The Problem of Olive Mill Wastewater in Turkey and some Solution Alternatives

Renan TUNALIOĞLU [1] (✉)
Tolga BEKTAŞ [2]

Summary

Olive, as a fruit, cannot be consumed directly due to the oleuropein substance it contains and needs to be processed into either table olives or olive oil through various production systems. The process of olive oil extraction results in olive oil as the main product, and two by-products, with olive pomace being one and brown-coloured Olive Mill Wastewater (OMWW) as the other. OMWW has no direct use and it is usually discharged directly to soil, small rivers, lakes or sea, resulting in potential contamination of the environment. Turkey is the fourth largest olive producing country in the world and fifth in olive oil production. Turkey produces approximately 891 393 tonnes of OMWW on average per two years using the current mill production technologies, and hence faces the problem of OMWW. This study proposes and discusses various solution alternatives to overcome the problem of OMWW in Turkey. The results of this study aim to contribute to the ongoing efforts in resolving this problem by the olive industry and to aid policy making to tackle this important issue.

Key words

olive mill wastewater, Turkey, solution alternatives

[1] Adnan Menderes University, Faculty of Agriculture, Department of Agricultural Economics, South Campus, Aydın, Turkey
✉ e-mail: renan.tunalioglu@gmail.com
[2] University of Southampton, Faculty of Business & Law, School of Management, Southampton SO17 1BJ, United Kingdom

Received: February 3, 2011 | Accepted: June 9, 2011

ACKNOWLEDGEMENTS
Thanks are due to two reviewers for their comments and corrections on the initial version of this paper. This paper is based on an ongoing project between the Department of Agricultural Economics at Adnan Menderes University in Turkey and School of Management at the University of Southampton in the UK. The financial support from the Scientific and Technological Research Council of Turkey (TUBITAK/2010-1) and the in-kind support of School of Management at the University of Southampton provided for this project are gratefully acknowledged.

Introduction

Olive is grown in nearly 40 countries in the Mediterranean or under the Mediterranean climate (FAO, 2011). EU countries such as Spain, Italy, Greece, Portugal and France are significant producers of olive oil, with their overall production constituting 60% of the world's olive production, 40% of table olive production and 80% of olive oil production. Tunisia, Turkey and Syria are other important olive producer countries of oil (IOC, 2011). Adoption of healthier diets in many parts of the world has resulted in an increased interest in the adoption of the Mediterranean way of eating olives and consuming olive oil, and hence increased demand for this fruit.

There are several systems that could be used to extract olive oil. Whatever process is used, a dark brown-coloured substance named Olive Mill Wastewater (OMWW) is obtained as a by-product. Due to its environmental hazards, OMWW is a problem acknowledged by many olive-oil producing countries and the solution to this problem requires that political and economic measures are put in place (Tunalıoğlu *et al.*, 2008). In this paper, the problem of OMWW in Turkey is described and some solution alternatives are discussed. In what follows, a brief background on OMWW is provided.

Olive Oil Production Systems and Olive Mill Wastewater (OMWW)

Olive cannot be consumed directly due to the oleuropein it contains. It therefore needs to be processed into table olives or olive oil through various production technologies. There are a number of ways of extracting olive oil, ranging from the more traditional (classical) press-based techniques to more modern two- and three-phase systems. Modern methods are based on principles of centrifugation, percolation and combinations thereof (Yemişçioğlu *et al.,* 2001). Table 1 presents a tabulated classification of these systems.

The process through which olive oil is produced results in a number of by-products that are potentially harmful to the environment. One of such by-products is pomace, which can be re-processed as oil and used as raw material in food, or in industrial and energy sectors. The other by-product is OMWW, the composition of which varies with respect to the system it is produced under, but usually consists of water (83–92%) that is used as input to the various stages of olive oil production systems, organic matter (4–16%) and minerals (1–2%). OMWW has high salinity, low acidity and it is rich in matters such as N, P, K and Mg (Niaounakis *et al.*, 2006; Şengül *et al.,* 2002). Despite this fact, however, the OMWW is still considered a major problem and it is not yet considered to be reusable in a sustainable way unless treated.

Uncontrolled and direct use of OMWW on land (e.g., as often done in irrigation) is undesirable due to its highly phytotoxic content, which may have detrimental consequences on soil microbial populations (Paredes et *al.*, 1987; Roig *et al.*, 2006). Recent evidence suggests that long-term and intensive use of OMWW for irrigation would leave fields more prone to groundwater contamination (Mahmoud *et al.*, 2010). Discharging OMWW into sea, either directly or indirectly, is also not an option given as it would pollute the water posing a threat to the aquatic life (Akdemir and Ozer, 2008).

Significant olive producing countries prefer the modern (continuous) systems to extract oil. For example, while Spain uses a two-phase system, Greece and Italy have the three-phase system in place. The two- and three-phase production systems are similar in the steps involved. The fundamental difference between the two is in the output; whereas three-phase system results in pomace and OMWW separately, the OMWW in the two-phase system is a mixed solid-liquid waste consisting of pomace and OMWW. It has been suggested that the use of the two-phase system yields up to 20% energy reductions and savings of 80% in water usage over the three-phase system (Azbar *et al.*, 2004).

OMWW in Turkey

Olive trees grow in 41 cities and in seven geographic districts of Turkey. Aegean region has the highest amount of olive production, followed by the Marmara, Mediterranean and South East regions. Figure 1 shows the cities in Turkey ranked by their olive production and indicates that the province with the most production (25%) is Aydın shown as number 1 in the map. This is followed by İzmir (14%), Muğla (9%), Balıkesir (8%) and Bursa (5%). Increased financial support from the Turkish government for olive production since 2000 has resulted in olive fields expanding by 26% in the country, which has also increased the number of olive trees planted and the amount of olives grown. This continuing growth also implies increase in the amount of olive for olive oil, olive oil and OMWW produced in the near future.

Latest statistics show that 1 250 olive oil production facilities are in operation in Turkey and most of these are already using the three-phase system. Table 2 presents statistics on the amount of olive (for olive oil) and OMWW production in various provinces in Turkey. It can be seen from Table 2 that the amount of OMWW produced by these facilities is substantial and therefore poses a serious problem to the country (TBMM, 2006). This issue is one still waiting to be resolved, both under

Table 1. Olive oil extraction systems

Classical Systems	Modern Systems	Combined Systems
1. Vice (Press)	1. 2 Phases Systems	1. Percolation-Pressing Combined
2. Pressing	2. 2½ Phases Systems	2. Percolation-Centrifugal Combined
a. Super Press	3. 3 Phases Systems	3. Pressing-Centrifugal Combined
b. Hydraulic Press		4. Binary Centrifugal

Source. Adapted from Yemişçioğlu et al., 2001.

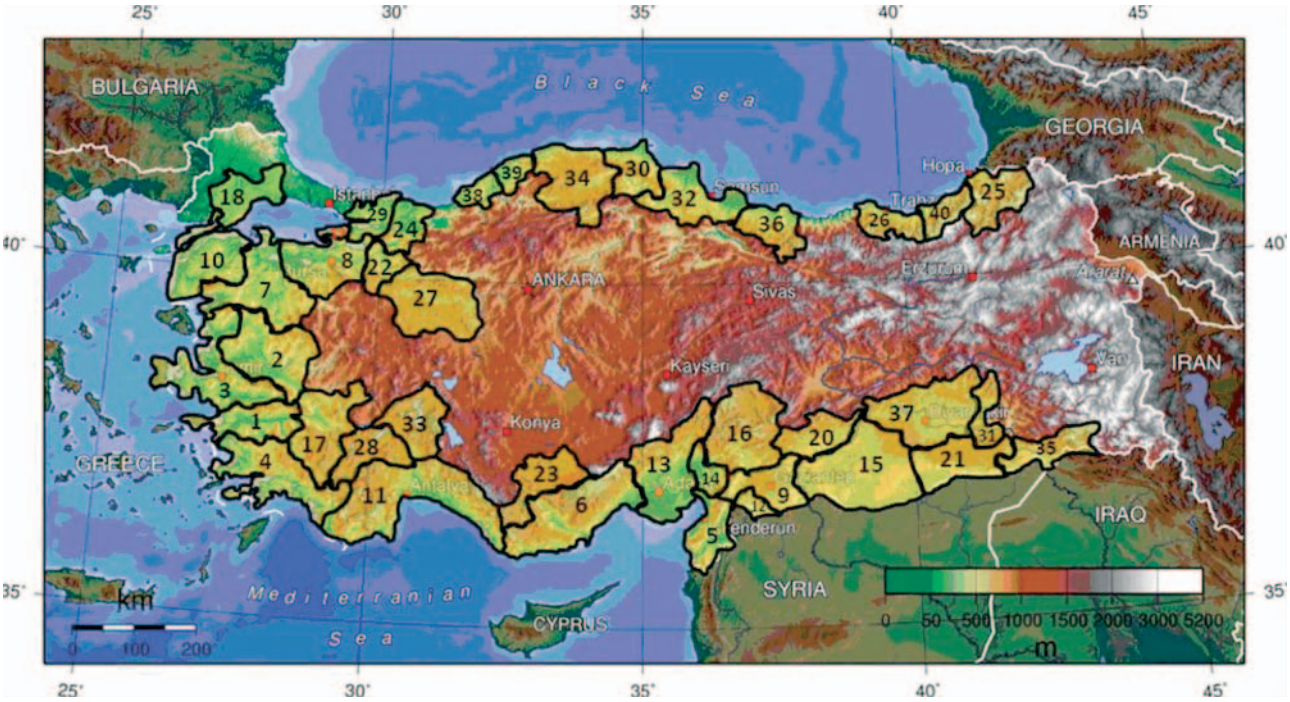

Figure 1. Map showing a ranking of olive producing provinces in Turkey in terms of production amounts (Özkaya et al., 2011)

the European Union's harmonization efforts, and the under the new regulations of the Turkish Environmental Law.

The current practice with managing OMWW in Turkey is that it is either discharged into the environment (e.g., lakes, small rivers, sea or soil) or collected in lagoons that form part of many olive mills, left for natural evaporation. The discharge of OMWW into the environment is a major problem in the country. For this reason, the Ministry of Environment and Forestry has put strict policies in place to control and fine such hazardous practices (Tunalıoğlu, 2010). The olive mills themselves also acknowledge this problem but have little resources to deal with and properly dispose of OMWW. For this reason, more needs to be done to solve this problem in a collective manner, which requires financial support from the government. Although research and development activities are underway for the reuse of OMWW, as, for example, biofuel and animal feed (Tunalıoğlu and Armağan, 2008; TBMM, 2008), but these efforts are not yet at a level to tackle the problem fully and satisfactorily.

The next section discusses some possible solution alternatives for the problem of OMWW in Turkey.

Table 2. Olive for olive oil and OMWW production in Turkey by provinces

The Important Olive for Olive Producer Provinces	Olive for Olive Oil Production (t)	OMWW* (t/year)
Aydın	159 985	159 985
Balıkesir	115 628	115 628
Çanakkale	54 772	54 772
Hatay	104 098	104 098
İzmir	165 125	165 125
Manisa	37 429	37 429
Mersin	47 372	47 372
Muğla	95 696	95 696
Gaziantep	31 854	31 854
Antalya	33 362	33 362
Kilis	9 640	9 640
Other Provinces	36 432	36 432
Total	891 393	891 393

Source: Extracted from TUIK (2011) using average statistics for 2008–2009; (*) Calculations in this table have been made on the assumption that all olive oil production facilities are assumed to be operating under the three-phase system and that the amount of OMWW is equal to the amount of production of olive for olive oil.

Discussion

Several possible solution alternatives for disposal or treatment of OMWW in Turkey are detailed below:

1. A traditional and conventional method is the use of lagoons in which OMWW is kept until it naturally evaporates. This method is particularly applicable in countries where a sufficiently warm climate allows for natural evaporation, as in Turkey. Although lagoons only require minimal investment cost, they are not an efficient and a desirable way for OMWW disposal for several reasons. Apart from the obvious space requirements, OMWW kept in a reserve for prolonged periods of time would potentially lead to ground contamination unless the lagoon is properly fitted. A further problem issue would be the growing odour, which would provide for

rapid breeding of flies around the lagoon and ultimately lead to an unhygienic environment (Azbar *et al*., 2004).

2. For facilities operating under a three-phase system, transition to a two-phase olive oil production system would lead to reduction in water requirements in various stages of the extraction process. This alternative, however, requires a substantial invesment by the olive oil mills, as the switching cost from one technology to the other is significantly high. Furthermore, one must bear in mind that the resulting mixed solid-liquid waste would still need to be processed further to separate the pomace from water. Unless subsidised or partially funded by the government, small or medium sized olive oil mills in Turkey are unlikely to cover the costs of such transition on their own, despite the significant benefits.
3. Another possible option is to consider the use of integrated olive mills (Azbar *et al*., 2004) wherein facilities are built in which olive oil extraction and wastewater treatment can be done in an integrated and sequential manner. As with the second option, however, the cost of this option is also very significant and unlikely to be adopted unless subsidized by the government, private institutions or unions.
4. There are several ways in which OMWW can be treated, such as physico-chemical including flocculation, coagulation, filtration, incineration and biotechnological, including microbiological treatments, composting, anaerobic and extraction processes (Roig *et al*., 2006). Akdemir and Ozer (2008) state that the treatment of OMWW through such methods has not entirely been successful, and suggest ultrafiltration as a viable alternative to those already mentioned. The modern strategy for olive mill wastewater management is combining wastewater treatment and valorization. In other words, producing valuable products from wastewater and thus compensating the high costs of treatment. Designing centralized plants to collect wastewater from small olive mills within a regional radius offers a feasible economic solution. However, one should bear in mind that the high cost of building and running such facilities will require the financial support of private oil mills as well as the government, but this is not likely to be as expensive as technology switching as mentioned in (2) above.

In summary, OMWW is an increasingly growing problem in both Turkey and other olive producing countries in the world. The increasing number of olive trees planted as a result of continued government support will result in more olive production in the future, hence more olive oil and OMWW. We believe any solution adopted for the problem of OMWW in Turkey will need to be socially and economically feasible. Solution should also be acceptable to and supported by the government and other authorities.

References

Akdemir E.O., Ozer A. (2008). Application of a statistical technique for olive oil mill wastewater treatment using ultrafiltration process. Separation and Purification Technology. 62: pp 222–227

Azbar N., Bayram A., Filibeli A., Muezzinoglu A., Sengul F., Ozer A. (2004). A review of waste management options in olive oil production. Critical Reviews in Environmental Science and Technology. 34:pp :209–247

FAO. (2001) .www.fao.org (Access date, 15 January 2011)

IOC. (2011). http://www.internationaloliveoil.org (Access date, 15 January 2011)

Mahmoud M., Janssen M., Haboub N., Nassour A., Lennartz B. (2010). The impact of olive mill wastewater application on flow and transport properties in soils. Soil & Tillage Research, 107:36–41

Niaounakis M., Halvadikis C.P. (2006). Olive Processing Waste Management:Literature Review and Patent Survey. Waste Management Series 5, Elsevier, Amsterdam.

Özkaya MT., Tunalıoğlu R., Özkaya Durlu,F., Ulaş M. (2011). Following Olive Footprints in TURKEY. AARINENA Olive Network Focal Point Book Chapter (in press).

Paredes M.J., Moreno E., Ramos-Cormenzana A., Martinez J. (1987). Characteristics of soil after pollutionwith wastewaters from olive oil extraction plants. Chemosphere, 16:1557–1564

Roig A., Cayuela M.L., Sanchez-Monedero M.A. (2006). An overview on olive mill wastes and their valorisation methods. Waste Management, 26:960–969.

Şengül F., Oktav E., Çatalkaya Ç. (2002). Zeytinyağı Üretim Prosesine Bağlı Olarak Oluşan Karasuyun Kirlilik Karakteristikleri ve Arıtım Teknolojileri, I. Zeytinyağı Üretiminde Çevre Sorunları ve Çözümleri Uluslararası Çalıştayı, Zeytinli, p. 35–45, Edremit, Balıkesir, Turkey (in Turkish).

TBMM (The Grand National Assembly of Turkey). (2006). 22. Dönem T.B.M.M" (14 February - 14 June 2006) Türkiye Zeytin ve Zeytinyağı İle Diğer Bitkisel Yağların Üretimindeki Sorunların Araştırılarak Alınması Gereken Önlemlerin Belirlenmesi Amacıyla Kurulan Meclis Araştırması Komisyon Raporu (10/41, 170, 177, 263, 295) Ankara, Turkey (in Turkish).

TBMM (The Grand National Assembly of Turkey). (2008). 23. Dönem T.B.M.M. (11 March 2008–11 July 2008) Zeytin ve Zeytinyağı ile Diğer Bitkisel Yağların Üretiminde ve Ticaretinde Yaşanan Sorunların Araştırılarak Alınması Gereken Önlemlerin Belirlenmesi Amacıyla Kurulan 10/27,34,37,40,102 Esas Numaralı Meclis Araştırması Komisyon Raporu, Ankara, Turkey (in Turkish).

TUIK. (2011). Turkish Statistical Institute - www.tuik.gov.tr (Access date, 08 May 2011)

Tunalıoğlu R. (2010). Environmental Impacts and Solutions Olive Vegetable Water Investigation of Possibilities in Turkey: Aydın Province. TUBITAK 2010/1 BIDEB Project Proposal Report. Ankara, Turkey (in Turkish).

Tunalıoğlu R., Armağan G. (2008). Aydın İlindeki Zeytinyağı İşletmelerinde Elde Edilen Yan Ürünlerin Tarım-Sanayi ve Çevre İlişkileri Boyutunda Değerlendirilmesi Türkiye VIII. Tarım Ekonomisi Kongresi Bildiri Kitabı. Cilt 2. Bursa, Turkey (in Turkish).

Tunalıoğlu R., Seferoğlu S., Armağan, G. (2008). The Weakest Ring of Olive Oil Production in Turkey: Olive Oil Mill Waste Water. VI. International Symposium On Olive Growing, Evora, Portugal.

Yemişçioğlu F., Gümüşkesen A. S., Otağ R. M. (2001). Zeytinyağı üretiminde kullanılan sürekli sistemler ve bu sistemlerin klasik presleme yöntemi ile karşılaştırılması. TMMOB Gıda Mühendisliği Dergisi, 9, 26–31, Turkey (in Turkish).