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Management of Table Olive Wastewater (TOWW) in Turkey

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Abstract: Table olive is very important agricultural product for Turkey. It has a great market share in the country and also have high export potential. Management of table olive wastewater (TOWW) is an emerging and important issue, since large volumes of TOWW are discharged with high concentrations of organic matter, phenolic compounds, suspended solids, alkalinity, and conductivity. Current practices in many countries are the storing the wastewater in evaporation ponds or discharging to municipal wastewater treatment plants, if the ratios are relatively acceptable. Application of evaporation ponds in Turkey is not suitable, because of high population densities in olive production areas and high prices of land. Plus, generally the locations of the production plants are far away from the sewerage systems. Those facts impose the planners and engineers to develop technological treatment based technological in-site solutions for the management of TOWW. In order to perform proper treatment methods, the quantity and quality of wastewater should be known first. However, it is not an easy job, because neither producer provides reliable information nor there is enough information in the literature. In the paper, a questionnaire survey carried out app.30 firms located in the Akhisar Olive and Olive Derivatives Specialized Organized Industrial Zone (AZIOSB) The questionnaire helped to project the data on wastewater generation as well as the processing techniques of table olives. Plus, the sampling studies for quantity and quality of the wastewater are conducted at the main outlet of the AZIOSB, and accordingly treatment alternatives for TOWW are discussed.

Keywords: Table olive wastewater, olive processing, TOWW treatment, evaporation, biologic treatment, chemical oxidation

1. Introduction

Olive tree is one of the vital plants of Mediterranean region. The fruits of the tree are used for olive oil production as well as table olive production. Table olive is an important fermented food of Mediterranean Diet and the most of the world production of table olives is concentrated in the Mediterranean region. It is highly important agricultural product for the countries in Mediterranean basin such as Spain, Italy, Greece, Turkey, Tunisia, Egypt, and Morocco. The total worldwide production of table olives reached more than 3.1 million tons in 2020, with around 30% produced in Europe. Among the International Olive Council (IOC) member countries, Spain produced 20.5% of the world's table olives; Greece, Italy, and Portugal followed the Spain (https://www.cbi.eu). Other IOC member countries are ranked as Egypt, Turkey, Algeria, Morocco, Argentina, and Iran. In Turkey approximately 25% of harvested olive is processed as table olive, and the rest 75% is used for olive oil production. According to the IOC reports, estimations on table olive production for the 2021/22 crop year, is about 402.000tons (IOC, 2022).

The table olive manufacturing processes contain a series of steps include cleaning, de-bittering, washing, and fermentation depending on the type of the product. All these steps generate waste streams which their quantities and compositions vary widely depending on the cures applied in each production process. The common strategy for management of TOWW especially in the Mediterranean countries is to store the wastewater in evaporation ponds (Rincón-Llorente, 2018). However, anaerobic conditions occur in those ponds and lead to unpleasant odor, insects, and there are risks of surface and groundwater contamination. Thus, evaporation ponds may no longer be considered as an ideal solution. Therefore, alternative solutions have to be developed for the treatment of TOWW at the industrial level. Consequently, management of TOWW is still a serious problem and requires (country–based or region based) tailor made solutions.

The presented study focuses on the table olive wastewater management in Turkey. In this context, olive processing techniques, wastewater generation, quality of the wastewater, and treatment methods is evaluated. The studies carried out in the Akhisar Olive and Olive Derivatives Specialized Organized Industrial Zone – AZIOSB. The production techniques and water consumptions are reviewed by a questionnaire survey carried out for app. 30 firms. Plus, the wastewater quantity and quality are measured app. one year at the main outlet sewer of the district. The obtained data are assessed, and treatment alternatives that might be proposed for the area are discussed.

2. Table Olive Production in Turkey

Table olives can be categorized into three groups considering the preparation processes in production. These are (1) Alkaline-treated olives – Spanish green olives, (2) Brine-treated black olives – Californian type black olives, and (3) Untreated olives produced by natural fermentation (Greek type). In Turkey, these three conventional methods and additionally some slightly modified processing techniques have been used in table olive production. Slightly modified types can be launched to the market, namely slit and crushed, salamura, sele, kalamata, caustic, natural fermented, etc..

2.1. Green olives processing methods (Spanish-style)

The Spanish-style processing consists of immersing in sodium hydroxide solution (NaOH) for debittering, rinsing, brining, packaging and pasteurization stages. Harvested olives are treated with an alkaline lye, as first. The olives are immersed in a dilute aqueous solution of NaOH. Natural bitterness in olives deriving from oleuropein is eliminated by alkaline treatment. When NaOH solution has sufficiently penetrated into the olive fruit, rinsing is applied. Then, the olives are placed into the brine for fermentation (appx. 10%). Fermented olives are packaged and then sterilized (i.e. pasteurization) to prevent progressive deterioration.

In Turkey, various methods such as Spanish method, slit and crushed have been used in green table olive production. In Spanish type production, harvested olives are treated with 1– 2.5% NaOH solution until it penetrates 2/3 of the grain. Following to debittering, rinsing is done. Then, the olives are placed in brine through 1-3 months for fermentation. The ripened olives are pasteurized and presented to the market. The slitted olive processing method is similar to the Spanish method except for debittering. In this technique, alkaline treatment is not applied. Following to rinsing, olives are slitted form 2 or 3 places and placed in covered containers for fermentation. Debittered olives are put in 7% brine and fermented for 1-2 months. Olives that are ripe for eating are packaged and presented to the market. In crushed type, olives are broken or punctured protecting their natural structure. Removing the bitterness is done as in the slitted olives (Dölgen and Alpaslan, 2020).

2.2. Black olives processing methods

Different processing techniques have been used for black olives. Californian-style production consists of storage in brine, debittering, rinsing, immersion in a ferrous salt solution, rinsing, packaging and sterilization steps. Harvested olives are pre-treated in diluted brine solution, as first. Then, several treatments of sodium hydroxide solution (1%-2%) is performed. The alkaline treatment is stopped when the lye has penetrated about 2/3 of the olives. After that, olives are aerated until to darken the surface of the fruit. Later on, olives are rinsed and alkaline materials are removed. In order to obtain permanent dark color, olives are retained in ferrous salt solution throughout 24 hours, and then rinsed several times. Darkened olives are usually canned in brine solution (2-5% NaCl) and preserved by heat sterilization.

In Turkey, the caustic type (so called “confit”) table black olive production is an example of California type production. It is preferred for quick launching of the product to the market. Aeration is applied during the rinsing. Then, olives are pasteurized or sterilized in a packaging brine prepared with low salt. If there is no possibility of heat treatment, olives prepared by adding preservatives, and presented to the market in 10% packaging brine (Dölgen and Alpaslan, 2020).

2.3. Naturally processed black olives production

It is traditional Turkish and/or Greek style olive processing method. The olives are directly put into brine solution (8-10%). The fermentation process takes longer time as the olives have not been treated previously with NaOH and thus, oleuropein is removed slowly. The fermentation period takes around 8-12 months. Fermented olives are aerated to eliminate the differences in color (24-48 h) and, following the fermentation, the olives are packaged and transferred to the food market.

In Turkey, the Gemlik style processing is generally used to produce natural black olives. This method uses high salt concentrations (10%) in brining. In this style, olives are layered with salt in a containers and heavy weights are loaded on top of the tanks for compression. Direct contact of olive fruit with brine allows high penetration of salt into the olive fruit, and olive and salt layers are replaced couple times. Then, tank is filled with clean water. Salt content in the tank is around 10% of the total weight of olives. If necessary, salt is added during fermentation. Fermentation takes around 6–8 months (Dölgen and Alpaslan, 2020).

Dry-salted black table olive processing is another common method in Turkey. It is known as sele which is very popular. In that style of production, after cleaning and washing, olives and 10%–20% salt of the total weight of olives are put into the baskets in alternate layers. After that, baskets are closed by cloth. Once in a few days, the baskets are turned and rolled to increase the contact of olives with salt. Before packaging, salt must be removed by sifting instead of washing. Olives can be dry packaged after dipping into olive oil and vinegar or putting into jars including brine solution (Dölgen and Alpaslan, 2020).

3. Management of TOWW in Turkey

Table olive processing generates large volumes of wastewater which are specified with a high value of organic matter, phenolic compounds, suspended solids, alkalinity, and conductivity (Cappelletti et. al., 2011; Kopsidas, 1994; Cifuentes-Cabezas wt. al. 2023). Currently, there is no standard treatment for these wastewaters. Although storing these wastewaters in large ponds is the most common method in many countries, this is not a suitable solution in Turkey. Because the population densities are high in table olive production areas which results high land prices. Besides production plant locations are far to the central (domestic) sewerage sytems. Furthermore, as it stated above, removal of the TOWW in evaporation ponds may cause certain problems such as bad

odors, insects and the contamination of ground water. In addition, some factories have been started to be clustered as “cooperatives” or “Specialized Organized Industrial Zones” in order to manage wastewater effectively. Those facts enforce the planners to apply of more technological and central wastewater treatment plants in Turkey.

The first step for the design of central wastewater treatment plants for TOWW is the determination of the wastewater quantity and quality. Based on the literature, table olives (green, naturally black etc.) produces wastewater 0.5-6 liters/kg (Cappelletti et. al., 2011; Kopsidas, 1994). The production of wastewater of the California-style black olives is about 6 L/kg of olives. On the other hand, untreated olives (i.e. naturally black, green or turning color olives) production generates lower volumes of wastewaters (~1 L/kg olives produced).

In Turkish case, within the scope of the study, about 30 firm located in the AZIOSB were examined by means of a questionnaire survey. The questionnaire was designed to obtain a general information about table olive manufacturing plants including enterprise name, capacity, production type, number of olive wells/container, and water consumption. The data collected from firms were shown that the amount of wastewater for green olive production was about 42.272m^3. Thus, the amounts of wastewater generated per unit production (kg olives) is calculated as about 2,54m^3/ton olives. For black olives, app. 33.112m^3 wastewater is generated in season for 75.055ton product. Therefore, for black olives, the amount of wastewater generation per unit production was determined as 0,4m^3/ton olives. Besides the amounts, a significant seasonality is observed both quantity and quality of wastewater. This is also confirmed by the flowrate measurements of the main outlet sewer of the AZIOSB.

The quality of the wastewater is another important matter in wastewater management. The wastewater from black olive processing has color from dark brown to black; and contains aromatic compounds and high concentrations of sodium chloride. It has a chemical oxygen demand (COD) and suspended solids contents about 40g/L and 6.9 g/l respectively. The lye wastewater and olive washing wastewater noticeable differ due to high pH and strong alkalinity, and relatively lower phenolic compounds. In order to determine the wastewater quality, the samples were taken from the main outlet sewer system of AZIOSB. The COD and SS parameters were monitored throughout one year in 2022, and annual distribution of data are presented in Figure 1. The organic matter (COD), suspended particles (SS), pH, and conductivity measurements were about 5,000-10,000mg/L, 5,000-10,000mg/L, 6-8, and 10-30µS/cm, respectively. Here, another crucial issue is the combined or separate collection of process wastewater and washing wastewater which affect quality parameters significantly.

In literature, numerous methods have been proposed to treat the TOWW such as aerobic and anaerobic biological processes, oxidation processes, ultrafiltration, membrane treatment, evaporation, and combination of those methods (Kotsou et.al. 2014; Brenes 2000; Ayed et.al., 2017; Tatoulis et.al., 2017; Dölgen and Alpaslan, 2022). In Turkey, the studies on table olive wastewater treatment is limited. However, the results from existing TOWW treatment plants have shown that classical aerobic biologic and chemical treatment can effectively treat the wastewater. Among them, extended aerated activated sludge and coagulation- flocculation-sedimentation processes together with head works and storage tanks are used successfully.

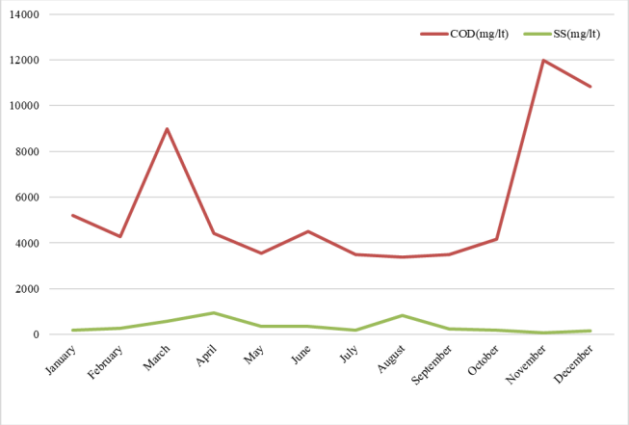

Figure 1. Annual distribution of COD and SS parameters

4. Discussions and Conclusion

As it discussed above, in TOWW management, determination of the wastewater characteristics and selection of the appropriate treatment method are important matters. In addition, collection of washing and processing waste streams, i.e. combined or separate collection, is other components to be considered in this process (Rivas, 2000). Recently, valorization of the wastes (e.g., phenols, brine, etc.) in wastewater using advanced treatment stage has also been started to discuss (Papadaki and Mantzouridou, 2016; Garcia-Ivars et.al., 2015).

The easiest way to determine the quantity and quality of the wastewater is to obtain data from the literature. However, wastewater quantity varies depending on manufacturing processes and affected from local conditions. The amount of wastewater generated per unit production (kg olives) is in a wide range (0.5-8.5 L/kg olives) which may cause problems in determining the capacity of the treatment plant. Using literature values may causes overdesign or insufficient treatment performance. Another important issue is the seasonality of wastewater quantity and quality. Since the process of removing the bitterness is done right after the olive fruits are harvested, it does not last all the year, it only takes place during the olive picking period, covering several months of the year. The wastewater generated from the fermentation process, can last throughout the year and may vary according to the demand from the market, as it is related to the sale of the product. For these reasons, before designing, the data regarding the wastewater quantity and its temporal variation should be provided by conducting field studies.

Another factor to be considered in the design process is the quality of wastewater. Although the wastewater characterization differs depending on the table olive

processing techniques as well as wastewater collection type, it generally contains high amount of organic matter, phenolic compounds, chloride, and dissolved solids as mentioned before. For this reason, it is beneficial to provide the data on wastewater quality through well-planned field studies during the design process.

Regarding to treatment, there are many different treatment technologies for TOWW wastewater. The simplest option is to convert wastewater from liquid phase to solid phase by direct evaporation by accumulating in shallow lagoons, and then to remove or evaluate the solid part by floor scraping at certain intervals (every few years). However, as it is known, the natural treatment method requires very large areas. In addition, it creates negative environmental effects, and is affected by meteorological conditions. In Turkey, the areas where table olive processing is generally located at highly populated and valuable lands. Therefore, implementation the technological-based treatment plants instead of natural methods have been used. In addition, besides the individual production plants, clustering the plants as Organized Industrial Zones are promoted by the Government. Such organizations offer joint collection and treatment services of TOWW. By this way, the wastewater disposal problem of the table olive producers has been solved with common facilities instead of separate treatment plants. The Akhisar Olive and Olive Derivatives Specialized Organized Industrial Zone (AZIOSB) and Akhisar Olive Cooperative are examples of this approach. The wastewater treatment plant in Akhisar Olive Cooperative (Zeytinliova) has 2000m^3/day capacity and consists of physical, chemical and biological treatment steps. The wastewater from 11 olive producer in the region has been collected with same system and conveyed to Zeytinliova Treatment Plant, and discharged into receiving environment after fully treated. The wastewater treatment plant project of AZIOSB is in tendering phase. Treatment plant contains storage (equalization) tanks, evaporation unit (for black process water and will be implemented if needed), physicochemical treatment (dissolved air flotation – DAF), biological treatment (extended aeration), and finally coagulation, flocculation and sedimentation. At that point, it should be noted that management of TOWW asks for reliable data which should be obtained from extensive site surveys. Since there is no recipe solutions for the treatment methods, the data characteristics must be assessed carefully, and proper configuration of conventional treatment units should be implemented.

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