CEVİZ KABUKLARININ YAPI MALZEMESİ ÜRETİMİNDE KULLANIMI: KISA BİR İNCELEME

THE USE OF WALNUT SHELLS IN THE PRODUCTION OF BUILDING MATERIALS: A BRIEF REVIEWS

Erdal AKTAŞ
AKTAŞ Harita ve Mühendislik A.Ş., Merkez, Kırıkkale
Dr. Öğretim Üyesi Hakan ÇAĞLAR
Kırşehir Ahi Evran Üniversitesi, Mühendislik Mimarlık Fakültesi, İnşaat Mühendisliği Bölümü, Merkez, Kırşehir
Doç. Dr. Arzu ÇAĞLAR
Kırşehir Ahi Evran Üniversitesi, Mühendislik Mimarlık Fakültesi, Mimarlık Bölümü, Merkez, Kırşehir

ÖZET

Yapı malzemesi, yapı inşasında kullanılan tüm materyallerdir. Bu yüzden yapı malzemelerinin geliştirilmesi ve iyileştirilmesi kaliteli yapı üretiminde oldukça önemlidir. Yapı malzemelerinin iyileştirilmesi çeşitli malzemelerle yapılmaktadır. Bu iyileştirmede atık kullanımı ön plana çıkmıştır. Endüstriyel atıklar, inşaat ve yıkıntı atıkları, plastik ve polimer atıkları bunlarda birkaçıdır. Son zamanlarda, yapı malzemesi iyileştirilmesinde tarımsal ve biyokütle atıkların kullanımı ivme kazanmıştır. İvme kazanan tarımsal ve biyokütle atıklarından biri de ceviz kabuğudur. Bu çalışmada, tarımsal atıklardan olan ceviz kabuğunun yapı malzemesi üretiminde kullanımı araştırılması amaçlanmıştır. Araştırma, literatürde yer alan akademik çalışmaları kapsamaktadır. Çalışmada, ceviz kabuklarının beton, tuğla vb. yapı malzemelerinin teknik özellikleri üzerine yapılan çalışmalar detaylı bir şekilde irdelenmiştir. Çalışma sonucunda; ceviz kabuklarının öğütülerek agrega yerine betona ikame edildiği görülmüştür. Böylece hafif beton üretimi yapılmıştır. Ceviz kabuğu ikamesinin yapı malzemelerinin porozite ve su emme değerlerini artırdığını, birim hacim ağırlık değerlerini düşürdüğü anlaşılmıştır. Beton, tuğla gibi ana yapı malzemelerinin termal özelliklerini ve ses yalıtım özelliğini iyileştirdiği tespit edilmiştir. Ceviz kabukları tarımsal yan ürün olduğu için maliyetinin düşük ve çevreye etkisinin az olduğu anlaşılmıştır. Ceviz kabuklarının yapı malzemesi üretiminde kullanımının geri dönüşüm ve çevre sağlığı açısından önemli olduğu görülmüştür. Optimum oranda kullanıldığı takdirde, yapı malzemesi iyileştirilmesinde rahatlıkla kullanılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Ceviz kabuğu, yapı malzemesi, geri dönüşüm, sürdürülebilirlik.

ABSTRACT

Building materials are all materials used in building construction. Therefore, the development and improvement of building materials are crucial for high-quality building production. The improvement of building materials is carried out using various materials. Waste utilization has come to the forefront in this improvement. Industrial waste, construction and demolition waste, plastic and polymer waste are a few examples. Recently, the use of agricultural and biomass waste in building material improvement has gained momentum. One of these agricultural and biomass wastes is walnut shells. This study aims to investigate the use of walnut shells, an agricultural waste, in building material production. The research encompasses academic studies in the literature. The study examines in detail the studies on the technical properties of building materials such as concrete and bricks using walnut shells. The study concludes that walnut shells, when ground, can be used as aggregate in concrete. Thus, lightweight concrete is

produced. It has been found that walnut shell substitution increases the porosity and water absorption values of building materials and reduces their unit weight. It has been determined that walnut shells improve the thermal and sound insulation properties of main building materials such as concrete and brick. Since walnut shells are an agricultural byproduct, it has been found to be inexpensive and have minimal environmental impact. The use of walnut shells in building material production has been found to be important in terms of recycling and environmental health. It has been concluded that, if used in optimum proportions, they can be easily used in improving building materials.
Keywords: Walnut shell, building material, recycling, sustainability.

GİRİŞ

With population growth and rapid technological advancements, a rapid increase in industrial activity has been observed. The waste generated as a result of these activities has become a major problem for living organisms and the environment. This situation has made it imperative to combat environmental pollution more effectively (Kaya et al., 2011). One type of waste generated is agricultural waste. Agricultural waste, which has uses in many fields, is one of the wastes that has significant value in the production of environmentally friendly materials that can be used in the construction sector (Abdulwahid et al., 2024).

One of the agricultural wastes used in the construction sector is walnut shells (Ren et al., (2025). Walnut shell (WS) is a byproduct of walnut production and is generally considered waste by farmers (Çavuşoğlu et al., 2023). Walnut shells have become a popular choice in the production of building materials due to their cost-effectiveness and environmentally friendly nature. In the construction sector, it has become a viable option to achieve sustainability (Jannat et al., (2022). Replacing the mineral components of concrete with walnut shells not only makes the concrete production process more environmentally friendly and cheaper, but also solves a significant problem related to waste disposal for the agricultural industry (Beskopylny et al., 2023). Concrete production consumes large quantities of fine and coarse aggregate. Therefore, eliminating or reducing aggregate consumption in concrete can enable the production of environmentally friendly building materials (Hilal et al., 2020).

The development of fired bricks with agricultural waste additives is an important step towards obtaining lightweight, eco-efficient bricks with improved thermal insulation properties. This ensures safe waste disposal and cost effectiveness. It is also a giant step towards environmental sustainability (Barnabas et al., (2023).

The use of walnut shells in the development of geopolymers can lead to the creation of a new type of material, a reduction in energy consumption, waste generation, global CO2 emissions and natural resource extraction (Kozub and Castro-Gomes, (2022). In recent years, although it is considered an agricultural waste, it has been suggested that walnut shells be utilized through innovative applications such as the development of polymers with added walnut shells (Akhlaghi et al., 2021; Hashemi et al., 2016). Walnut shells contain tannins (10-15%), a naturally occurring phenolic compound. This compound is added to polymer materials to increase strength and provide resistance to UV radiation (Pasbakhsh et al., 2017).

This study aims to investigate the use of walnut shells, an agricultural waste, in the production of building materials.

WALNUTS AND WALNUT SHELLS

The walnut tree is a species of tree in the genus Juglans, also known as the nut family. The walnut tree and its fruit shown in Figure 1 grow in temperate and subtropical climate zones (Çakır and Karagöz, 2021). Walnut trees can reach an average height of 25-30 meters and have a lifespan of approximately 50-75 years (Çakır and Karagöz, 2021; Juglans, 2022). Walnuts are an important fruit species due to their content and nutritional value, which have positive effects on human health.

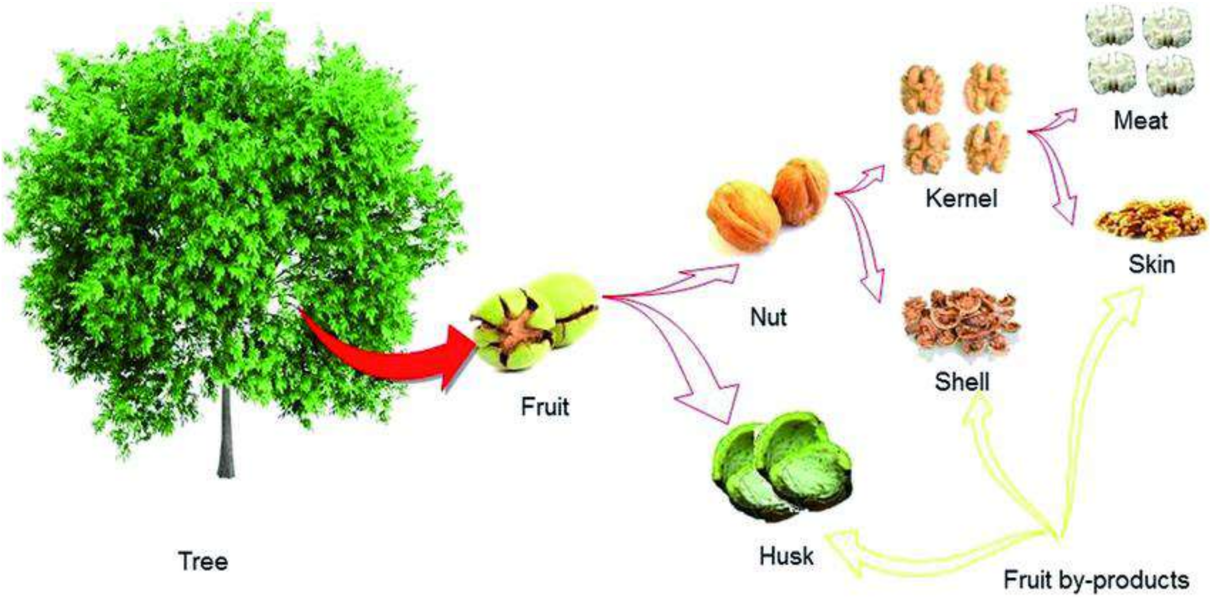

Figure 1. Walnut fruit by-products (Alizada, 2020)

Walnut cultivation is carried out in many countries around the world. According to the Food and Agriculture Organization (FAO) data for 2019, walnuts rank among the top three in the world in terms of area covered by hard-shelled fruits, accounting for 9.3%. In terms of production volume, it ranks first with a 25.8% share.
Figure 2 lists the major countries according to their walnut growing areas. China ranks first in walnut cultivation in all three years. The USA ranks second and Türkiye ranks third (Agricultural Products Markets, 2021). Walnut production area has increased by 4.2% compared to the previous year, reaching approximately 1.3 million hectares.

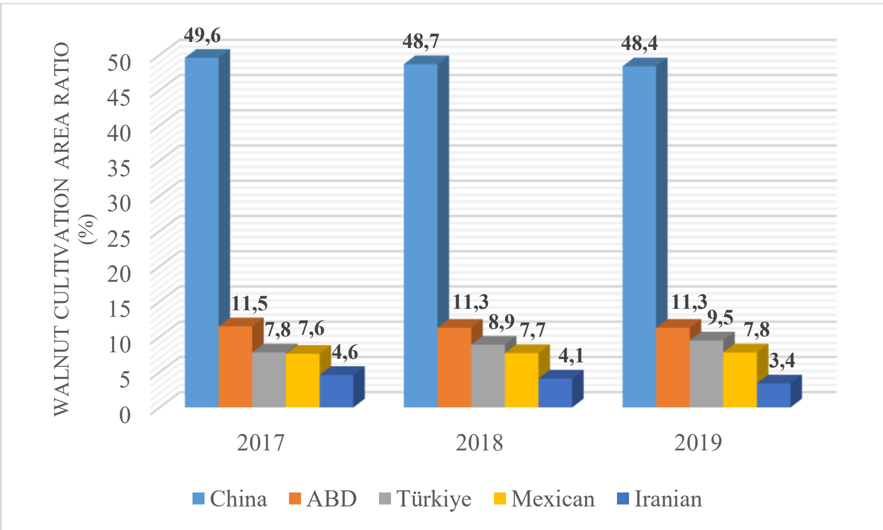

Figure 2. Major walnut-producing countries (%)

Walnut production increased by approximately 3.5% in 2019 compared to the previous year. Approximately 4.5 million tons of walnuts were produced.
Figure 3 shows the major walnut-producing countries. China, the world's largest walnut producer, increased its production by 5.7% in 2019. This increase amounted to approximately

2.5 million tons. China accounted for 56.1% of total world walnut production in 2019. In walnut production, the US comes second after China, with a production of approximately 592,000 tons. Türkiye ranks fourth with a 5.0% share and 225,000 tons. China accounts for 48.4% of walnut production areas, the USA for 11.3%, and Türkiye for 9.5% (Agricultural Products Markets, 2021).

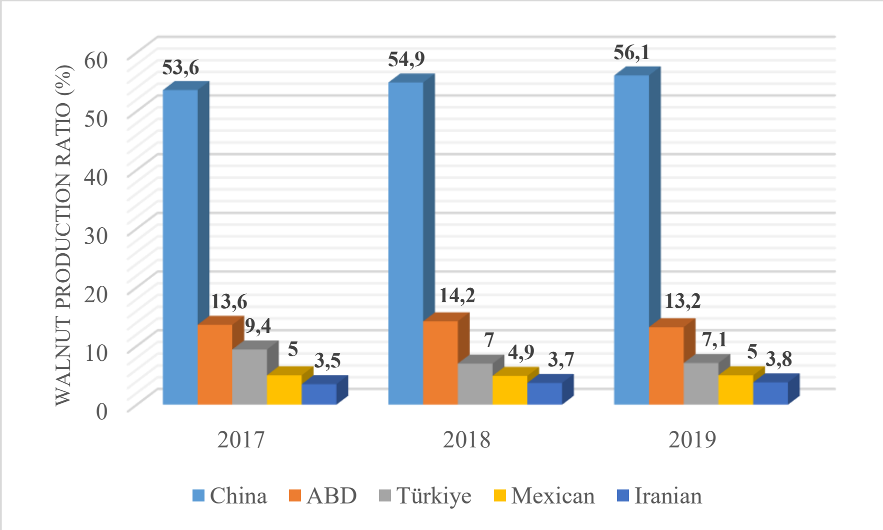

Figure 3. Major walnut-producing countries (%)

Figure 4 shows a map of the provinces in Turkey where walnuts are produced. In Turkey, 287,000 tons of walnuts were produced in 2020. Bursa ranks first with 19.3 thousand tons. Mersin with 16.5 thousand tons and Kahramanmaraş with 13 thousand tons are followed to Bursa. In Turkey, walnut production increased by 27.4% in 2020 compared to the previous year. Walnut yield per kg/tree increased by 14.2% in 2020 compared to 2019 (Agricultural Products Markets, 2021).

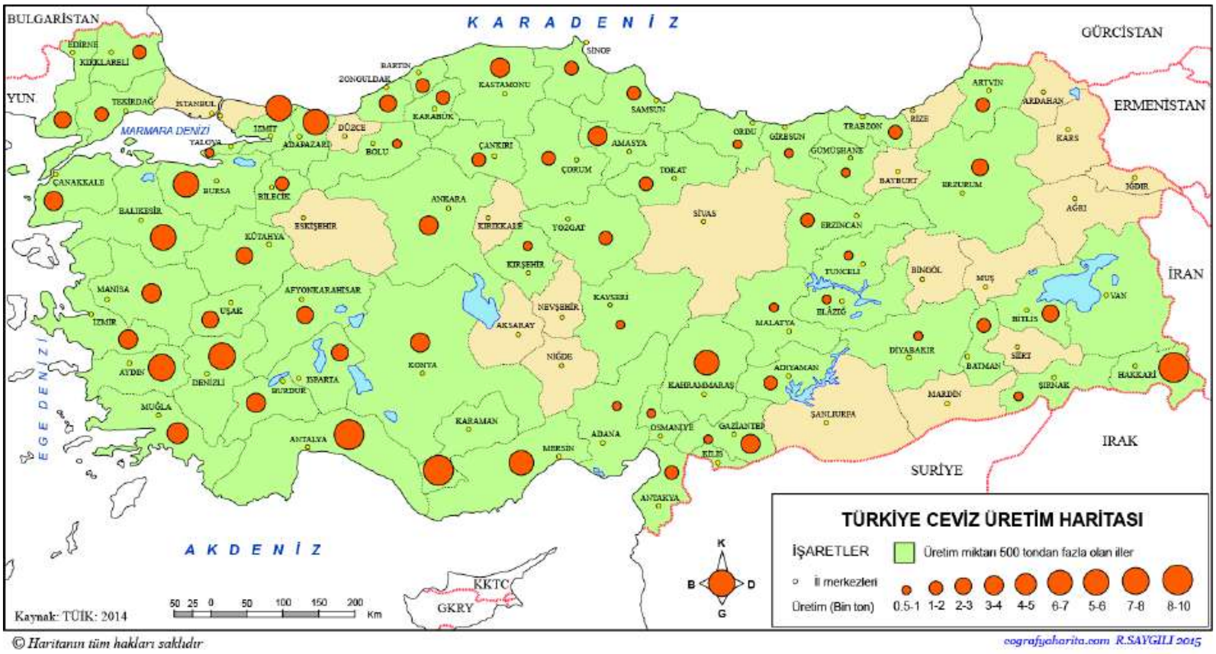

Figure 4. Map of walnut-producing provinces in Turkey (Web message 1)

According to Turkish Statistical Institute (TUİK) data for 2017, 260,000 tons of walnuts were produced in our country. Approximately 135,000 tons of waste walnut shells were generated from this walnut production (Sönmez et al., 2018).
Walnut shells consist of two parts in terms of structure. It consists of a hard, woody outer shell and an inner membrane that acts as a barrier. alnut shells are sensitive to moisture and water. According to the Mohs hardness scale, the hardness value ranges from 2.5 to 3.5. They belong to the class of trees whose shells can be scored with a needle or a penknife. Lignin, which forms the woody structure of walnut shells and provides them with strength, constitutes 50.3% of the chemical composition. Cellulose constitutes the second largest material group after lignin, at 23.9%. In addition to cellulose and lignin, the structure contains 22.4% hemicellulose and 3.4% other components (Adıbelli, 2022). Thousands of tons of walnut shells harvested each year are consumed as fuel. Walnut shells have no economic value. Due to its cellulosic nature, hard structure, and abundance in our country, walnut shells can be used as fillers in thermoset and thermoplastic matrix polymer composites. It is used in production to composite materials due to reasons such as low environmental impact, recyclability, and ease of processing (Adıbelli et al., 2022).
Due to the lower amounts of hygroscopic components compared to wood and the higher amounts of hydrophobic components in walnut shells, polymer-based composite materials containing walnut shell filler have significant commercial advantages in outdoor products requiring high environmental resistance, such as flooring or fencing (Jahanban-Esfahlan et al., 2019).
Walnut shell derivatives are used as absorbents to remove hazardous substances such as heavy metals, hazardous compounds, and synthetic industrial colors (Fordos et al., 2023).

ACADEMIC STUDIES CONDUCTED

Fordos et al. (2023), in their study, examined the latest developments regarding the functional aspects of walnut waste (shell and shell/trunk) in various fields. They investigated the creation of walnut shell (WS) and carbon-based materials such as activated carbons and unmodified/modified WS as adsorbents. As a result of the study, it was understood that WS has antioxidant properties. It was found that it can be used in textile and protein filters. It was determined that these wastes can be used as sustainable and environmentally friendly alternatives in agriculture, laboratory, medicine and food industries.
In their article, ***Abdulwahid et al. (2024)*** investigated the use of walnut shells in some building materials. As a result of the study;

- ✓ Walnut shells can be included in the manufacture of some building materials to ensure sustainability in the construction sector,
- ✓ It is an agricultural waste that can be converted into usable materials,
- ✓ The low specific gravity of walnut shells makes them an inexpensive agricultural waste for the development of building materials,
- ✓ It was understood that walnut shells in granular form can be used in the production of building elements and thermal insulation concrete.

Beskopylny et al. (2023) analyzed the effect of compositional factors on the properties of concrete by partially replacing coarse aggregates with walnut shells. They investigated the optimum composition that provides the maximum reduction in concrete density and the minimum reduction in strength properties. They produced cube and prism laboratory specimens from normal density concrete with coarse aggregate substitution at rates of 5%, 10%, 15%, 20%, 25%, and 30% by volume. They examined the main mechanical properties of the concrete specimens, such as density and strength (compressive, tensile, and flexural tensile strength). They observed an increase in strength properties of up to 3.5% and a maximum value in the strength/density ratio of the concrete when the walnut shell dosage was 5%. They determined that partially and effectively replacing coarse aggregate with walnut shells led to a reduction in crushed stone consumption of up to 10% and a reduction in concrete mass of up to 6%.

Ren et al. (2025) used walnut shell (WS) as an internal curing agent to reduce the AS value of ultra-high performance concrete (UHPC) in their study. They investigated the effect of WS on AS, internal relative humidity, mechanical strength, heat of hydration, and the microstructure of the UHPC matrix. According to the results obtained:

- ✓ When 3-9% WS was added, the AS value of the UHPC matrix decreased by 47.0%-74.5% in 7 days.
- ✓ The compressive and flexural strengths of the UHPC matrix decreased by 7.0%-15.5% and 8.9%-17.1%, respectively, on the 28th day.
- ✓ After adding 3%, 6%, and 9% WS, the average chain length of C-S-H increased by 35.5%, 50.4%, and 73.8%, respectively, compared to plain samples.

El Hamri et al. (2025), in their article, investigated the use of walnut shell particles (WSP) as a sustainable reinforcement material in cement boards (WSCB). They used super white cement (SWC) as a binder. They aimed for a density of 1300 kg/m³, a thickness of 10 mm, and a water-cement ratio of 0.6:1, and produced boards with WSP content ranging from 10% to 50% by weight. The mixtures were cold-pressed at room temperature for 24 hours at 3 MPa pressure using a hydraulic press, and then cured at room temperature for 28 days. They evaluated physical properties such as density, water absorption, and thickness swelling, and mechanical performance through bending tests. They determined that the 24-hour water absorption rate of the board containing 30% WSP was 14.05%. They reported that it exhibits an optimum balance of physical and mechanical properties with a modulus of fracture (MOR) of 6.53 MPa and is suitable for non-structural applications. They determined that the board containing 50% WSP has the best thermal insulation performance with a low thermal conductivity of 0.079 W/mK.

Jannat et al. (2022) used eggshells and walnut shells in the production of unbaked clay blocks in their study. First, they produced three series of samples using eggshells (10-50%) and walnut shells (5-20%) separately, and then a mixture (5% walnut, 10-30% eggshell). They then evaluated the physical and mechanical properties of the unbaked clay blocks. Density, capillary water absorption, linear shrinkage, flexural and compressive strength tests were conducted in the study. As a result, they reported that:

- ✓ When the materials were used separately, eggshell increased the strength compared to the control sample,
- ✓ Walnut shell decreased the strength,
- ✓ Combining the two materials in the mixer further reduced the strength of the samples,
- ✓ Adding waste materials reduced the density, capillary water absorption coefficient, and linear shrinkage of the samples,
- ✓ Eggshell has great potential for the production of unburned clay blocks,
- ✓ The integration of walnut shell requires further research.

Chilmon et al. (2025) investigated the effects of ground walnut shell (GWS) on the structural, load-bearing, contaminant retention properties of permeable concrete and on the water treatment efficiency of heavy metal zinc. They evaluated the effect of GWS as an internal curing agent on the basic mechanical and physical properties of permeable composite. They found that this modification had a statistically significant effect on the properties studied. As a result:

- ✓ GWS increased the porosity of the cement matrix by acting as an internal curing agent.
- ✓ They observed a slight deterioration in the mechanical performance of permeable concrete at lower GWS contents (2% and 10%).
- ✓ Reference samples exhibited significantly higher compressive strength relative to their effective porosity compared to mixtures modified with GWS.
- ✓ The presence of GWS altered the typical strength-porosity relationship observed in permeable concrete.

- ✓ Due to the increased capillary pore content, the immobilization efficiency of GWS-modified concrete doubled under static test conditions compared to the reference series (from approximately 27% to 54%).
- ✓ In dynamic flow tests, contaminant contact was limited to the outer cement matrix layer.
- ✓ The interface transition zone (ITZ) between the cement matrix and the internal curing agent (GWS particles) was a factor that significantly affected the immobilization potential of the permeable concrete.

In their study, ***Da Silva (2017)*** evaluated the ability of walnut shell-modified Medium Density Fiberboard (MDF) to regulate RH, toluene, limonene, dodecane, and formaldehyde. They evaluated the adsorption and desorption behavior of MDF containing up to 15% walnut shells in 2-liter environmental chambers under dynamic conditions at 23 °C and 50% RH. They analyzed the porous microstructure and chemical composition of MDF and walnut shell using SEM, XRD, and FTIR. The porous surface of the walnut shell increased the specific surface area of the panel and thus its adsorption capacity. Improved moisture stabilization capacity occurred. The ability to adsorb water-soluble VOCs such as formaldehyde was enhanced. This research provides significant evidence that walnut shell-modified MDF can improve indoor air quality.

Kozub and Castro-Gomes (2022), in their article, investigated the effects of different weight percentages of ground walnut shells and quartz sand on the density and strength properties (including compressive and flexural strength, thermal conductivity, salinization, and water absorption) of fly ash-based geopolymer composites. They analyzed the microstructure of the geopolymers studied using scanning electron microscopy (SEM). They observed that the addition of ground walnut shells reduced the density and mechanical properties, increased the absorption properties, and decreased the porosity of the fly ash-based geopolymers. Furthermore, they reported that the addition of ground walnut shells significantly reduced salinization on the surface of the tested geopolymer composites.

Charai et al. (2022) investigated the thermal performance of a novel biocomposite (clay-walnut shell) in their study. First, they performed geotechnical analysis on the soil. To evaluate the thermal effect of walnut shell on unfired clay bricks, they substituted walnut shell at different weight percentages (0%, 10%, and 20%). Then, they compared the thermophysical properties of the produced biocomposites with those of clay alone. They measured the thermal conductivity properties using the hot disk method. They compared the dynamic thermal behavior of two types of walls (concrete block wall and clay brick wall - 20% by weight walnut shell). Thermal analysis showed that walnut shell improved the thermal insulation of unfired bricks while reducing their density. The addition of 20% by weight walnut shell reduced the thermal conductivity of the clay by 45.22%, increasing its thermal resistance. Numerical findings revealed that the use of the developed composites improved the energy performance of residential buildings and provided energy savings of 10.8% and 7.94% for heating and cooling needs, respectively.

Abdulwahid and Abdullah (2021) investigated the effect of walnut shells on different properties of mortar. They examined the dry density, thermal conductivity, compressive strength, and flexural strength of the mortar. They determined the percentages of walnut shells used as substitutes for sand as 5%, 10%, and 15%. The walnut shells used in the study were treated by soaking them in boiling water for half an hour and one hour. In all mortar mixtures, cement, sand, and water were used in a ratio of 1:3:0.7 by weight, respectively. The test results showed that using 15% walnut shells treated for half an hour reduced the density and thermal conductivity of the mortar by 15% and 31%, respectively. The compressive and flexural strength of the mortar decreased by 17% and 25%, respectively, after 28 days of moist curing compared to the control mortar. They found that soaking walnut shells in boiling water for half an hour improved the properties of the mortar compared to those that were not soaked.

Hilal et al. (2020), in their study, selected crushed walnut shells (CWS) as a partial replacement for coarse and fine aggregates at rates of 5% to 25%. First, fine aggregates were replaced with CWS at the specified rates. Second, coarse aggregates were replaced with CWS at the specified rates. Third, fine and coarse aggregates were replaced with CWS at the same rates. All samples were subjected to absorption rate, compressive strength, flexural strength, splitting strength, and dry density tests after 28 days. The results reported that all properties except absorption rate decreased when CWS was used. They stated that the best results were obtained when both fine and coarse aggregates were replaced with CWS. They achieved advantageous values with a 15% CWS replacement for both aggregate types.

RESULTS

Walnut shells have become a subject of research in building material production for bio-based, lightweight, and environmentally friendly solutions. Walnut shells have been shown to reduce the unit weight of concrete and mortar, increase water absorption, and provide heat and sound insulation. Walnut shells, thanks to their fibrous and porous structure, are used in the production of thermal insulation panels and acoustic insulation boards. Walnut shell powder or granules, used in the production of composite materials, are utilized as filler or reinforcement material in wood-plastic composites (WPC) and fiberboard (MDF-like panels). This reduces the petrochemical content of the composites and provides an aesthetically pleasing, natural texture. Walnut shells burn during the firing of bricks, creating voids. This void reduces the density and thermal conductivity of the brick. It is possible to produce energy-efficient, lightweight bricks by substituting walnut shells. Decorative panels and interior coverings with a natural texture can be produced by using walnut shells in the production of surface coating materials.

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