ENVIRONMENTAL RISKS AND EVALUATION OF BY-PRODUCTS OF OLIVE OIL PRODUCTION

ЭКОЛОГИЧЕСКИЕ РИСКИ И ОЦЕНКА ПОБОЧНЫХ ПРОДУКТОВ ПРОИЗВОДСТВА ОЛИВКОВОГО МАСЛА

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Olive production has been carried out in Turkey for many years. Olive is an important product in Turkey in terms of both production amount and economic value. Olives and olive oil obtained from olives have been important nutrients for humans for centuries. In olive production, which has a very important place in the country’s economy, in addition to main products such as olive oil and table olives and olive oil, solid and liquid by-products such as “Pirina” and “Blackwater” are formed in olive oil factories. Against pomace, which can be evaluated economically, black water is left indiscriminately to the environment. Most of the wastes that occur on average as 200 billion tons each year are either left to nature as garbage or used as fuel, animal feed or fertilizer with a little processing. Environmental pollution that appears with increasing industrialization and population, and the economic consumption used to eliminate pollution cause wastes to become a biomass problem. Olive black water contains sugars, organic acids, polyalcohols, pectins, colloids, tannins and lipids. Valuable products can be produced by biotechnological conversion from solid and liquid wastes from the olive oil industry.

Производству оливок в Турции уже много лет. Оливки являются важным продуктом в Турции с точки зрения как объема производства, так и экономической ценности. Оливки и оливковое масло, получаемое из оливок, на протяжении веков были важными питательными продуктами для человека. В производстве оливок, которое занимает очень важное место в экономике страны, помимо основных продуктов, таких как столовые оливки и оливковое масло, твердые и жидкие побочные продукты, такие как «Жмых» и «Сточные воды» образующиеся на заводах по производству оливкогвого масла. В отличие от жмыха, который можно оценить с экономической точки зрения, сточные воды без разбора остаются в окружающей среде. Большинство отходов, образующихся в среднем в количестве 200 миллиардов тонн в год, остаются в виде мусора, либо используются в качестве топлива, корма для животных или удобрений с небольшой переработкой. Загрязнение окружающей среды, которое появляется с ростом индустриализации и населения, экономическое потребление, используемое для устранения загрязнения, приводит к тому, что отходы становятся проблемой биомассы. Сточные воды, образующиеся при производстве оливкового масла, содержат сахара, органические кислоты, полиспирты, пектины, коллоиды, дубильные вещества и липиды. Ценные продукты могут быть получены путем биотехнологической конверсии твердых и жидких отходов производства оливкового масла.

Keywords: olive, processing, olive by-products, waste, blackwater, prina (pomace)

Ключевые слова: маслина, обработка, побочные продукты при производстве маслин, отходы, сточные воды, жмых (выжимки).

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It is obtained by mechanical means from the fruits of the evergreen tree Olea europaea. Olive fruit contains 35–70 % oil in dry matter. Olive oil is one of the oldest and most important oils in the world (Nas et al. 1992). The food industry has a wide working area and high production capacity in terms of raw material sources used. As a result of production, high amounts and various types of waste are generated. It is also important to evaluate these wastes and to recover the valuable components they contain in relation to the increasing environmental problems. Creating a waste awareness for this sector will also contribute to our country economically (Yıkar et al. 2006).

Olive black water; contains sugars, organic acids, polyalcohols, pectins, colloids, tannins and lipids. Valuable products can be produced by biotechnological transformation from solid and liquid wastes from the olive oil industry (Şener and Ünal, 2008).

a. Fleshy part (Mesocarp): It makes up 65-83 % of the grain. It contains water, oil, sugar, polysaccharides, protein, pectin, organic acid, tannin, oleuropein, color and mineral substances. The fleshy part contains 50-60 % water, 15-30 % oil, 2-5 % nitrogenous substances, 3-7.5 % sugar, 3-6 % cellulose, 1-2 % minerals, 2-2.25 % phenols.

b. Seed: In this part of the grain, there are 30 % water, 27.3 % oil, 10.2 % nitrogenous substances, 26.9 % sugar, 1.9 % cellulose, 1.5 % minerals, 0.5 % polyphenols.

c. Core (Endocarp): It makes up 13-30 % of the grain. The kernel consists of the kernel shell and the seed inside. In the core part, there are 9.3 % water, 0.7 % oil, 3.4 % nitrogenous substances, 41 % sugar, 38 % cellulose, 4.1 % minerals, 0.1 % polyphenols (Kaya, 2009). The general composition of olive fruit is shown in Table 1.

Table 1 – Composition of olive fruit (Kaya, 2009)

Components	**Concentrations (%)**
Moisture	83.20
Sugars	2.80
Nitrogen	1.20-2.40
Organic acids	0.50-1.50
Polyhydroxy component	1.00-1.50
Pectin	1.00-1.50
Salt	1.80
Oil	0.03-1.00

Definition of Olive and Composition of Olive Fruit. Olive fruit (Fig. 1) is an agricultural product that can be processed for oil and table use and its by-products can be evaluated (Erden et al. 2016). Olive contains a number of phenolic and bioactive compounds that differ from the flavonoids, vitamins and carotenoids found in other fruits and vegetables (Annab et al. 2019).

Olive and Olive Oil Processing Industry Wastes. The olive oil processing industry is of great importance in terms of environmental sustainability due to the amount of waste and the difficulty of treatment (Caputo et al. 2003). Olive black water and olive pomace are considered as olive oil processing industry wastes as a result of mechanical oil extraction from olive leaves and olives during the cleaning process before the olive collection and oil extraction.

Olive leaf. Olive leaves; It is exposed during the pruning of olive trees, the harvesting of olives and the cleaning process prior to oil extraction from the olives. The amount of olive leaves obtained is between 12–30 kg/tree, depending on the age of the tree and the type of pruning. In some regions where olive cultivation is common, olive leaves are used for feeding livestock or the leaves collected with olive branches are used as fuel. As with many natural products, the chemical composition of olive leaf extract varies depending on the region where the olive is grown, the structure of the soil, the variety and the method used (Basmacıoğlu Malayoğlu and Aktaş, 2011).

Olive seeds. In recent years, while olive oil is being produced, the seeds are separated from the pomace with a special centrifuge and 4 mm sieve system. In this way, the feed value and digestibility of the olive pulp are increased and the kernels are evaluated separately. Cellulose and lignin-rich kernels contain approximately 3500–5000 kcal/kg of energy and are considered as environmentally friendly solid fuels with very affordable high calorie and low ash content (0.2–0.4 %) (Dalkılıç, 2018).

Blackwater. It is the sap in the structure of olives. It has dark brown – violet tones and even black colour, with a strong olive oil odour. It contains a significant amount of potassium, magnesium and phosphate salts, lipids, and is rich in carbohydrates as shown in Table 2 (Çelik et al. 2008).

Table 2 – Composition of olişve blackwater (Kaya, 2009)

Components	Concentrations (%)		
	highest	lowest	mean
Water	94.15	82.40	83.40
Organic matter	16.55	3.96	14.80
Oil	2.30	0.03	0.02-1.00
Organic nitrogen	2.40	0.06	1.20-2.40
Total sugar	8.00	0.10	2.00-8.00
Organic acid	1.50	0.20	0.50-1.00
Pectin and tannins	1.50	0.20	0.50-1.30
Polyphenols	2.40	0.13	0.50-1.00
Minerals	7.20	0.40	1.80

**Minerals: P, K, Ca, Fe, Mg, Mn, Na, Zn, Co, Cu, Si, Cl.*

The amount and properties of black water released during olive oil production; It varies depending on the olive oil production process, the type of olive to be processed, the type of pesticide and fertilizer used during olive cultivation, and the climate of the region where the cultivation is made. No chemicals are added during the production of olive oil. Therefore, the resulting black water mainly contains pollutants in olives (Oktav and Özer, 2007). The amount of liquid sub-product obtained from the processing of olives into oil varies from 100 kg olives to 40–55 liters with the pressing system, and between 85–120 liters with the centrifugation system (Nas et al. 1992).

How is black water formed, what are its characteristics? It is known that the structure of the black water effluent shows complex characteristics according to its geographical distribution. Depending on the production technology used in olive oil production, the amount of black water per ton of olive processed and the pollution characteristics of black water change. The characteristics of the black water originating from each olive oil plant vary greatly depending on the soil and climate characteristics of the region where the olives are grown, as well as the chemical properties of the water used in the enterprise. The olive oil industry produces large quantities of olive black water. Two different methods are used in olive oil production as batch (press) and continuous (centrifuge). In both methods, two by-products such as pomace and black water are formed as a result of production. The concentration of olive black water, which is released as liquid waste, varies greatly depending on the production process and operating conditions (Çelik et al. 2008).

Environmental importance and treatment of black water. Blackwater or olive blackwater is the residual water formed during the production of olive oil. The amount of waste water released after olive oil production varies depending on the type of production. The pH of these wastewaters formed during olive oil production is acidic and the organic matter content is high. Blackwater; It is rich in suspended solids, sugar, phenol and vegetable oil content (Tezcan, 2010). This wastewater, which is dark brown, acidic, and shows high chemical oxygen demand, causes important environmental problems (Kaya, 2009).

In recent years, the disposal of the olive oil industry territorial waters, which has a high pollution potential, by landfilling has come to the fore as an important alternative. Olive black water carries a serious pollution risk for surface and underground waters due to its content. It is seen that studies based on activated carbon are also carried out in the removal of some components of black water. Using activated carbon for initial regulation not only provides a useful agent in purifying the polluted environment from phenolic derivatives; it also contributes to the reduction of solid waste. The most important reasons for the difficulties experienced in the treatment of black water is that this water contains toxic substances such as high organic matter and polyphenols. Olive black waters spread to the water surface in receiving environments due to their oil content. This, in turn, reduces the oxygen uptake of the water and the transmission of sunlight, preventing the normal development of plant and animal life (flora and fauna) in the receiving environment. In addition, olive black water causes the consumption of dissolved oxygen due to its high organic matter content (Çelik et al. 2008; Orhan and Büyükçorak, 2016).

Giving olive black water directly to the soil affects the physical and chemical properties of the soil. It can also be used as direct irrigation water. However, since the phenolic component concentration in black water is high, these components pass directly to the surface waters during tillage. The high sugar content activates microbial respiration and lowers the dissolved oxygen concentration in the water (Çelik et al. 2008).

Pomace (prina). Pirina is the name given to the olive pulp left over after the olives are pressed in olive oil factories. pomace; consists of oil, water, core and pulp parts (Tezcan, 2010). An average of 35–45 kg dry pomace is obtained from the processing of 100 kg of olives. There are three types of pomace, depending on whether it is obtained from olive oil factories that apply traditional pressing, 3-phase centrifugal decantation process and 2-phase centrifugal decantation process. The three types of pomace in question are distinguished from each other by the fact that they contain 25-30 %, 45–55 % and 60–75 % moisture, respectively. The pomace that is processed is named differently: According to this;

• Raw pomace: It is the first product formed after the olives are de-oiled.

• Seedless pomace: It is pomace that is formed as a result of separating the seeds from the pulp by the ventilation process by passing through a sieve.

• Degreased pomace: It is pomace obtained by removing the oil from the raw pomace as a result of solvent extraction (Hocaoğlu et al. 2015).

Alternative Uses of Wastes from Olive Oil Production. When we classify the studies carried out to evaluate the waste products generated in olive oil production in the world, according to their fields; alternative energy production (biodiesel, biogas, bioethanol, biohydrogen, pellet), livestock (feed) and agricultural applications (soil conditioner), food (gelling, functional foods), pharmaceuticals, nutraceuticals, cosmetics (preservatives, natural humectants) applications, and we encounter biotechnological applications such as bioplastic/biopolymer, biological surfactant and lipase production (Üstündağ, 2015).

The use of olive black water in animal nutrition. In a study conducted with hay and dry grass + concentrated black water as roughage in rams, dry matter digestibility from 54.6 % to 61.4 % and organic matter digestibility from 56.9 % to 61.9 % in the blackwater group. They found that it increased to. It has been reported that the use of dried black water at a dose of 5 and 10 g/kg in broilers does not affect performance data, while meat color and pH are positively affected, and most importantly, black water has a positive effect on the shelf life of meat (Dalkılıç, 2018).

The use of pomace in animal feeding. The use of pomace in animal feeding is more common. Factors such as the method used in olive oil production, the geographical condition of the region where the olives are obtained, the harvest period and the separation of the seed from the olive pomace affect the chemical composition of the olive pomace. These situations affect its use in animal nutrition (Dalkılıç, 2018). In order to produce animal feed additives from raw pomace, the very high acidity of the pomace must be adjusted and its oil must be removed. Solid pomace, whose oil has been removed and acidity has been regulated, is sent to animal feed factories where it is processed into animal feed. The biggest disadvantage is that it is poor in protein and contains a high amount of cellulose (Baysan et al. 2017).

Use of pomace for fertilization purposes. Utilization as fertilizer is the main recommended evaluation method for many industrial wastes. The most important benefit of this method is to bring the high amount of nutritive components carried by the waste to the soil naturally. Raw pomace (50 % moisture) contains nitrogen (0.96 %), phosphorus (0.56 %) and total organic carbon (60.45 %). These components are added to the soil with the humus-like product obtained from the enrichment of pomace by fermentation in an airless environment. During fermentation in an airless environment, biogas, another evaluation method of pomace, is also obtained. Thus, biogas and fertilizer are obtained in the same plant. The biggest advantage of using it as a fertilizer is that it is natural, high nitrogen content, and it can spread easily and directly to the soil. However, its use has been restricted in many countries due to the odor problem and the risk of polluting water resources. There is also the possibility of burning tree roots if not used carefully (Göğüş et al. 2009).

Production of pectin and polyphenol from black water and olive pomace

In a study where pectin and polyphenol were produced from black water and olive pomace, in addition to polyphenols, pectin was also recovered. Pectin, a complex polysaccharide found in olive pomace, is used as a gelling agent and thickener in foods. The oil and water contained in the waste are separated by the pre-treatments carried out by centrifugation and evaporation. After two-step solvent extraction (ethanol:water) and centrifugation, alcohol-soluble polyphenols were concentrated by NF, RO, filtration processes. Alcohol-insoluble lignins, tannins and polysaccharides were separated by centrifugation, and fibers by precipitation. Soluble dietary fibers (pectin) were separated from insoluble dietary fibers by centrifugation (Üstündağ, 2015).

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