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VALORIFICAREA ÎN INDUSTRIA AGROALIMENTARĂ A DEȘEURILOR PROVENITE DE LA POMII FRUCTIFERI

VALORIZATION IN THE AGRO-FOOD INDUSTRY OF WASTE FROM TREES FRUIT TREES

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Abstract

In the context of the circular economy, the recovery of wood waste from fruit trees as well as fruit residues contribute greatly to sustainable development. The main bioactive products from fruits and fruit trees have multiple properties including antioxidant, antimicrobial, antifungal, biostimulant, anti-inflammatory, cardioprotective anticarcinogenic. From an economic and ecological point of view, the implementation of the concept of biological recovery of waste and its incorporation into a sustainable and renewable cycle is possible, but this requires integrated technology and systematic management. This work highlights various applications, methods and effective solutions for the recovery of waste from fruit trees in the agro-food, pharmaceutical and cosmetic industries.

Cuvinte cheie: deșeuri lemnoase, pomi fructiferi, dezvoltare durabilă.
Key words: wood waste, fruit trees, sustainable development.

1. Introduction

For sustainable development in the context of the circular economy, the recovery of waste from wood from fruit trees and fruit waste is very important.

In the European Union, fruit tree crops occupy an area of 11,301,345 hectares (ha). From the annual grooming of these fruit trees alone, about 25 million tons of wood remain. Among the most cultivated varieties of fruit trees but also the main producing countries are highlighted in FigureS 1 A and B (FAOSTAT). Available online: https://www.fao.org/faostat/en/#home).

Waste from fruit trees accumulates rapidly and can take up a problematic amount of space, and can harm local ecosystems (Proto et al., 2021).

The management of agricultural waste is vital to ensure that there are no negative effects on the environment. Improper disposal of this waste, such as burning or burial, can lead to air, water and soil pollution. In Romania there is Law 24/2007, regarding the Regulation and administration of green spaces in the built-up area of localities, amended and supplemented by Law 47/2012, which prohibits the burning of plant residues.

To promote continuous and optimal production by controlling the physiology of trees, at least once a year crown pruning is carried out. The main purpose of this operation is to facilitate crown shaping for optimal fruit production and efficient harvesting, but also for a better distribution of nutrients in the trees, thus quantitatively and qualitatively improving the fruit tree crops. (Cichy et al., 2017, Velázquez-Martí et al., 2013).

2. Material and methods

The collection of timber that remains after the annual felling, involves encountering a series of logistical difficulties, due to their dispersion in the territory, the size and location of the plantations, but also the production of vegetal biomass per hectare which is much lower than that of forest wood (CIRCE: Zaragoza, Spain; CERTH: Athens, Greece, 2018). However, waste from fruit trees is a good source of biomass.

Felling residues, from cultivated areas, can be directed to energy conversion to obtain renewable forms of energy (heat and electricity). This action is an alternative, given that replacing the use of fossil fuels with renewable energy sources and reducing carbon emissions is an international target under the Paris 2014 agreement (https://data.consilium.europa.eu/doc/document/ST-169-2014-INIT/en/pdf).

The most conume species of fruit trees in Europe are olive trees, vines followed by almonds and other nuts and on the fourth place are the fruits of berries (apples and pears).

Olive trees contain an important amount of cellulose, hemicell-lulose and lignin, carbohydrates, various sugars, fatty acids, nitrogen compounds. (Zabed et al., 2017, Ballesteros et al., 2011, Romero-García et al., 2014).

3. Results and discussions

Recovery from waste of olive wood

Olive wood is characterized as a hard and versatile wood, which is why it is used as wood for the manufacture of furniture, in the manufacture of handicrafts or even tools (OliveWood—Characteristics, Types and Uses. Available online: http://www.woodassistant). But the main application of olive wood is biomass as an energy source, with economic advantages and a considerable reduction in CO_2 emissions (Amirante et al., 2016, Vera et al., 2019).

Regarding the use of waste for the content of bioactive compounds, not many studies are available, but we can mention some examples. Olive wood extract was used as an in vitro antifungal agent on *the fungus Pleurotus ostreatus,* and the result showed that the fungus was inhibited in the proportion of up to 80% (Ate ̧s et al., 2015).

Another study highlighted the in vitro antimicrobial and antifungal properties of olive wood against various fungi (*Aspergillus niger*, *Aspergillus flavus*, and *Penicillium purpuro- genum*) and bacteria (*Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Listeria monocytogenes*, *Enterococcus faecalis* and *Klebsiella pneumoniae*) present in plants. The results showed the inhibiting ability of olive wood for all bacteria and fungi studied but the best results were on *K. pneumoniae* and *S. aureus* (Tarfaya et al., 2014).

Vines. Of the 3.2 million hectares under vines in Europe, only 60 351 ha (around 78%) were used for the cultivation of table grapes for wine production (Vineyards in the EU—Statistics). Available online: https://ec.europa.eu).

During the operation of grooming the vine, shoots of vines (also called vine strings) are the main by-products, with about 2-5 tons / ha each year, which is a huge amount of untapped wood (Arvanitoyannis, I.S. and others 2006).

Vine shoots have a high content of high carbohydrates (3496-44,200 mg/kg) which makes them suitable for use as hybrid plates, and have significant concentrations of minerals (K, P, Ca, Fe, Mg, Zn) that are of interest to human health (Çetin.et al., 2011).

Recovery of vine waste

The vine shoots were used to obtain energy or in the production of biorafinary compounds or bioactive carbon (Ioannidou et al., 2007; Zacharof, 2017). Because they have a high content of lignin they are used to obtain particle board (chipboard) (Wong et al., 2020).

But the main use of vine shoots is compost on the field, since the high content of lignin, cellulose, nitrogen and potassium bring benefits to the vineyard.

The waste from the vines has antimicrobial activity and it has been proven that they can act in the control of *P. viticultural*, one of the main fungal pathogens in the vine, but also as an insecticide against *Leptinotarsa decemlineata* (Colorado potato beetle) and *Spodoptera littoralis* (Gabaston et al., 2018; Sánchez-Gómez et al., 2017).

Due to their high content of phenolic compounds, carbohydrates, and minerals, vine extracts can also be used as biostimulants for increasing the amount of gallic acid, hydroxycinnamoyl tartaric acid, acylated anthocyanins, flavonols and stilbenes in grapes (Pardo-García et al., 2014; Sánchez-Gómez et al., 2016).

Fortheir high antioxidant and antimicrobial populations, they are also used as an alternative to SO_2 in the wine industry to correct certain defects (Guerrero and Cantos-Villar, 2015).

In conclusion, vine waste can be used, as compost for vineyards or other crops, for energy production, for the treatment of several pests of plants or even in the agri-food industry.

Almonds and different types of nuts

In Europe, almond and nut production accounts for over 35% of the annual fruit production, and among the most widespread are almonds, walnuts, hazelnuts, chestnuts and pistachios, as can be seen in Figure 2 (www.atlasbig.com).

The annual management of Europa nut orchards, which is spread over an area of over 1,000,000 hectares, also brings with it an imported amount of waste (Silvestri et al., 2021). The amount of cutting biomass is estimated to be for almonds between 1.6 and 2.4 tons/ha per year (Bilanzdija et al., 2012) for hazelnuts, between 1.4 and 2.7 tons/ha of felled wood (Di Giacinto et al., 2014) have been estimated for chestnuts between 22 and 33 tons/ha of wood residues (Di Gennaro et al., 2020; Nati et al., 2018). As for the walnuts of the cuts it generated about 0.5 tons/ha per year (Bilanzdija and Aces, 2012).

The waste from painstaking wood is not much recovered, in addition to obtaining biomass it can also be used as food additives or in cosmetics due to their antibacterial and antioxidant properties (Bisignano et al., 2013).

Walnut wood waste also has antioxidant properties, it has been shown to have cleansing, reducing, inhibiting lipid preoxidation activity (Fernández-Agulló et al., 2021).

Another application of walnut wood manure is like antifungal, walnut wood has been used to treat against *Trametes versicolor*, a white rot fungus responsible for poplar wood disease. The wood extract did not show a noticeable slowdown in the development of the fungus attack (Hosseini-Hashemiet al., 2011).

Also, waste from walnut wood can be used in the wine industry, since wine that stays in contact with walnut chips has been proven to have more developed sensory properties (Costa et al., 2021).

Gallic acid and ellagic acid present in walnut wood are used for their benefits as an anti-inflammatory, antibacterial with a role in decreasing lymphocytes, and their supplementation could reduce allergic reactions in nuts (Hamada et al., 2019; Wang et al., 2018). And in the dairy industry, ellagic acid and quercetin derivatives from walnuts can be used for antibacterial effect and prevents contamination with *S. aureus* (*Golden staphylococcus*) (Gomes et al., 2018).

Apples and pears

In the European Union, fruit trees are the fourth most widespread crop, which annually reaches over 600,000 ha. Of the total fruit production, apples occupy about 80% of production.

The waste of apple and pear wood annually reaches up to 2-5 tons / ha except for wood fallen due to climatic events or fruit harvesting processes, resulting in a huge amount of wood that should be recovered (Burg et al., 2017).

Applications of apple and pear wood waste in the agri-food industry

Although mainly used as fire lemens or as a fertilizer applied directly in the field (Landínez-Torres et al., 2021), apple wood and hair waste due to its high calorific value (around 15.7 MJ/kg) can be used to obtain thermal or electric energy or biochar (Ali et al., 2020) but also for the production of biocarbon or vinegar (Xun et al., 2020).

Due to the lignocellulosic content of apple and pear wood waste, they constitute a good substrate for the cultivation of oyster mushrooms, *P. ostreatus* (Oyster) one of the most cultivated species of edible mushrooms (Landínez-Torres et al., 2021).

Apple wood is also used in the production of structural particle board or furniture (Kowaluk et al., 2020), but it is also used in the food, pharmaceutical and cosmetic industries because they have antioxidant and antimicrobial activity (Withouck et al., 2019).

Bristle wood due to its high cellulose content is used in the production of paper, plastics, magnetic tapes, protective coatings and electrical parts, photographic film (Israel et al., 2008).

Stone fruit trees

Stone fruit is the fifth fruit category out of the total fruit grown in Europe, with an area of 0.6 million ha. Of the most cultivated stone fruits are peaches in the proportion of 42%, plums 20%, nectarines 16% followed by cherries 13% and apricots 9% (Stone Fruit Statistics. Available online: https://ec.europa.eu).

Regarding the residues generated by the maintenance of stone fruit orchards, the values are between 1.2 and 2.9 tons of wood cut per hectare (Burg et al., 2017; Pari et al., 2018).

Recovery of waste peach wood

Wood waste from peach cutting has been studied, and the results have shown that the main active compounds present can be used as natural antioxidants with a role, anti-lipase and even anti-dementia (Nakagawa, T. And others 2018). It has also been discovered that peach wood extract can be a natural antihypertensive that can be introduced into the nutraceutical or pharmaceutical industries (Kim et al., 2019).

Recovery of plum wood waste

The biomass of plum wood, presented antimicrobial and antibiophilic activities against several food microorganisms such as: *Salmonella enterica*, *E. sheets*, *S. aureus*, *L. klebsiella terrigena, Enterobacter sp.* These aspects show that the biomass of plum wood can be used as a biocide or even preservative in the food industry (Ortega-Vidal et al., 2022).

Another capitalization of plum wood is at the ageing of cognac, in addition to oak wood, the use of plum wood has increased its quality and organoleptic evaluation (Novikova et al., 2020).

Recovery of waste cherry wood

Like plum wood thickets, cherry wood can be used as an antimicrobial agent or food preservative for the food industry. The activity of active cherry wood bushes have been tested for their antimicrobial-bial and antibiophilm activity against stems from the collections of crops of type *S. enterica*, *E. sheets*, *S. aureus* and *L. monocytogenes*, as well as on multiresistant strains as: *B. cereus*, *E. casseliflavus, E. faecium*, *S. aureus*, *S. saprophyticus*, *L. casei*, *P. aglomerans*, *K. terrigena*, *Enterobacter* sp., and *Salmonella* sp. (Ortega-Vidal et al., 2021).

Cherry wood rich in flavonoids, has been studied for use in the aging of wine and vinegar. The results showed that the use of cherry wood barrels promoted a faster evolution of catechins, procyanidines and flavonols. Due to the action of some existing phenols, both tannins and pigments of red wines have been stabilized (Chinnici et al., 2015).

Recovery of apricot wood waste

Among the newest uses of apricot shoots is the obtained gum exudate. This fluid/semi-solid was composed of a high molecular weight polysaccharide with arabinogalactanic structure. It is a natural polymer that due to its wide range of hydrocolloid applications in different industries, has attracted the attention of many researchers (Salarbashi et al., 2021).

Wood cut from apricot plantations has antioxidant lipid peroxidation inhibiting properties, an antifungal role, and can be used in agriculture and perfectly integrated into a circular economy system.

4. Conclusions

Millions of tons of waste from fruit trees are generated annually. Their incorporation into the soil is the main utitilisation, but in recent years they have been used as biomass to produce energy thus helping to reduce the use of fossil fuels, reduce greenhouse gas emissions and mitigate climate change.

Since they have many bioactive properties and are an important source of secondary metabolites, wood waste, is directly involved in the basic functions of development, growth and reproduction of the organism. Hence the interest of researchers to study these compounds in wood residues.

Worldwide, over the past ten years, studies based on the recovery of wood waste have increased almost sevenfold.

It has been proven that extracts from the wood of fruit trees are suitable for use both in the pharmaceutical industry for the prevention of various diseases such as Alzheimer's and diabetes, in the food industry or in agriculture due to their antioxidant, antimicrobial or anti-fungal properties.

Due to the bioactive properties of wood waste, they have beneficial effects on durability and an important contribution to the circular economy, but they need to be studied more closely in order to be able to use them to their true value.

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Figures

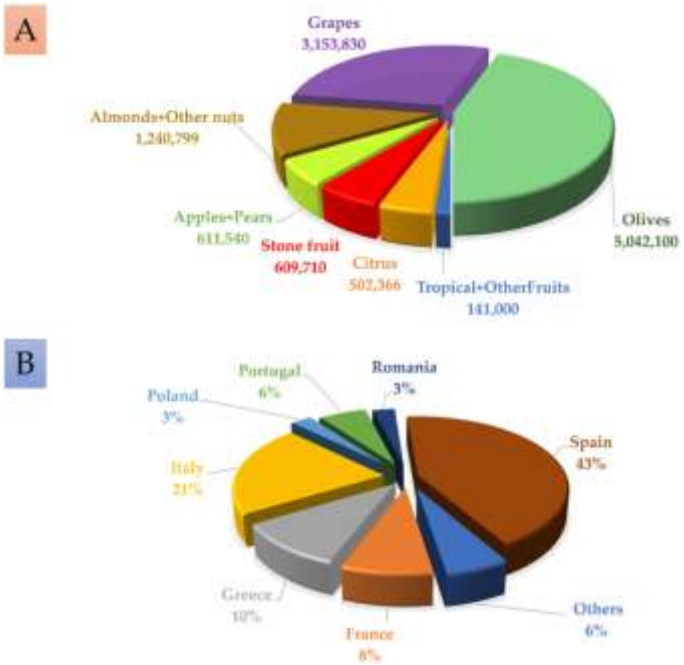

Fig. 1. (A) The area of fruit trees in the EU and (B) the distribution of fruit tree areas in EU countries (1B)

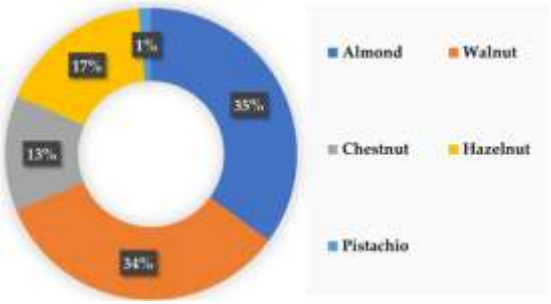

Fig. 2. Proportion of nut production in Europe