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## Eco-friendly insulation material production with waste olive seeds, ground PVC and wood chips

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## ABSTRACT

The waste of the olive oil production process has been a notably important pollution source in Mediterranean countries, such as Italy, Spain, Greece, and Turkey. In recent years, the environmental impact of this type of waste created a rich source, and researchers have been focusing on the treatment of olive oil mill waste. Furthermore, olive seed, waste PVC and wood chips are wastes that cause significant detrimental effects on the environment, following the production stage.

In this study, insulation materials containing waste olive seeds, ground PVC, wood chips, plaster and epoxy were produced, and their properties were investigated. The unit weight, water absorption rate, ultrasonic penetration velocity, thermal conductivity coefficient, compressive and flexure strengths properties of the samples were determined. It can be seen from the results that most properties have improved with the addition of the additives,

The unit weights of the samples and their thermal conductivity coefficients decreased, thanks to olive seeds, PVC and wood chips. However, the decrease in the unit weight was accompanied by an increase in the water absorption and a decrease in the flexural and compressive strengths of the samples, luckily remaining at acceptable levels for the additive rates in the samples.

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## 1. Introduction

Heating of buildings is a real energy cost problem of economy both worldwide and in Turkey. Hence, research on the conservation of energy in this respect is of utmost importance. Due to the foregoing reason, the thermal insulation of buildings and new insulation materials of construction rendered research on [1]. Energy consumption in Turkey in the last 15 years increased by 100% and dependence on foreign sources increased from 51% to 74%. Hence, efficient use of energy is becoming a more important issue every day. In this respect, in the Energy Efficiency Technology Roadmap of the Turkish government, the development of technologies for producing new generation materials and elements of construction to support the energy efficiency in buildings and industry has been set as a target [2].

As many authors have shown in their studies, nowadays, waste is of great importance. Making use of alternative wastes is inevitable due to the rapid depletion of natural resources [3].

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Petrochemicals (mainly polystyrene) and other materials obtained from natural sources are processed with high energy consumptions (glass and rock wools) for the insulation of buildings. These materials cause significant pollution on the environment, particularly, during the production when nonrenewable materials are used and fossil energy is consumed. Also, during the disposal of some materials, there are problems in reusing or recycling them at the end of their original use. The researchers aiming at developing thermal and acoustic insulating materials using natural or recycled materials were encouraged to introduce the concept of “sustainability” in building design. For example, hemp or wood fiber are already being used commercially but they must be further improved for being widely used, because their performance is similar to the synthetic ones. Some others are only at an early stage of being developed and are currently being studied [4].

Like other organic materials, sunflower stalk fibers have also been used to produce insulation materials. There is a significant amount of sunflower production in Turkey. After the production the sunflower stem poses a serious pollution problem. Sunflower stems are cleaned, burned or used for simple heating purposes, causing serious environmental problems. To prevent this problem, the present study proposes a useful way of using those waste materials for the insulation of buildings [1].

The insulation materials sector in Turkey constitutes more than

50% share of the petroleum-derived products. Widely used ones are the extruded polystyrene foam (XPS) and expanded polystyrene foam (EPS). These products are not produced in Turkey and are supplied by importing, causing an economic loss for the country. Development of new generation materials will render alternatives to the current domestic products and it is expected that they do not cause the inconvenience observed in the inorganic structures and existing products and, yet, are easily applicable.

95% of the total worldwide olive and olive oil production occurs in the Mediterranean countries, i.e., Greece, Italy, Spain, Syria, Tunisia, and Turkey. During the production process of olive oil, a significant number of olive seeds remain [5,6]. Olive seeds from olive oil production and the solid waste, which consists of pulp parts, compose 3–6% oil and 40–65% humidity in the process. Although olive seeds were only used as a natural method of preventing weed growth in old Roman times, it has many applications today. Olive seeds are used as an additive and mixed with bitumen for use in road construction. Although the calorific value of the seed varies depending on the type of olive trees, soil structure, feeders in the climate and soil, and oil production technology, olive seeds provide great advantages as fuel [7–9]. This type of waste can be used as a solid fuel and an additive for animal feed. In addition, it is used in the preparation of composite fertilizers. Previous studies have suggested that the seed, which is non-phytotoxic and has organic material content, can be used in the fields where the soil needs to be strengthened. Additionally, chemicals such as lipase can be produced by fermentation [10,11]. Activated carbon, methanol, acetic acid and carbon have been successfully obtained by distilling using the hydrolysis process. The process of obtaining active carbons from bagasse has been used widely in recent years. Environmentalists claim that this efficient approach can render the benefit of waste from olive oil mills for cogeneration applications possible.

A 16 MW plant built in Spain uses 105 thousand tons of seeds per year for fuel and satisfies the electricity demand of approximately 50 thousand homes [12]. In this facility, 0.8 kg seed is required as fuel to produce 1 kWh of electricity.

Since, the heating costs in winter and cooling costs in summer are too high in Turkey, buildings are insulated to reduce these costs. Approximately 40% of the energy in Turkey is consumed in residences, 80% of which is for heating purposes. Therefore, various insulation materials are used in existing buildings in Turkey [13,14].

The quantity of natural resources is decreasing because of the increase of the world population. Natural resources can be protected by recycling. Additionally, material consumption can be reduced and natural resources can be efficiently used when waste is recycled. Therefore, recycling is important for the protection and efficient use of natural resources [15]. In recent years, many waste materials are widely used for various purposes in constructional engineering [16–18].

Energy conservation has recently gained importance for many economic and strategic reasons. For example, 40% of the total consumed energy in the EU is consumed in the buildings, and half of this energy is lost through the walls [19]. Recently, new building materials and construction systems have provided many benefits in terms of building characteristics and comfort. In this context, the insulation of building walls is a new popular research subject because proper insulation saves energy [20–25].

Previous studies have shown that the reuse of wastes is of worldwide significant importance. This study intends to produce an insulation material using olive seeds, ground PVC, and wood shavings. With the method in this study, wastes can be reused, which will help to create employment in mass production and contribute to the national economy.

## 2. Materials and methods

### 2.1. Materials

#### 2.1.1. Olive seeds

The prominent oil production countries in the world are Spain, Italy, Greece, Turkey, Tunisia, Portugal, Morocco, Algeria, Argentina, Syria and Jordan (Fig. 1). Turkey ranks first in the world in edible-olive production and consumption, followed by Spain, Greece and Italy. In addition, the olive oil production and consumption per person ranks fourth. In Turkey, there are 83 million olive trees on 8 million acres, and this figure increases yearly. In the past two decades, the number of olive trees has tripled. The olive pulp is 10–25% oil, and the seed is 25–50% oil. Olive seeds were collected as waste from the olive mills in the City of Kahramanmaraş, in the Southeastern Region of Turkey.

#### 2.1.2. Wood chips

Wood chips are waste material from wood cutting in various timber production facilities and factories (Fig. 1). World timber production has decreased between the years of 2005 and 2009. The production capacity decreased from 437 million cubic meters in 2005 to 362 million cubic meters in 2009 [26]. The world's largest timber manufacturer is the United States. In 2009, the United States produced 61.9 million cubic meters of timber, followed by Canada, China, Brazil and Germany [27]. Turkey, with its 5.8 million cubic meters production, is the thirteenth largest producer among 166 countries in the world timber production and has 1.6% share of the world production [28]. Wood chips used in this study were obtained from the carpenters in the city.

#### 2.1.3. Ground PVC

Plastic can be turned into fibers and used in the textile industry. PVC material is used as an alternative to wood in window frames. Thus, PVC usage reduces tree cutting and protects forests. Additionally, PVC profiles do not require painting, whereas, wood requires it several times, and PVC is much lighter than wood. In this study, waste PVC was obtained from waste collection sites (Fig. 1).

#### 2.1.4. Plaster

Gypsum is a mineral whose chemical composition is calcium sulfate. The type of calcium sulfate with two crystal-water molecules is called gypsum ( $\text{CaSO}_4 + 2 \text{H}_2\text{O}$ ). Plaster crystals are found in clay, marl, salt and spaces of plaster Mountains. It is found in Anatolia, particularly the upper side of the Red River with rock salt as large rocks. Two different plaster stone species can be obtained using two processing methods. In this study, dehydrated gypsum used in plaster works is used.

#### 2.1.5. Epoxy

Epoxy is an adhesive chemical resin from the thermoset group. It is notably resistant against water, acid and alkali, and it does not lose its strength properties over time. Epoxy adhesive that is used to fill cracks converts the discontinuous environment created by the crack into continuity by smoothly connecting both sides of the opening along the crack, preventing stress concentration.

### 2.2. Method

#### 2.2.1. Production of insulation material

Waste PVC is ground up in the cement size in the grinding machine and mixed with plaster and epoxy as binders. The samples produced are described by the volume mixing ratios and by the weights of the samples in Table 1. Using the foregoing raw materials, various samples were produced with different rates.

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