institute, Bornova, Izmir

To date, 161 genotypes including variety, type and clone have been selected from all over the country and kept under conservation at the Olive Field Gene Bank in Kemalpaşa (Figure 3.a).

Izmir World Olive Collection

The Olive Research Institute is establishing a worldwide germ plasm bank as part of the project "The Establishment, Conservation and Management of the World Olive Collection", under the auspices of the IOC. After the Cordoba and Marrakesh collections in the west, the eastern Mediterranean is the natural location for the third collection, particularly due to the importance of olive growing in this region.

The primary objective of this project is to conserve the genetic diversity of olives for all olive growing countries to make this diversity sustainable in the event of climate or environmental change. The second objective is to conduct research to be made available to the whole scientific community. The installation of this collection in Izmir also helps to ensure the survival of the genetic resources held in other collections (Cordoba and Marrakech) in the event of incidents caused by natural disasters, fire, pests, epidemic diseases, etc. The Izmir World Olive Collection comprises the varieties cha-

Figure 3. a) Olive Field Gene Bank in Kemalpaşa **b)** Plant stocks of the main Turkish cultivars

racterised (primary and secondary characterisation) and certified by the member countries of the IOC. To date, it has registered 1198 olive varieties from all olive growing countries in the world. A significant proportion of these varieties have been already protected in the collections of Cordoba (established in 1970) and Marrakesh (established in 2003).

The project was launched in 2012 and since then varieties have gradually been incorporated into the collection from Albania, the Marrakesh World Olive Collection and Cordoba University, to reach 187 varieties to date. The Izmir World Olive Collection is going to be established in the Experimental Station of the Olive Research Institute in the Kemalpaşa district. The Turkish Ministry of Development invested in the infrastructure of this project, which includes a greenhouse, lath house, offices, laboratories and the agricultural equipment and machinery needed to manage the collection. This collection is expected to provide accurate and reliable material for researchers and to promote the development of an international network for cooperation between olive growing countries for future research activities.

Creating awareness of the importance of Turkish olive germplasm through a mobile olive oil extraction system

M.T. Ozkaya[a], N.F. Ustunel[b], D. Sivri-Ozay[c],

[a] Ankara University, Faculty of Agriculture, Department of Horticulture, Ankara, 06-110, Turkey
[b] Nar Dogal Urunler Tur. Tic. San. A.S., Umraniye-Istanbul, Turkey
[c] Hacettepe University, Department of Food Engineering, Ankara 06-800, Turkey

There are 1250 olive varieties in the world with 3000 synonyms (Bartolini *et al,* 1998; Olea database [2000 varieties]; FAO 2010 (2629 accessions); Muzzalupo *et al*, 2014).

The olive tree originates in Turkey, which is an important source of olive germ plasm. In 1968, the National Olive Collection was established at the Olive Research Institute in İzmir. Since then, the Ministry of Food, Agriculture and Livestock and various universities have conducted clonal selection and crossbreeding programmes to develop new varieties and clones exhibiting a number of traits – high yield, high quality, low alternate bearing, resistance to pests, etc. – for table olive and olive oil production.

In Turkey, olive trees are cultivated in 40 municipal districts (Fig. 1). Aydın, İzmir, Manisa, Muğla, Hatay, Mersin, Balıkesir and Bursa are the most important ones in terms of the number of trees grown. Olive oil producers are located mainly in Balıkesir, Muğla, Kilis, Aydın, İzmir and Gaziantep, while table olive producers are concentrated in Bursa, Manisa and Aydın.

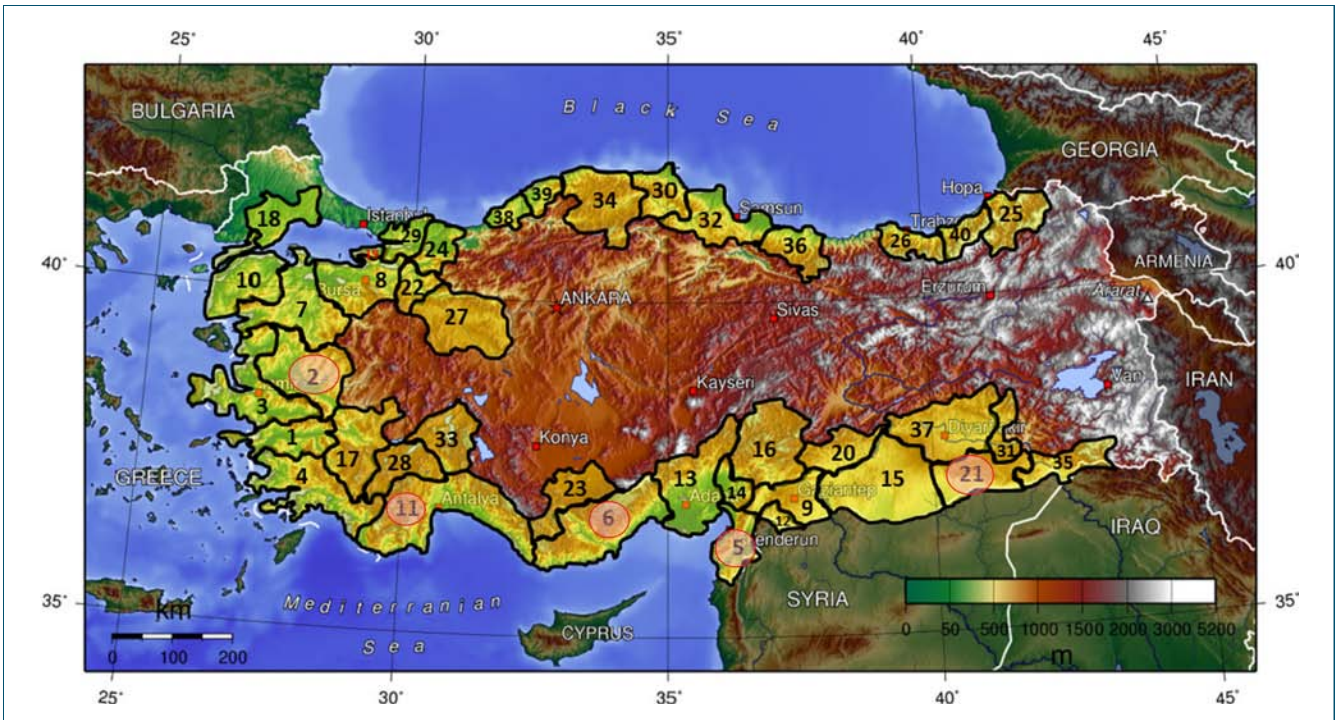

Figure 1. Map of the number of olive trees in Turkey, ranked by district, e.g. the Aydin district (district 1) has the most olive trees. Numbers in a red circle indicate the project areas: 2: Manisa; 11: Antalya; 6: Mersin; 5: Hatay; 21: Mardin

Turkey is very important for its olive germplasm. Many olive cultivars are available to farmers but only a few have economic potential in the olive oil and/or table olive market. Farmers who grow local varieties therefore want to switch to better-known cultivars but the fact is that they have never produced or tasted the high-quality extra virgin olive oils (EVOOs) that can be obtained from the local varieties.

A mobile olive oil processing unit (MOOPU) was therefore designed (Fig. 2) to produce top-rate EVOOs from local varieties and so demonstrate their distinctive characteristics and minor constituents, and encourage farmers to continue growing them in their area of origin, the ultimate objective being to preserve local varieties and increase farmers' income.

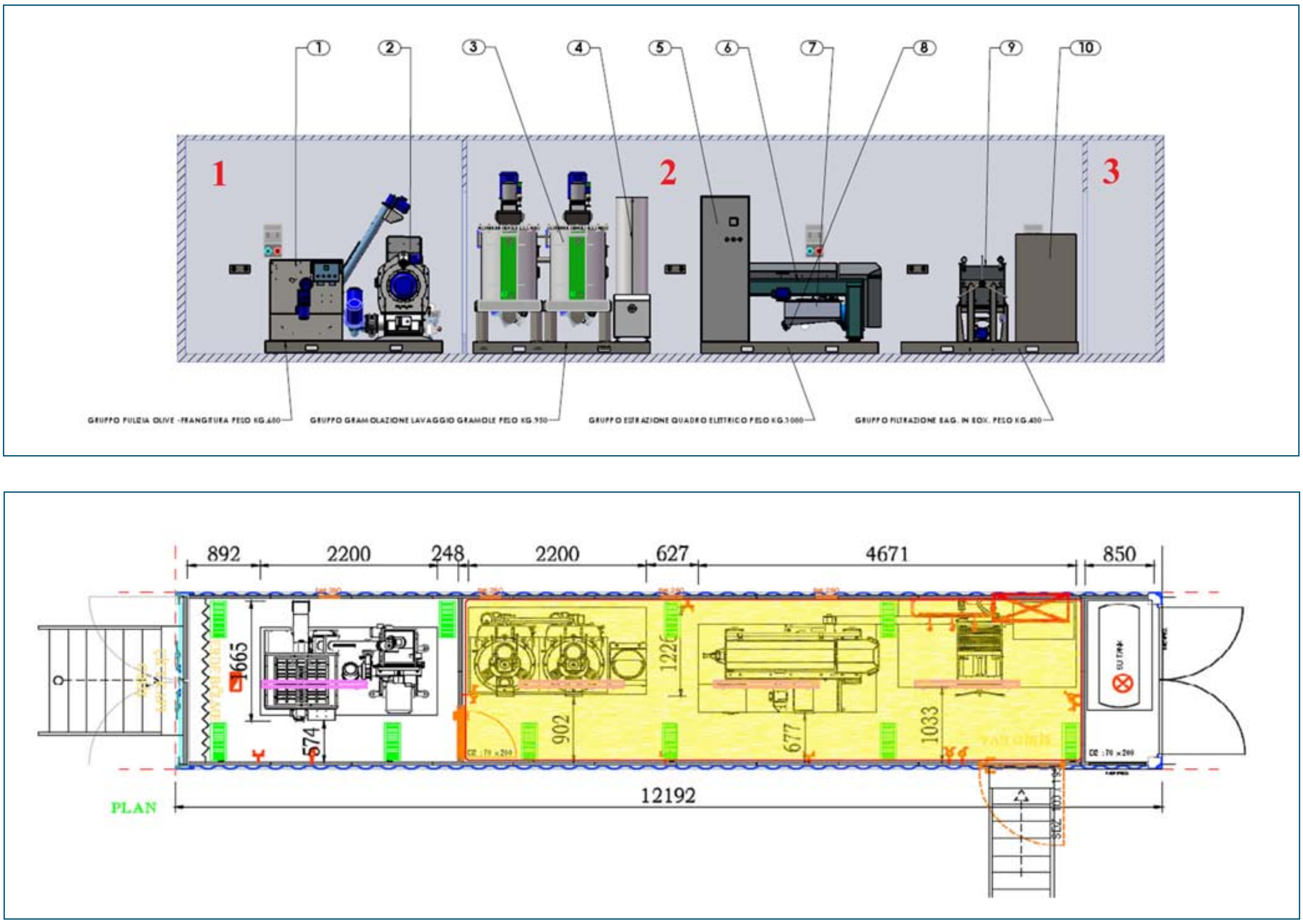

Figure 2. MOOPU design. Number 2/red area is the food handling area where only the operator is allowed.

The mobile unit is an articulated lorry with a special semi-trailer measuring 2438 x 12 192 x 2896 mm which is divided into three separate sections for EVOO production (Fig. 3). The first section is the olive reception area, equipped with a fruit bin, leaf-removal machine and washing and crushing units. The second section is the processing area and houses the machinery for malaxation, settling, filtration and packing, while the third section contains the generator and water supply tank. Since the processing section is a food handling area, it is protected from temperature changes, dust and extraneous smells and equipped with air conditioning, isolation and filtered ventilation systems to ensure hygienic conditions. The olive pomace left over from oil production is collected in barrels and transferred to the nearest olive pomace oil extraction plant.

Support was received from TEM Oliomio (Italy) for the machinery in the olive oil processing unit (TEM Oliomio 500-2GV, Italy), which is equipped with a knife crusher and two-phase decanter (Oliomio D500, Italy) with a capacity of 500 kg/h.

During the harvest season, the MOOPU was driven to olive orchards in the different regions of Turkey where local varieties are cultivated (Fig. 3g). The olive fruits are picked by hand and processed within hours, thereby resulting in top-quality EVOOs. For most of the local varieties, it was the first time that they had ever been made into premium EVOOs.

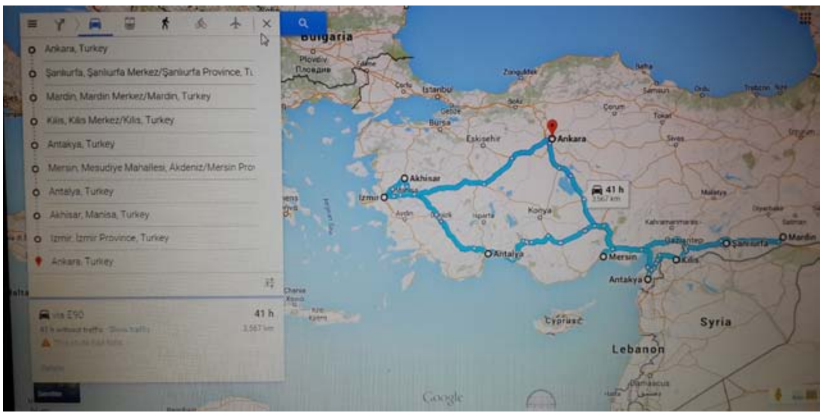

Figure 3. Pictures taken during the project trip:

(a) Mobile olive oil processing unit (MOOPU)
(b) MOOPU on the road to olive orchards
(c) First section: washing and crushing
(d) Third section: generator and water tank
(e) Second section: hygienic processing area
(f) MOOPU at work in the olive orchard
(g) MOOPU itinerary: more than 3500 km

Conclusion

Ever since it was first realised that the olive fruit is a wonderful gift of nature, much research has been carried out to investigate its health-promoting attributes. Olives contain many antioxidants and aromatic, phenolic and other compounds which, though minor, are important for health. It is essential, therefore, to take care at every stage of production – from the olive orchard to the bottling plant – to preserve those minor compounds.

The amount of major and minor compounds contained in the olive fruits differs according to genotype. It is necessary, therefore, to find out more about the health-promoting properties of each genotype. For instance, some cultivars have a high content of polyphenols, squalene or oleocanthal, which must not be lost during processing.

Ecology is central to olive oil quality. Ecological conditions in Turkey vary widely (elevations from 0 to 1200 m, rainfall of 100 to 1000 mm, temperatures ranging from -7 °C to 45 °C, gradients of 4–45%, etc.), producing olives and olive oils that offer a wide spectrum of tastes and aromas.

It is important to preserve all the minor compounds contained in the oils produced from local varieties. It is common knowledge that olives should be processed straight after harvesting and in hygienic conditions.

Educating consumers about the health benefits of olives and olive oil has helped to boost consumption. Obviously, price influences consumption of olive oil, as it does in the case of other agricultural products. This is corroborated by the drop in olive oil consumption recorded in Spain, Greece and Italy due to the economic crisis, but consumers who decide to eat olive oil for health-related reasons never stop consuming it.

The Turkish olive sector will see higher production and consumption, mainly of table olives but also of olive oil, especially for the gourmet segment of the market. This growth will be accompanied by increasing demand from health-conscious consumers for top quality olive oils from growers and processors. Healthy olive oil equates with extra virgin olive oil processed at below 27 °C, which is kept away from air, light, water, plastic and metal (except stainless steel) in order to retain all the healthy compounds found in the olive fruits.

In short, olive oil is no ordinary oil. It is a healthy fruit juice packed with vitamins and antioxidants and it has an excellent fatty acid composition. The rationale behind the MOOPU project is to protect local olive germ plasm and varieties by creating awareness of their health benefits and quality potential.

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Innovations in table olive processing

Mustafa Findik*, Ebru Mutlu, Marmarabirlik, Bursa

* Corresponding author: mustafafindik@marmarabirlik.com.tr

Abstract

As in all industries, research and development (R&D) and innovation policy is becoming more and more important in today's olive sector. This review describes some examples of the R&D activities designed and carried out by Marmarabirlik Zeytin Tarım Satış Kooperatifleri Birliği, Turkey's leading table olive sales cooperative.

Introduction

Nowadays, R&D and innovation is the precursor of improved competitiveness. As in all industries, it is becoming more and more important for olives. Generally, the goal of R&D is to develop new products and processes; find new uses for existing products and materials; devise new production techniques or elaborate on existing techniques; increase company productivity and lower production costs. As a leading agricultural sales cooperative in Turkey, Marmarabirlik attaches great importance to R&D. Some examples of what it is doing are explained below.

In Turkey, the conventional Gemlik method is generally used to produce natural black olives. This method uses high salt concentrations in the fermentation brine to ensure product safety. As a result, the salt ratio of the fruit flesh rises to very high levels, which is not to the taste of all consumers. However, the conventional method can be adapted to produce low-salt olives. As a result, consumer preferences for natural and low-salt olives are met.

When conventional methods are used, it can take 8–9 months for the fermentation of natural black olives to be completed. The start and rate of fermentation depend on the microorganism concentration and the free sugar content of the environment and require the right environmental conditions to allow the microorganisms responsible for fermentation to do their job. When conditions (right temperature, right pH and appropriate salt concentration) are optimal for the growth of the fermentation microorganisms, the rate of fermentation increases and the bitterness of the olive fruits is removed more quickly.

By modifying the existing conventional method of natural olive production and ensuring the necessary environment (stable temperature, salt concentration and pH values) in the fermentation brine, it is possible for natural black olives to be ready within three months.

Product differentiation studies have been performed with new production techniques. Research has investigated the conditions and machinery required for continuous drying and packing of black olives that have been naturally fermented in brine. The resultant low moisture/high dry matter products were differentiated in terms of their improved flavour. The aim of the studies was to reduce manpower needs at the production and packing stages.

After packaging, it is of key importance to ensure that table olives are free from spoilage throughout their shelf life. Mould growth is the main post-packing problem that occurs in natural black olives. Mould development is caused by oxygen that is left when the product is packed and that enters the package during the shelf life of the product due to the oxygen permeability of the packaging material. Hence, it is essential to package the product in a modified atmosphere and to prevent subsequent oxygen entry by ensuring the permeability of the packing material. Research has revealed that oxygen-barrier labelling can help to reduce the oxygen permeability of the plastic containers used for packaging table olives, so preventing product spoilage and extending shelf life.

Research has also explored ways of creating new uses for table olives, such as a filling for chocolates. After fermentation is completed, the salt is removed from the olives and they are made into jam to which orange peel is added for aroma. The chocolates are then filled with the sweet olive jam.

Conclusion

R&D is crucial for the development of the olive industry. It plays a key part in expanding the production of natural, healthy, top-quality products, as well as in increasing the number of differentiated products, raising productivity, lowering production costs and supplying more products for more consumers. Innovative research needs to continue on all the processes involved in olive production, from the orchard to the kitchen table.

Zero discharge of olive waste: green energy application

Mehmet ŞEN[a], Anıl YENTÜRK[b]

[a] mehmetgen@marmarabirlik.com.tr
[b] anilyenturk@marmarabirlik.com.tr

Introduction

There are more than 800 million olive-bearing trees in the world. Mediterranean countries account for around 97% of world olive crop area, estimated at approximately 10 000 000 hectares (ha). Turkey is the world's 6th biggest olive producer.

Disposing of the waste from olive oil mills and table olive processing facilities, which we will call olive waste (OW), has always been a problem for olive and olive oil producing countries.

OW contains compounds that are harmful to the environment. Consequently, the uncontrolled discharge of non-treated OW causes regional and global environmental problems. Since 1995, many research projects, pilot studies and regional initiatives have been carried out all over the world and numerous systems have been developed for the treatment of OW. However, there is still an urgent need for OW management guidelines using cost-effective and practical technologies that help to mininimise its environmental impact and lead to the sustainable use of resources through the application of common domestic policies.

This study aims to provide a practical and effective solution to OW in Turkey, which is one of the world's main olive and olive oil producers. There are many olive oil mills and table olive processing facilities in the country, both big and small. Marmarabirlik is one of the big enterprises and is important in Turkey because of its brand, capacity and worldwide products.

Marmarabirlik is the biggest olive association in the world. It is located on the southern shores of the Sea of Marmara, from which it takes its name, with Lake İznik to the east and Mürefte in Thrace to the west. It is a very important industrial concern that generates added value for the Turkish economy. Its modern, hygienic plants have the capacity to pack approximately 150 t of olives per day and to produce and pack 220 t of olive oil per day. It purchases and processes 40–45% of the edible black olives cultivated in the region and delivers its products nationwide through 60 agencies in 53 cities, besides exporting to Germany, Denmark, Switzerland, the Turkish Republic of Northern Cyprus (TRNC), Bulgaria and elsewhere in Europe, as well as further afield to Canada and Australia, and particularly the United States. The company plays a major role in leading the innovation that is essential to the Turkish economy.

The objective of this article is to present a zero discharge and green energy solution for OW designed by Marmarabirlik.

1. Conception of the project

The wide variety of compounds found in OW makes it necessary to apply different technologies to eliminate the environmentally harmful pollutants.

In recent years, many management options have been proposed. Analysis of research papers and patents has revealed that numerous conventional treatment technologies have been applied to solve OW problems, with varying degrees of success. However, most call for substantial financial outlay and often fail to take resource efficiency into consideration. Accordingly, their application is largely limited because cost factors take precedence over treatment capabilities. In addition, they often focus on destroying the biophenols in the OW and produce concentrated secondary waste that requires further treatment.

The ongoing need for new technologies for the technically and economically sustainable treatment of OW has to contend with a number of constraints. It has to be a valid, easily reproducible solution for OW disposal that requires a low level of expertise and has a low overall environmental impact; lastly, the process has to be adaptable to the seasonal nature of OW. OW management is therefore still badly needed in the olive sector. Figure 1 traces the rationale of the project.

Figure 1. Conception of the project.

2. Project process

OW comprises liquid and solid waste. Liquid waste is generated when preparing/washing olives, brining green/black olives and producing olive oil according to the three-phase extraction system. Solid waste includes the wet pomace left over from three-phase olive oil extraction, which has a high content of organic compounds. Marmarabirlik has its administrative centre in Bursa. It makes table olives, olive oil and olive paste from the olives cultivated by partners in the South Marmara Region and sells these products on the domestic and foreign markets. It purchases and processes 40–45% of the edible black olives cultivated in the region and delivers its products nationwide through 60 agencies in 53 cities, besides exporting to Germany, Denmark, Switzerland, TRNC, Bulgaria and elsewhere in Europe, as well as further afield to Canada and Australia, and particularly the United States. Figure 2 outlines the production process at Marmarabirlik, in addition to the types of waste generated and waste disposal methods.

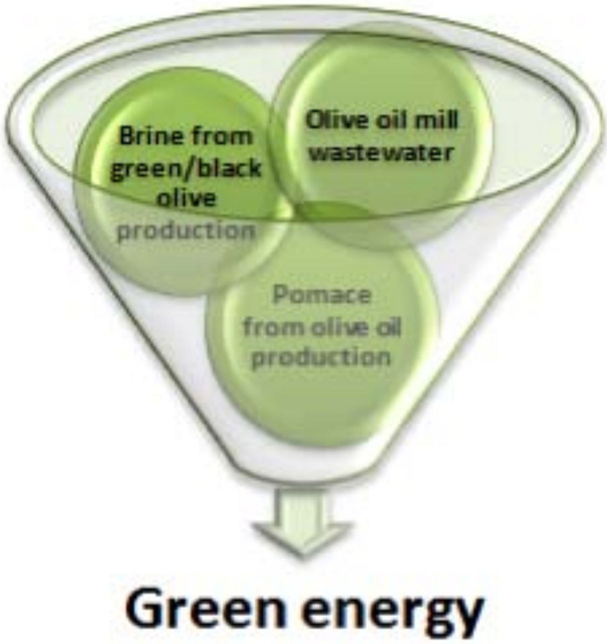


Figure 2. Process of the project.

3. Marmarabirlik zero OW discharge project

The main objective of the project is to develop OW recovery solutions that serve as a guide for the olive industry in Turkey and worldwide.

Up to now, most of the solutions proposed for OW treatment have been based on conventional systems with high energy demands and high operational and maintenance costs requiring the services of specialised personnel. However, it is necessary to develop cost-effective, practical OW management solutions, especially for small producers. Feasible solutions from the technical and economic points of view are not yet available. As a result, facilities discharge their waste into the environment illegally and without control. Waste management guidelines are therefore urgently needed to harness technologies that help to minimise the environmental impact of waste and ensure the sustainable use of resources. Other factors to bear in mind are that some treatments are not sufficiently efficient to provide a full solution to the environmental problem linked to OW; most are also not cost-effective.

Marmarabirlik, which is the leading company in the Turkish olive and olive oil industry and a major world player, has designed an OW management project for the treatment of wastewater and olive pomace generated by three-phase olive oil extraction, wastewater from the production of black/green olives and liquid waste from fruit washing and preparation processes. The goal of the project is to put forward a solution to the major environmental problem of OW, minimise its harmful environmental effects and comply with regulations. By implementing the project, Marmarabirlik can show

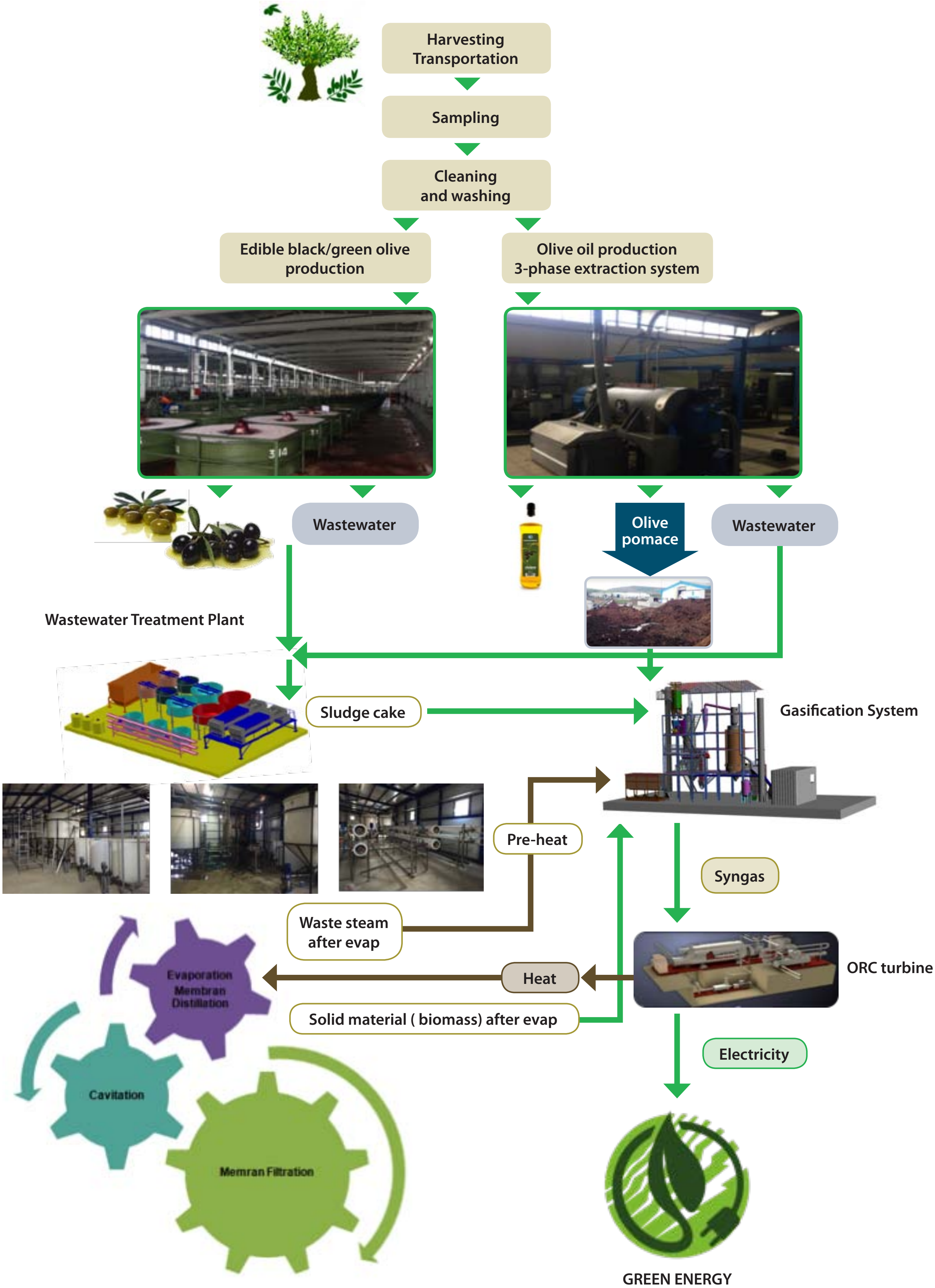


Figure 3. Marmarabirlik OW management flow diagram

small facilities in Turkey and elsewhere how to manage OW in an environmentally-friendly, innovative and cost-effective way.

The Project (No. 3130469) received support under the R&D programmes of the Scientific and Technological Research Council and the Directorate of Technology and Innovation Support Programmes (TUBITAK–TEYDEB). It incorporates various systems to solve the problem of OW management, specifically a wastewater treatment plant to treat the wastewater from three-phase extraction and other liquid waste, gasification facilities to produce syngas from olive pomace waste and an organic Rankine cycle (ORC) turbine to generate electricity from the syngas. All the systems are integrated with each other to form a symbiotic cycle (Figure 3) featuring minimum costs, minimum energy consumption and maximum performance.

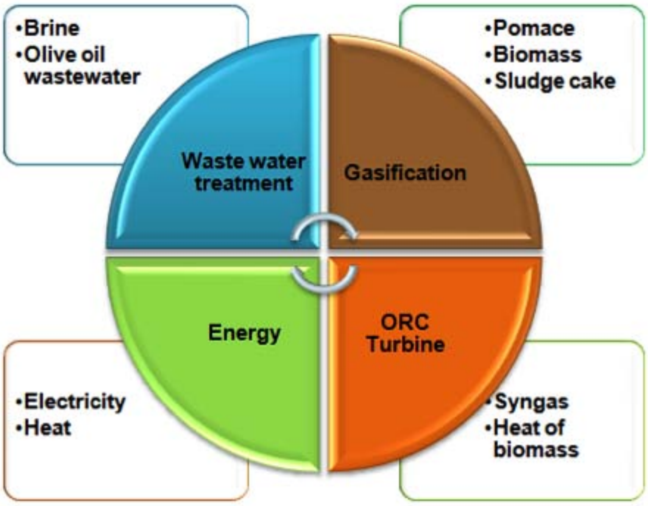


Figure 4. Marmarabirlik wastewater-biomass-energy symbiotic cycle

This Marmarabirlik project is new and original because the goal is to develop facilities permitting sustainable olive production with zero waste discharge and the recovery of water and raw materials. As yet, there are no such facilities in Turkey. The project will therefore produce technical benefits in the global production process and will be an innovation with a potentially significant economic and environmental impact at national and international level.

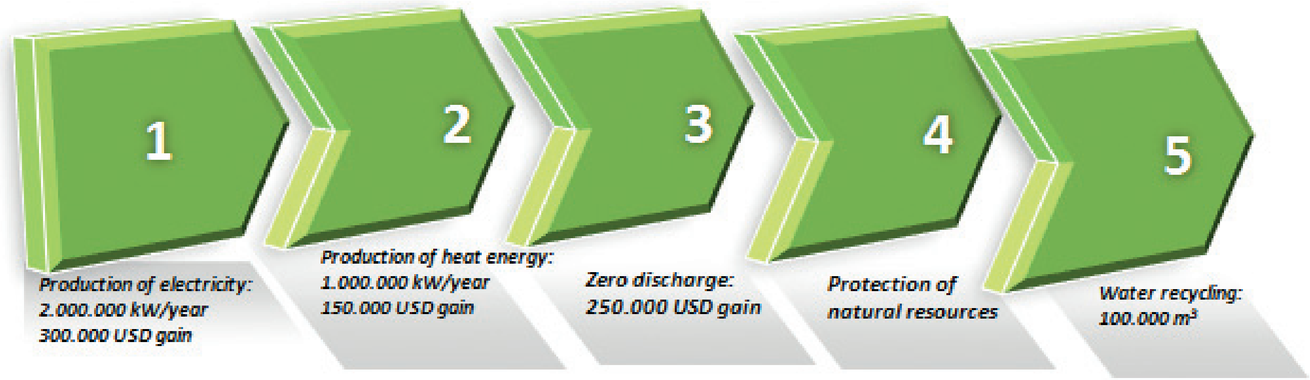
The prime objective is to take an innovative approach to OW treatment and disposal through integrated management and recycling (water, salt and energy). In the case of liquid waste, the process applies pre-treatment and physico–chemical treatment after cavitation with membrane filtration, membrane distillation and evaporation. Research will explore the possibility of using the resultant concentrated waste as a source of energy. In the case of solid waste (olive pomace), the pilot-scale process uses condensed pyrolysis gasification in a partial oxidation reactor, oxidation and reduction (gasification) to convert the waste into synthesis gas. The aim is to recycle the by-product of the gasification process for use as fuel for boilers in the cement industry. The development of the process is of major significance for the whole olive industry, which is concentrated in the Mediterranean region.

The development of this type of waste management system will help to lower treatment and production costs in the sector and to achieve sustainability. Pilot-scale studies will be carried out after evaluation of the laboratory-scale studies. The aim is to install a pilot system at Marmarabirlik's Başköy Integrated Facilities in Bursa with the capacity to handle approximately 5 m^3/day. The facility will comprise the following units: a rapid mixing unit for chemical coagulation, a slow mixing unit for flocculation, a settling tank, a filter press unit, a nanofiltration unit (at least two stages), a reverse osmosis unit for evaporation, and a membrane distillation unit. For the evaporation system, hot oil at a temperature of 315 °C will be used as the source of heat and will come from the ORC turbine, which in turn works on the syngas obtained through gasification of the pomace, following which the oil will be cooled to 255 °C. The difference in heat will be transferred via a tube heat exchanger to treat the brine waste left over from the production of green or black olives and the wastewater from three-phase extraction. The OW in the evaporation tank volatalises at 108–114 °C and the resultant solid waste left over after evaporation is transferred as fuel for the gasification system. There are also plans to use the evaporated water or waste steam for pre-heating the gasification system.

Conclusion

Turkey, like other olive oil producing countries, has to contend with serious problems of environmental pollution. One such problem is the waste generated by olive oil mills and table olive processing facilities, primarily the liquid and solid waste from the three-phase extraction system that produces oil, olive pomace and wastewater.

Up to now, there have been numerous research initiatives, publications and pilot and full-scale projects for OW management, all with advantages and disadavantages. At present, there is no globally reliable management plan or flexible legal framework for the agricultural reuse of treated OW.



This study provides an economic solution to OW management for Turkey, based on zero-waste discharge and the production of green energy. Currently, no facilities in the country use such a process, which incorporates gasification-wastewater treatment and the use of an ORC turbine, with the ensuing significant economic and environmental impact. The proposed process is therefore an innovation of national and international importance because it offers a zero-waste discharge process that is eco-friendly and cost-effective and that takes a green energy approach.

All the component parts of the facility have been installed, integrated and automated and are controlled by a supervisory control and data acquisition (SCADA) system (Fig. 4). Recycled energy is used for OW disposal, which means no extra energy demand is created. This OW management initiative is cost-effective and practicable and features SCADA control; initial investment costs are low, it requires minimum manpower while delivering maximum performance, does not require extra energy and complies with legal requirements. In addition, it generates extra gains in terms of the sale of green energy.

The project is expected to produce the following results:

- Electricity production: 2 000 000 kW/year, generating USD 300 000 in extra earnings;

- Heat energy production: 1 000 000 kW/year, generating USD 150 000 in extra earnings;

- Zero-waste discharge: USD 250 000 USD in extra earnings;

- Protection of natural resources;

- Water recycling: 100 000 m3.

It is the first such project ever to be implemented in the world and is remarkable because of its innovative nature and benefits, and the zero-discharge approach it takes while producing green energy from olive pomace.

Figure 5. Photographs of the Marmarabirlik project plant

Olive cultivation in Çanakkale

N. Kaleci[1], M.A. Gündoğdu[1*]

[1] University of Çanakkale Onsekiz Mart, Faculty of Agriculture, Department of Horticulture, Turkey
[*] Corresponding author: magundogdu@comu.edu.tr

Abstract

Çanakkale is the name of a city and a province in Turkey that are closely associated with ancient legend and boast some 5000 years of history and culture. The province is also one of the most important agricultural areas in Turkey with livestock, fresh fruit and vegetables among its most significant products. It accounts for 1.19% of Turkey's total agricultural area and 5.01% of its olive orchards. Olives are grown primarily for oil production, 'Ayvalik' being the main cultivar planted. Local producers sell their olive oils to retailers or wholesalers and cooperatives after setting aside an amount for their own consumption. In addition, large olive fruits are selected after harvest and used for green and black pickled olives to meet local demand.

Keywords

Ayvalik cultivar, Çanakkale, table olive, olive oil, Turkey

Introduction

Çanakkale is the name of a city and a province in Turkey that are closely associated with ancient legend and boast some 5000 years of history and culture. The province is also one of the most important agricultural areas in Turkey with livestock, fresh fruit and vegetables among its most significant products. It accounts for 1.19% of Turkey's total agricultural area and 5.01% of its olive orchards (Anonymous, 2008). The Ayvacik and Ezine districts along the Aegean coast are densely blanketed with olive orchards, which spread along both sides of the Dardanelles strait at the entrance of the Sea of Marmara, where they are found in low-lying valleys protected from northern winds. The main bulk of the olives produced in Çanakkale are use for olive oil production but a small amount is reserved to meet local demand for split green table olives. Among the benefits it brings for the region, olive production is a major source of employment for the local people (Koca, 2004).

Overview of Çanakkale Province

Çanakkale Province stretches across 9737 m^2 in the Gallipoli peninsula of the north-western part of Turkey and the Biga peninsula of Anatolia (Figure 1), while the city of Çanakkale makes a significant contribution to the Turkish economy through earnings generated by its history, nature tourism and agricultural infrastructure.

The climate is Mediterranean with hot, dry summers and cool, rainy winters; ordinarily there are a few days of snow every winter, especially inland in the Marmara and Aegean regions. The average annual temperature is 14.9ºC. The temperature rarely falls below zero while the maximum does not exceed 40ºC. Olive orchards in the Marmara region grow in a semi-humid climate, where summer temperatures are never as high as in Mediterranean-climate areas and winter temperatures never fall as low as in inland Anatolia.

Figure 1: Çanakkale Province and Districts (1: Gallipoli, 2: Eceabat, 3: Centrum, 4: Lapseki, 5: Biga, 6: Yenice, 7: Can, 8: Bayramic; 9: Ezine, 10: Ayvacik, 11: Gokceada, 12: Bozcaada, 70: Aegean Sea, 71: Dardanelles (Hellespont), 72: Sea of Marmara) (Anonymous, 2016b).

Temperature extremes are not a major problem for olive growing in the Çanakkale region, although low temperatures in some years have led to major frost damage to olive trees. Similarly, albeit very rarely, snowfalls have damaged the branches of the trees and negatively affected the next season's crops (Ergün and Zeyrek, 1999; Koca, 2004).

The average annual rainfall in Çanakkale Province is 628.8 mm; however, irregular rainfall has a significant impact on yield and quality, thus making it necessary to irrigate olive orchards in the summer months (Anonymous, 2003; Koca, 2004).

Sandy–loam, loam, loamy–sandy, clay–loam and silty-loam soils offer optimum conditions for olive root development, because of their permeable texture and adequate water-holding capacity. The soil textures in Çanakkale Province vary according to the topography, climate and crops (55.7% loam, 37.9% clay–loam, 3.9% clay and 2.5% sandy soil).

Olive cultivation in the agriculture of Çanakkale

Çanakkale Province extends over an area of 993 300 ha. Fifty-four per cent of this area is forest and moor, while 34% is arable agricultural land, 23% of which is suitable for irrigation (Anonymous, 2008). Olives are farmed on 30 351 ha or 11.58% of the arable land in the province (Table 1).

Temperature conditions, particularly winter frost, are the main determining factor for olive cultivation in Çanakkale. Consequently, olive trees can be grown in all the districts of the province except Can and Yenice, as well as in places bordering the Aegean Sea, which are protected from the northern winds, such as Ezine, Kucukkuyu and Ayvacik, which are the chief olive growing and production areas. The villages and valleys between the towns of Kucukkuyu and Babakale, bordering the Gulf of Edremit and the Aegean Sea, are where olive cultivation is most abundant (Figures 2, 3, 4 and 5).

Table 1: Distribution of arable land in Çanakkale

Distribution of arable land	Çanakkale (2014) (ha)	Ratio (%)
Field crops (including fallow)	18 8682	71.90
Olives	30 351	11.58
Vegetables	20 529	7.82
Fruit and vine	22 811	8.69
Total	**262 407**	**100**

Olive and olive oil production

There are 5 415 301 olive trees in the province of Çanakkale, 90% of which are of crop-bearing age (Table 2). Ninety-three percent of the bearing trees are cultivated for oil production. 'Gemlik' and 'Ayvalik' are the main cultivars, although 'Domat' has started to be planted in recent years for green table olive use.

Average crop yield per tree varies from year to year (Table 2) and has swung from 10 to 32 kg over the last two years. Olive production also oscillated from 70 958 t to 104 592 t between 2013 and 2014, while olive oil production ranged from 13 503 t to 18 404 t (Anonymous, 2016a).

Çanakkale has the potential to produce some of the best olive oils in the world owing to its climate, a potential that locals are beginning to realise.

The 'Ayvalik' cultivar in the Ayvacik-Çanakkale area has been assessed for the pomological characteristics of its fruit and the composition of its oil (Kaleci, 2010).

It was observed that in Çanakkale the fruit yield of this cultivar varied from 21.30 kg/tree^{-1} to 20.46 kg tree^{-1} and fruit weight differed from 332.35 g/100 fruit^{-1} to 373.40 g/100 fruit^{-1} (Table 3). Fruit width and length ranged from 16.45 to 18.30 mm and from 20.05 mm to 21.80 mm, respectively. Gundogdu and Kaynas (2015) reported that 'Ayvalik' fruit width and length varied from 16.24 mm (25 NOVEMBER) to 18.16 mm (22 December) and from 20.38 mm (25 NOVEMBER) to 22.76 mm (22 December), respectively. The same researchers showed that the weight of 'Ayvalik' olives changed from 323.7 g/100 fruit^{-1} to 422.4 g/100 fruit^{-1} between 25 NOVEMBER and 22 December.

When analysed, 'Ayvalik' olives grown in the province of Çanakkale were found to have an oil content of 32.38%, free acidity of 0.79% expressed as oleic acid and a saponification value of 193.1 mg KOH/g, all of which comply with the requirements specified in the IOC trade standard (Table 4) for extra virgin olive oil (Table 4). The values for the iodine value (83.95%), density (0.972 20°C/20°C water) and refractive index (1.469 nD 20°C) were also inside IOC limits (2003).

Figure 2: Çanakkale, Centrum district

Figure 3: Olive orchards in the Çanakkale-Küçükkuyu district

Figure 4: Olive orchards in the Çanakkale-Ayvacık district

Figure 5: Olive orchards in the Çanakkale-Ezine district

Şeker *et al.* (2008) recorded values of 80.77% and 1.469 nD 20ºC for the iodine value and refractive index of oils extracted from the 'Ayvalik' cultivar. Oktar (1988) reported that extra virgin olive oil produced in Çanakkale had a refractive index of 1.4685 nD 20ºC, a water density of 0.9127 20ºC/20ºC and a saponification value of 189.03 mg KOH/g.

The fatty acid composition of oils produced from 'Ayvalik' olives in Çanakkale region is shown in Table 5. As can be observed, the main fatty acids were determined: oleic acid (C18:1) 73.61%, palmitic acid (C16:0) 12.76%, linoleic acid (C18:2) 9.67%, stearic acid (C18:0) 1.60%, palmitoleic acid (C16:1) 0.95%, linolenic acid (C18:3) 0.41%, arachidic acid (C20:0) 0.40%, eicosenoic acid (C20:1) 0.14% and behenic acid (C22:0) 0.01%. The distribution of the fatty acid composition of the oils complies with the IOC trade standard (2003). Table 5 also lists the fatty acid limits fixed in the IOC standard.

Table 2: Olive cultivation in Çanakkale

Year	Use	Olive orchards (ha)	Olive production (t)	Oliveoil production (t)	Yield (kg tree^{-1})	Number of bearing trees	Number of non-bearing trees	Total number of olive trees
2013	Table	17 562	3 445		10	339 160	51 186	390 346
	Oil	304 059	67 513	13 503	15	4 508 900	478 910	4 987 810
	TOTAL	321 621	70 958	13 503	12.5 (mean)	4 848 060	530 096	5 378 156
2014	Table	17 536	10 731		32	339 150	52 181	391 331
	Oil	303 854	93 861	18 404	21	4 531 876	492 094	5 023 970
	TOTAL	321 390	104 592	18 404	26.5 (mean)	4 871 026	544 275	5 415 301

Table 3: Some pomological characteristics of the 'Ayvalik' cultivar in the Çanakkale area in 2005 and 2006

Fruit yield (kg tree^{-1})		Fruit weight.(g 100 fruit^{-1})		Fruit width (mm)		Fruit length (mm)	
2005	2006	2005	2006	2005	2006	2005	2006
21.30	20.46	332.35	373.40	16.45	18.30	20.05	21.80

Table 4. Quality composition of olive oils produced from the 'Ayvalik' cultivar in the Çanakkale area (2005)

Oil (%)	Free acidity (% oleic acid)	Saponification value (mg KOH/g)	Iodine value (%)	Density (20ºC/20ºC water)	Refractive index (nD 20ºC)
32.38	0.79	193.1	83.95	0.972	1.469

Table 5. Fatty acid composition of 'Ayvalik' olive oils produced in the province of Çanakkale in 2005

Fatty Acids (%)	IOC limits (IOC, 2003)	'Ayvalik' cultivar in Çanakkale
Palmitic acid (C 16:0)	7.5 – 20.0	12.76
Palmitoleic acid (C 16:1)	0.3 – 3.5	0.95
Stearic acid (C 18:0)	0.5 – 5.0	1.60
Oleic acid (C 18:1)	55.0 – 83.0	73.61
Linoleic acid (C 18:2)	3.5 – 21.0	9.67
Linolenic acid (C 18:3)	< 1.0	0.41
Arachidic acid (C 20:0)	< 0.6	0.4
Eicosenoic acid (C 20:1)	< 0.4	0.14
Behenic acid (C 22:0)	< 0.2	0.01

Conclusion

The olives cultivated in Çanakkale are chiefly channelled into olive oil production because 'Ayvalik' is the main cultivar found in its olive orchards. Local producers sell their olive oils to retailers or to wholesalers and cooperatives after they have set aside an amount for their own consumption. Large olive fruits selected after harvest are used to make green and black pickled olives to satisfy local demand (Kaleci, 2012).

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Industry–university partnership for the simultaneous biotechnological degradation and value enhancement of olive mill wastewater

Alper Karakaya[1], [2]*, Yahya Laleli2, Serpil Takaç[3]

[1] Institute of Biotechnology, Ankara University, Ankara, 06100, Turkey
[2] Düzen Laboratories, Atatürk Bulvarı, No 237/39, 06680, Ankara, Turkey
[3] Department of Chemical Engineering, Faculty of Engineering, Ankara University, Ankara, 06100, Turkey

* Corresponding author: Tel.: 00.90.312.203 34 34; fax: 00.90.312.212 15 46; e-mail: alper.karakaya@gmail.com

Abstract

Olive mill wastewater poses a serious problem for olive oil producers in Mediterranean countries. As part of an industry–university collaborative initiative, this by-product was subjected to several microbial treatments to lower its high phenol content and simultaneously produce useful spinoff products. Two non-conventional yeasts – *Rhodotorula glutinis* and *Debaryomyces hansenii* – were used for the biodegradation of the olive mill wastewater in batch, fed-batch and continuous bioreactors. More than 85% of the total phenol content of the olive mill wastewater was removed. The resultant single cell oil and cell biomass were proposed as value-added biodegradation products for potential use in the energy sector and as a food supplement, respectively.

Introduction

Since 2009, a biotechnological process generating useful spinoff products from the dephenolisation of olive mill wastewater (OMW) has been developed as part of an industry–university partnership. The collaboration has entailed conducting R&D projects to treat OMW generated by the olive oil processing plant owned by the Düzen Company in Burhaniye (Laleli Olive Oil Company). Specifically, the OMW has been subjected to several treatments to reduce its phenolic content prior to its disposal on the land or use in the production of microbial products. These research activities have been supported by national projects funded by the Scientific and Technological Research Council of Turkey (TUBITAK) (Takaç, 2015b; Takaç, 2012; Takaç, 2011) and Ankara University (Takaç, 2013; Takaç, 2015a). MSc and PhD theses, international papers and congress presentations are other academic outputs of the partnership. In the light of the results of laboratory-scale experiments carried out in Ankara University, studies are now aimed at designing, setting up and operating a pilot-scale bioprocess unit near the olive oil processing plant at Burhaniye.

The aqueous by-product of olive oil production, known as OMW for short, is a serious problem for manufacturers in Mediterranean countries owing to its high phenolic content and organic load. It is estimated that the olive oil industry produces 30 million m^3 of wastewater annually (Karakaya et al., 2012). The generation of this huge amount of wastewater in a short production season triggers severe ecological problems when discharged into the environment without treatment. High degrees of chemical oxygen demand (COD= 40-220 g/L) and phenolic content (0.5-24 g/L) lead to oxygen depletion in underground and surface water and have toxic effects on plant and microbial strains (Karakaya et al., 2012). The pollutant effect of 1 m^3 of OMW is reported to be equivalent to 200 m^3 of municipal waste (El-Abbassi et al., 2012).

In these biodegradation studies, two different non-conventional yeasts, namely *Rhodotorula glutinis* and

Debaryomyces hansenii, have been used. The red yeast *R. glutinis*, which is known for its ability to synthesise carotenoids, can also accumulate lipids. The extremophilic yeast *D. hansenii* is proposed as a promising future source for the production of several useful products. The common feature of these yeasts, which led to their being chosen as model cells for OMW biodegradation, is that they are capable of surviving in oil-containing media. In the proposed bioprocess, we aim to *(i)* remove a large proportion of the total phenol content of OMW, *(ii)* produce value-added products, mainly microbial oil, and *(iii)* cultivate sufficient yeast for simultaneous use as a food supplement.

Experiment

The defining characteristics of the OMW used in our studies were a total phenol concentration of 620–1800 mg/L, COD of 45 000-88 500 mg/L and pH of 4.25-4.60. *Rhodotorula glutinis* (DSM 70398) and *Debaryomyces hansenii* (NRRL Y-7426) were supplied by the manufacturers. During cultivation, the variations in yeast concentration and OMW characteristics were monitored. Biomass concentration was determined as dry cell weight; total phenol concentration was measured by using Folin Ciocalteau's method (Ayed et al., 2005) and COD level was monitored by the reflux colorimetric method (Karakaya, 2011). Ethyl acetate extracts of phenolic compounds were analysed with an HPLC (Karakaya et al., 2012) and enzyme activities were measured spectrophotometrically (Akardere, 2012).

Results

R. glutinis was cultivated in diluted and undiluted OMW supplemented with different nutrients. Batchwise experiments were conducted to investigate the effects of centrifugation and sterilisation of the OMW medium, the presence of nitrogen supplements, initial medium pH, temperature, agitation rate and cultivation time on cell growth, total phenol removal and COD reduction. *R. glutinis* was found to be capable of surviving in raw OMW as well as of decreasing total phenol and COD levels and increasing the pH of the medium. In all the cultivations, medium pH was observed to increase in close step with cell accumulation and biodegradation. Medium pH was therefore monitored as an indicator of cell growth and dephenolisation throughout the cultivations. The best conditions for batch biodegradation were found to be a high initial medium pH using urea as nitrogen supplement, 30^{o}C and 150 rpm. The addition of yeast extract to the growth medium and OMW sterilisation and centrifugation were not observed to have any effect on the bioremediation process. Under the best conditions for total phenol removal, 89% and 18% reductions in total phenol content and COD level were achieved after 120 hours of cultivation, respectively. The highest amount of yeast biomass accumulated in the OMW cultivation medium was about 4 g/L. The characteristic strong odour of the OMW disappeared after bioremediation (Karakaya, 2011; Karakaya et al., 2012).

The OMW was also treated with alginate-immobilised *R. glutinis* cells in a batch system. The effects of pellet diameter, alginate concentration, cell loading, initial total phenol concentration, agitation rate and reusability of pellets on OMW dephenolisation were studied. A dephenolisation rate of up to 87% was obtained after 120 hours of biodegradation in a diluted OMW medium supplemented with urea at 30^{o}C and 150 rpm. The number of pellets used increased with the addition of calcium ions to the biodegradation medium. Reuse of pellets five times every 48 hours led to a dephenolisation rate of approximately 70%. The structural properties of the alginate beads, such as diameter and hardness, had less effect on the extent of dephenolisation than operational parameters such as substrate concentration and agitation rate. This result indicates that the alginate gel tolerated the difficult properties of OMW, such as low pH and high salinity and phenolic content (Bozkoyunlu and Takaç, 2014; Bozkoyunlu, 2013).

OMW biodegradation was also carried out in fed-batch and continuous bioreactors in the light of the results of the batch experiments with *R. glutinis*. The strategy applied in the fed-batch operation was to add undiluted OMW intermittently to the batch medium to keep the medium pH stable. The addition of OMW to the biodegradation medium decreased the pH of the medium, provided fresh substrate for cells and kept cells active for biodegradation up to a critical pH value. This approach also enabled the biodegradation of high volumes of undiluted OMW. The total phenol removal rate achieved in fed-batch operations with free and immobilised cells was respectively enhanced approximately five- and two-fold relative to the corresponding batch-wise operations. Total phenol content decreased by 74% when free *R. glutinis* cells were used for 350 hours; however, this rate was 51% by the end of biodegradation with immobilised cells. On the other hand, in continuous biodegradation, the feed flow rate changed automatically according to the pH value set in the control system of the bioreactor to enable biodegradation to be carried out at a constant pH. In continuous operation, total phenol degradation rates of 89 and 83% were obtained in approximately 70 hours of operations using free and immobilised cells, respectively (Karakaya et al., 2013).

The other *D. hansenii* yeast used for the biodegradation of the OMW was cultivated in diluted OMW media containing different concentrations of urea and ammonium sulphate as nitrogen supplements and sodium chloride. The cells grew in all the medium compositions and decreased total OMW phenol content by up to 60 %. The highest value recorded for dry biomass was 1.2 g/L. In all of the media, the pH increased with cell growth and total phosphorus removal, thus showing that it could also be considered an indicator of biodegradation by both *D. hansenii* and R.glutinis. Biomass accumulation also increased with sodium chloride concentration in the OMW cultivation medium. Moreover, the addition of 1.3% sea water to the OMW resulted in a very high total phenol removal rate (73%) and a biomass accumulation value of 0.9 g/L after 72 hours of cultivation (Figure 1). The most interesting result of the *D. hansenii* studies is that sea water can be used to dilute OMW prior to biodegradation by this halophilic yeast (Karakaya et al., 2011).

In the case of fed-batch OMW biodegradation by *D. hansenii*, cells were inoculated into 50% OMW medium and the increase in medium pH was monitored. When the medium pH increased to 8, undiluted raw OMW was added to the cultivation medium. Total OMW concentration increased to 91% in the flask and a rate of 42% total phenol degradation was recorded. In the continuous operation with *D. hansenii*, 55% total phenol degradation was achieved (Karakaya et al., 2011).

The aromatic degradation ability of microorganisms is associated with the production of extracellular oxidase enzymes such as laccases, peroxidases, and tyrosinases (El Hajjouji et al., 2008). To explain the decrease in total phenol concentration we conducted biodegradation studies to monitor the variations in the activities of phenol-degrading enzymes and in the concentrations of phenolic compounds throughout the cultivations. The enzyme activities of tyrosinase monophenolase, tyrosinase diphenolase, laccase, manganese peroxidase and tannase enzymes by *R. glutinis* and *D. hansenii* were monitored. The variations in tyrosol, hydroxytyrosol, catechol, 4-methylcatechol and vanillic acid concentrations were monitored over time. The results showed that *R. glutinis* resulted in tyrosinase monophenolase, tyrosinase diphenolase and laccase activity in the OMW cultivation medium, whereas *D. hansenii* resulted in tyrosinase diphenolase enzyme activity. The yeasts degraded phenolic compounds in OMW to varying degrees according to their different enzyme activity (Akardere, 2012).

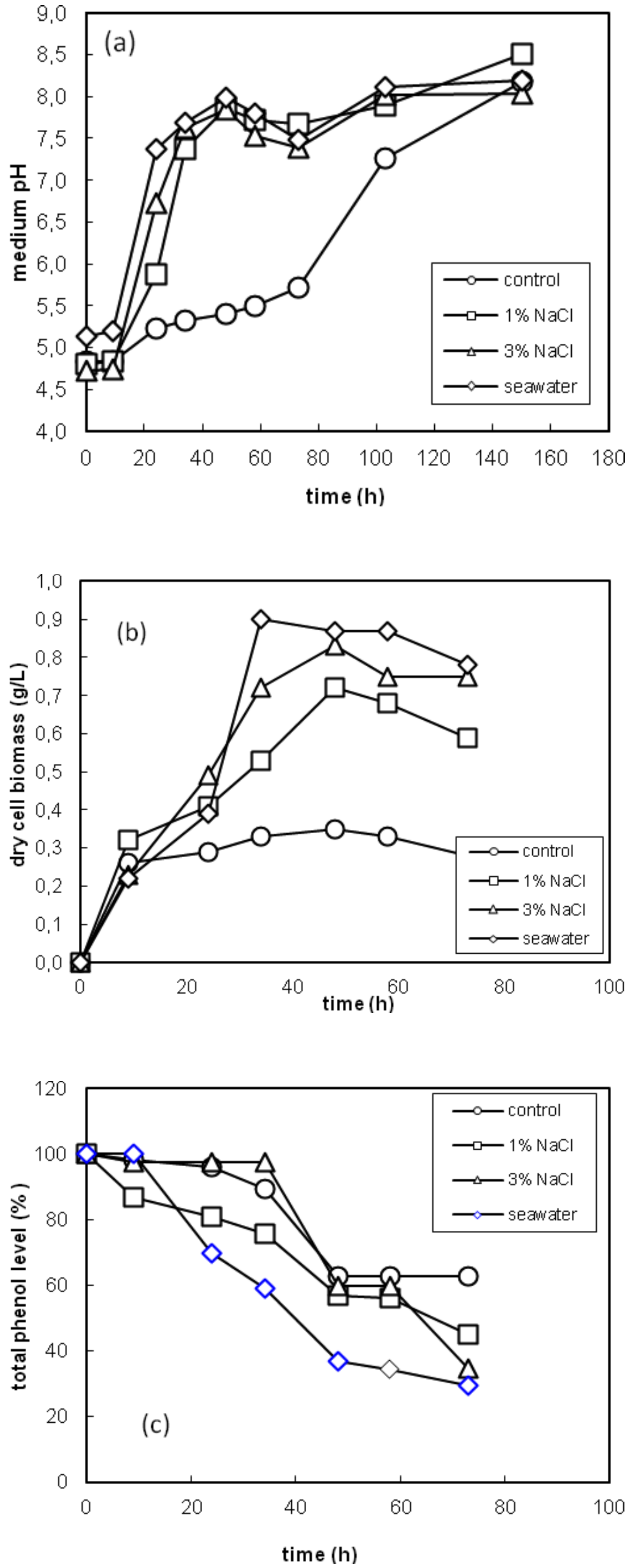

Figure 1: Effect of sea water on olive mill wastewater treatment by *D. hansenii* (OMW: pH=4.6; total phenol conc=32 mg/L, yeast extract, ammonium sulphate, seawater: 1.3 %). *(a)* time course of medium pH *(b)* time course of dry cell biomass *(c)* time course of total phenol level.

Our studies on biodegradation of OMW by *R. glutinis* also showed that some value-added products were also produced during cultivation. Because it is oleagenic, the *R. glutinis* yeast has the ability to accumulate lipids. Studies have shown that the fatty acid composition of the lipids produced by *R. glutinis* make them a suitable raw material for the production of biodiesel (Shales, 2007). We found that *R. glutinis* produced lipids representing more than 50% of its dry weight. The fatty acid composition of *R. glutinis* changed with the cultivation conditions, such as the addition of nutrient supplements to the medium, temperature and pH. We also observed that *R. glutinis* accumulated superoxide dismutase (SOD) and catalase (CAT) enzymes during its cultivation in OMW (Degirmenbasi, 2016).

Future aspects

Our seven-year research projects on the cultivation of *R. glutinis* and *D. hansenii* yeasts for the biodegradation of OMW have shown that olive oil industry wastewater is a promising and costless substrate for lipids and enzymes as well as for biomass production. Single cell oil has a growing potential in the world market. Our latest data reveal that it is possible to tailor the fatty acid profile by changing the cultivation conditions. Moreover, beta-carotene, which is produced by *R. glutinis,* is a trending product with important uses in the food and beverage industries. As the next step, we aim to set up a pilot-scale production plant near Laleli Olive Oil Company in order to optimise the large-scale production of single cell oil, carotenoids and microbial biomass in OMW media.

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Sensorial attributes of Turkish olive oil

Ümmühan TİBET*
*UZZK

In recent years, food products have come to occupy a strategic position due to global warming and the economic crisis. Despite the general stagnation in global demand, as millions of poor people suffer the tragedy of starvation and the rich minority faces health problems such as obesity, cancer, heart disease and atherosclerosis due to developments in technology, productivity and prosperity, the world's population is looking for healthy food alternatives. This has resulted in the rediscovery of the olive tree in the last 20 to 30 years in countries facing such extreme situations.

Campaigns to plant olive trees have been launched in the last few years in a number of countries, both rich and poor. Vast olive plantations are being developed, from the deserts of Saudi Arabia to India, Pakistan, Japan, Chile and Argentina. The olive tree that has been cultivated in the Mediterranean basin for centuries has now become a centre of gravity. This is explained by the fact that olive oil is a unique vegetable oil that is consumed in its natural form. The scientific studies and promotional activities carried out by the International Olive Council (IOC) have contributed significantly to the re-discovery of the importance of olive oil. It is one of the most important essential food substances for daily consumption, as even the most rigid diets cannot exclude oils altogether. Consequently, it is not surprising that people have at last become aware that the oil from this millennial tree is the healthiest oil available.

Our country has lost no time in catching up with this trend, even though olive oil has remained largely forgotten in its own homeland for almost 50 years. Olive trees and olive oil have thus been rediscovered. In fact, over the last 10 years, the number of olive trees in Turkey has increased by more than 50%, according to the data provided by the National Olive and Olive Oil Council (UZZK), to reach 167 million trees, and the Olive Research Institute has registered 90 different olive varieties in Turkey.

The excellent taste and flavour of olive oil depends on the olive variety, the climate and soil conditions, pesticides, the tree's nutritional status, the seasonal conditions, the degree of maturity, the harvest time and method, the working conditions of the olive pressing installation and the storage method. These factors affect over 100 components that conserve their natural characteristics and give flavour to the olive oil, creating different tastes and flavours in each new batch.

In our country, the homeland of the olive tree, the regions where the best flavoured olive trees are grown are Ezine, Kilis, Nizip, all the Marmara region and the Aegean, Mediterranean and south-east regions. Every olive tree in every region, district, and specific orchard, produces a different taste of oil every year due to the abovementioned factors. Given the right care, harvested at the right time and submitted to careful processing methods, the olive fruit offers us its oil as a unique gift of nature: a healthy ingredient with an excellent flavour.

The Ayvalık olive variety grows in the Turkish half-moon bay region, dotted over the districts of Çanakkale-Ezine, Küçükkuyu, Balıkesir-Edremit, Havran, Burhaniye, Ayvalık, and Zeytindağı. The moist and vaporous onshore winds that blow in from the north Aegean Sea blend with the oxygen produced by the flora of the Kazand Madra mountains and the rich vegetation of the Kozak plateau. The atmospheric conditions that this creates during the olive trees' oil forming process, gives the oil a colour range from dark green to light yellow, depending on the harvest time, and an appealing fruity aroma with hints of green almonds, green plums, green apples or grass and olive tree leaves. This experience leaves a light bitterness and pungent taste on the palate and tongue.

The olives from the Ayvalik (Edremit) region produce very popular olive oils, which have won a number of international prizes.

The Ayvalık variety can be consumed on a daily basis as a table olive or used for oil extraction. It contains approximately 25% of oil, the high texture of which makes it very popular. Alongside these characteristics, this ol-

ive is also well known for its excellence when dry cured, split or cut cured using traditional methods.

The Gemlik olive, which grows in the South Marmara region, comes from Bursa Gemlik but is grown throughout the country due to its structure, which makes it easy to produce, and its good adaptability to almost every region. It contains more than 30% of oil, has a small pit and its traditional natural fermentation method has made it well known as a widely consumed olive variety. Lately, however, it has been used in the olive oil extraction process. It generally has a dark green colour, which is associated with the region where it is grown; it has an intense fruitiness and it leaves a strong taste in the mouth.

The Erkence olive variety grows in İzmir and its surroundings; its sub-variety, the Hurma (date olive),

which has been the favourite among local people for centuries, is only found in the Urla-Karaburun peninsula. A fungus that grows on the tree during the olive's ripening period, from the end of October to December, causes the olive to go through a natural sweetening process, losing its pungent taste while on the tree.

The Erkence olive, which has recently been harvested before ripening, is in high demand due to the complex structure of its olive oil of medium bitterness and pungent taste, its pleasant fruity aroma and excellent harmony.

The Domat and Uslu olives, which come from Manisa Akhisar, are generally processed as table olives for daily consumption. Domat olives, in particular, being large with small pits, are in high demand in local and international markets as green appetizer olives with fillings. Furthermore, the olive oil produced from Domat olives, is becoming increasingly popular due to its peculiar aroma and taste.

A wider range of local olive varieties can be found in the south Aegean region of Turkey, with different tastes and flavours, especially due to the characteristics of the climate and soil. The olive oils produced here, particularly in the Aydın and Muğla regions where the Memecik variety is predominant, are a little darker and have a pronounced body, with a denser and more intense taste. We recommend this region's olive oils to consumers that prefer olive oils with a stronger

flavour. Memecik olive oils win gold medals in many international competitions due to their polyphenol content, which leaves a bitter and pungent sensation in the mouth, and the harmonisation of their sensory properties.

The Tavşan Yüreği (rabbit heart) variety originated in Antalya-Fethiye Akseki. Its 20% oil content, small pit and oval shape, makes it a very unusual variety waiting to be discovered. Even though it is not widely cultivated, it has specific characteristics of strong bitterness and pungency and it leaves a pronounced sensation in the mouth.

There are many local varieties in the regions of Mersin, Adana, Hatay, Gaziantep and Kilis. The Sarı Ulak variety from Tarsus is appropriate both for olive oil production and as a table olive for daily consumption. The Kilis Yağlık and Nizip Yağlık varieties are appropriate for oil production due to their 30% oil content and small fruit. Depending on the region and the flora where the olive trees grow, the oil can sometimes have a strong thyme flavour or a spicy flavour creating a pungent sensation, a fruity taste or a surprising aroma of grass and green almonds.

As an entirely natural product, extra virgin olive oil rarely has just one sensorial attribute. On the contrary, it produces an aromatic symphony. The different flavours that the aromatic properties of each olive tree offers at every new harvest, are like a new musical symphony that is composed every year. I invite our chefs to discover this precious treasure and present it in many new compositions with the "Chef's recommendation".

World Olive Day

This year, the member countries of the International Olive Council will hold a joint celebration of World Olive Day with a common message: Choose olives to protect our planet and our health!

Founded in 1959, the International Olive Council currently brings together 94% of olive oil and table olive producing countries.

As the only global institutional forum for the olive industry, its main missions are to work for the harmonisation of national and international regulations to ensure a better control of product quality and consumer protection; coordinate studies on the properties of olive oil and table olives; promote cooperation and research and study the impact of olive growing on the environment; publish information and statistics on the world olive and olive oil market; and promote consumption and the expansion of the international trade in olive products.

The olive tree, with its roots in the Mediterranean, is a universal symbol of peace and harmony. It has now spread to the five continents and contributes to sustainable economic and social development and the preservation of natural resources in many countries.

As an agent in combating global warming, olive growing has a positive carbon balance, sequestering more CO2 in its growth cycle than the greenhouse gases emitted in the production process of virgin and extra virgin olive oil.

Olive oil and table olives, as a proven source of nutrition and health, and key ingredients in the Mediterranean diet, offer a wide variety of aromas and flavours, opening up an abundance of culinary possibilities that are increasingly appreciated by the world's most renowned chefs. Furthermore, the action of their many therapeutic properties in preventing certain diseases is now widely recognised.

Countries that join the International Olive Council by adhering to the new International Agreement on Olive Oil and Table Olives, which has been deposited with the United Nations, are supporting the olive sector, sustainable economic and social development and the protection of our planet and health.

Conseil Oleicole International • International Olive Council • Consejo Oleicola Internacional • المجلس الدولي للزيتون • Consiglio Oleicolo Internazionale

Príncipe de Vergara, 154
28002 Madrid, Spain
Tel.: 34-915 903 638
Fax: 34-915 631 263
E-mail: iooc@internationaloliveoil.org
www.internationaloliveoil.org