Review
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Olive tree polyphenols as effective and sustainable grain preservatives

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Abstract

Whole grains play a crucial role in the human diet. Despite being cultivated in distinct regions, they are shipped everywhere, therefore making biosafety and security essential throughout the grain industry, from harvest to distribution. Phytopathogens, which have an impact on crop yield, induce grain spoiling and reduce grain quality in a number of ways, providing a constant danger to crop storage and distribution. Chemical control approaches, such as the use of pesticides and fungicides, are detrimental to the environment and hazardous to human health. The development of alternative, environmentally friendly, and generally acceptable solutions to ensure increased grain yield, biosafety, and quality during storage is crucial in order to guarantee sufficient food and feed supplies. As a means of self-defense against microbial infection and spoilage, plant matrices feature antimicrobial natural chemicals, which have led to their widespread usage as food preservatives in recent decades. Olive tree extracts, known for their high polyphenol content, have been widely used in the food preservation industry with great success, and are highly welcomed by people all over the world. In addition to their well-known health advantages, polyphenols are a valuable plant secondary metabolite because of their great antibacterial capabilities as natural preservatives. This article discusses the promising usage of polyphenols from olive trees as a natural alternative preservative, while also highlighting the future of olive eaves in the food industry. ***Clin Ter 2023; 174 Suppl. 2 (6):154-158 doi: 10.7417/CT.2023.2482***

Key words: *polyphenols, grain preservative, olive tree, natural molecules, antimicrobial*

Introduction

Humans heavily rely on cereal grains (like wheat, corn, rye, oat, rice, etc.) for sustenance and energy. However, cereals are subjected to a wide variety of biotic and abiotic stress factors during their development and storage. In particular, the cereal industry faces significant challenges from pathogenic and spoilage microorganisms such as bacteria, yeasts, and filamentous fungus (1). The quality of grains must be maintained during storage, transit, and conveyance, with the two extremes being short-term storage on the farm for drying and long-term storage for strategic reserves. To clarify, either on-farm or large-scale commercial storage options are viable (2). As the world's population rises, so does the demand for cereals; and also the amount of grain lost in storage rises to roughly 20% of the total production (3, 4).

Foods containing grains that have been contaminated with microbes pose a risk to human and animal health (4), so, the direct and indirect effects of fungal infection in stored food grains on food economies are of worldwide concern (2), with diseases wiping off about 20% of a year's worth of wheat production (3, 5). Mycotoxins, which are released by a wide variety of seed-borne fungus and can lead to a wide range of health issues in consumers, are another worry (5): for example, ochratoxin A, a mycotoxin of Aspergillus ochraceus, is found in 25-40% of cereals consumed worldwide (6, 7). Furthermore, the European Food Safety Authority's Panel on Contaminations in the Food Chain reported that grains and grain-based products are one of the three main chronic dietary sources of ochratoxin A. Aspergillus flavus is the primary source of the most hazardous mycotoxins, aflatoxins, and an estimated 4.5 billion individuals in developing countries are at risk of contracting aflatoxicoses (7).

However, the duration of storage, the water content of grains, the storage temperature, the humidity during storage, and the type of storage technology are all significant contributors to the development of mold and other types of fungi (8, 9). However, Aspergilli may have a greater prevalence than other fungi because of their saprophytic nature and capacity to colonize numerous substrates due to their secretions of various hydrolytic enzymes (11). This may explain why Fusarium spp., Aspergillus spp., and Penicillium spp. were shown to be dominant. The synthesis of fumonisins (Fusarium mycotoxins) has been observed to occur post-harvest, when storage conditions are poor (14), despite the fact that Fusarium species are typically thought

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of as field fungus. One of the greatest issues faced by food scientists is getting mycotoxins out of the food supply. Therefore, it is important to take measures to eliminate mycotoxin sources, such as mycotoxin-producing fungi, from the stored grains (8).

In order to achieve this goal, farmer employ many kinds of pesticides in large quantities. However, the increased use of pesticides has led to many side effects, such as pest resistance, outbreaks of novel pests, toxicity to non-target species, and adverse impacts on the environment (11). Synthetic pesticides play a crucial role in crop protection nowadays. Grain disinfection during storage is often accomplished using phosphine (PH3) or methyl bromide (CH3Br); however, the use of the latter is banned in Europe and in the United States (13). Therefore, novel fungicides/preservatives that both have enhanced performances and are also environmentally benign are necessary (12). Hermetic storage, microwave heating, gaseous ozone applications, cold plasma, ionizing radiation, pulsed light, or supercritical carbon dioxide (SCeCO2) are just a few of the novel control measures that have been extensively studied as nonchemical fungi management practices (8).

Plants are thought to have the greatest concentration of bioactive secondary metabolites that might be used as natural food preservatives: flavonoids and non-flavonoids, terpenes, aldehydes, ketones, aliphatic alcohols, organic acids, thiosulfinates, saponins, and glucosinolates are some of the most common types of active chemicals found in plants, herbs, and spices. New research shows that the bioactive chemicals found in plant extracts and essential oils can impede the growth or activity of foodborne pathogens (bacteria, yeasts, moulds, viruses). Using plant extracts and essential oils to combat seed-associated fungi might be a sustainable alternative that can also reduce the likelihood of disease resistance (10, 12). The antibacterial activity of many plant extracts has been the subject of several researches, showing their potential as synthetic preservative alternatives. As a result of this rising demand, several organizations and governments are pouring resources into research and development of all-natural food preservatives (15).

Methodology

This paper is a "narrative review". All the information used for its preparation is based on data from original documents and reviews. We selected the most relevant studies on olive tree polyphenols and their roles as antimicrobial substances and preservatives. We conducted an electronic search in MEDLINE, PubMed database, Google Scholar and Scopus, using the following string: (olive polyphenols(Text Word) OR polyphenols(Text Word)) AND (antimicrobial(Text Word) OR preservatives(Text Word)). The reference lists of selected articles were scanned to retrieve additional relevant research.

Polyphenolic profile of Olive Tree

In plants, the shikimate and polyketide pathways are responsible for the production of polyphenols, which are non-nutritional secondary metabolites and one of the most pervasive classes of plant-based chemicals.

There are both simple and complex phenolic compounds in olive fruit: these phenolics are responsible for the oxidation resistance and organoleptic qualities of the oil (16). Olive oil contains both simple and complex phenols, in concentrations of up to 1% by weight. Five to ten percent of the total contents of the olives is released into the oil during production (crushing), while the vast majority stays in the water phase (vegetation water) like hydroxytyrosol, tyrosol, and the lipid soluble oleuropein and ligstroside aglycones. About 90% of olive phenols are transported to the water phase during the pressing of the drupes, making vegetable water a significant source of phenolic antioxidants (1-1.8% w/v) (16).

It has been established that hydroxytyrosol, also known as 3, 4- dihydroxytyrosol or 3, 4-dihydroxyphenylethanol, is the primary phenolic component of olive extract and olive oil, and its presence has been detected and measured also in wines (17). Both hydroxytyrosol and oleuropein aglycone (an ester of hydroxytyrosol and elenolic acid) may be found in olive oil. Hydroxytyrosol in its purest form is a colourless, odourless, and flavourless liquid that can be either hydro- or lipo-soluble. It has the highest ORAC value of any phenolic antioxidant found in olive oil, making it the most powerful olive oil antioxidant. Considering several beneficial effects of hydroxytyrosol, it has been proposed as a dietary supplement for many conditions (18-21).

Moreover, the olive tree and other members of the Oleaceae family contain a phenolic secoiridoid glycoside, called oleuropein. This compound may be found in the tree's bark, leaves, and fruit. A bitter glycoside accounts for up to 14% of the dry weight of the drupe, making it the most prevalent phenolic compound in the fruit(17).

Effect of Oleuropein on Microorganisms

The antibacterial properties of oleuropein extend to a wide variety of microorganisms, including viruses, retroviruses, bacteria, yeasts, fungi, molds, and other parasites (22-25). Research has established that oleuropein has an antibacterial action against *Salmonella enteriditis*, and that it inhibits sporulation in *Bacillus cereus* (26,27). In addition, olive leaves were shown to have an antibacterial action against *Escherichia coli* and *Candida albicans*, and were particularly effective against Klebsiella and Pseudomonas, two bacterial taxa that represent severe resistance problem (25,28). A recent U.S. patent claims that oleuropein effectively inhibits the replication of herpes mononucleosis virus, hepatitis virus, rotavirus, bovine rhinovirus, canine parvovirus, and feline leukaemia virus (29).

The antimicrobial activity of oleuropein and hydroxytyrosol against American Type Culture Collection and clinical bacterial strains (*Haemophilus influenzae*, *Moraxella catarrhalis*, *Salmonella typhi*, *Vibrio parahaemolyticus*, and *Staphylococcus aureus*) was demonstrated by Bisignano et al. (30). Possible anti-HIV properties of the olive leaf have also been studied. These results demonstrated for the first time that oleuropein and hydroxytyrosol are part of a class of small molecules that can take on multiple roles in fighting the

AIDS virus, blocking the virus's ability to enter and integrate into cells both in and out of the body (31-33).

Preservative Properties of Olive Polyphenols

Recently, the consumers' preference for foods that have had minimum processing and appear to be natural and healthy have prompted an active quest for plant-derived natural preservation agents (33). These should be used instead of conventional preservatives, to increase food safety while also extending its shelf life (34). Due to their low toxicity and costs and thanks to their widespread availability, phenolic extracts of olive leaves and fruits have been the matter of various researches on food preservation. Due to olive oil's high antioxidant content and other health benefits, its production has increased in response to the rising demand from the Mediterranean diet. Therefore, a serious environmental hazard is posed by the massive quantities of waste created during the manufacture of Extra Virgin Olive Oil, specifically olive oil mill wastewaters. Olive oil mill wastewaters is appealing as a powerful source of natural antioxidants due to its high concentrations of sugars, nitrogenous chemicals, volatile acids, polyalcohols, pectins, lipids, and polyphenols. Therefore, research is being conducted to find the best ways to extract polyphenols from olive oil mill wastewaters and put them to good use (35, 36).

Olive trees have evolved a defensive system that involves the production of secondary metabolites, like polyphenols, in response to attacks by microorganisms and other animals. A number of studies has shown that polyphenols can be effective in preventing the growth of bacteria, yeast, and fungi that cause food deterioration (37–39). Plant polyphenols have also been shown to have antibacterial action, which supports their potential application as food preservatives. Today, polyphenols may be recovered from olive mill effluent by industrial valorization (40). For instance, at least five firms throughout the globe extract polyphenols from olive mill effluent and market them as bioactive additives or natural preservatives to be used in food and cosmetics. Several uses have been proposed for polyphenols, due to their potential as a food preservative. Bacteria are less likely to acquire resistance to the polyphenols when they are administered in conjunction with other antimicrobials and antibiotics, because each bioactive polyphenol has a unique action mechanism. Thus, polyphenols have the potential to halt this rising tide of drug-resistant bacteria and to protect consumers from their potentially harmful effects (41).

Polyphenol Safety Evaluation and Future Perspectives

There is a widespread misconception that any amount of naturally occurring chemical, no matter how much of it is consumed, poses no danger to one's health. As a result, currently only a limited amount of information is accessible in the scientific literature about the possible risks associated with the consumption of plant extracts. In addition, the long-term safety of taking significant doses of polyphenols as dietary supplements or food additives is not well understood in humans, and more studies need to be done on the topic before it can be considered established. The beneficial effects of polyphenols have been demonstrated by a number of experiments carried out on animals, despite the fact that the conclusions drawn from several sub-chronic and oral toxicity tests are still up for discussion. Because of the possibility of cytotoxicity posed by polyphenols and other naturally occurring compounds, it is absolutely necessary to determine what quantities are appropriate to use as food preservatives. The oral administration of proanthocyanin-rich grape seed extracts to rats at doses as high as 2 and 4 g/kg was shown to be safe in the study's evaluation of both acute and subchronic toxicity. The rats were administered the extracts via the gastrointestinal tract. On day 14 of the clinical study, during the acute examination, it was discovered that the lethal dosage was over 4 g/kg (42).

Extensive research on humans is required in order to ascertain the optimal dosage for risk-free use and to reduce the likelihood of potentially harmful adverse effects. A better knowledge of evolving safety issues will also be substantially supported by recent breakthroughs in omics techniques and strategies, as well as more methodically prepared animal trials. This is because both of these areas of research have been expanding rapidly in recent years. Deeper research into the structure-activity relationship of natural antimicrobials and their modes of action may help pave the way for their application in a wider range of food systems. Natural antimicrobials have the potential to prevent antibiotic resistance. Last but not least, regulatory organizations have to analyze food applications and guarantee safe long-term levels in order to safeguard consumers.

Conclusion

There is a lot of evidence suggesting that polyphenols, which are natural secondary metabolites, are good for human health; as a direct consequence of this, an increasing number of individuals are including polyphenol supplements into their dietary regimens. In addition, polyphenols have gained a substantial amount of interest as natural antimicrobial preservatives, representing a viable alternative to synthetic pesticides for inactivating crop spoilage and pathogenic bacteria spreding, while also increasing microbiological safety. This is mostly due to the rising desire among consumers for minimally processed and healthier foods. Since olive phenols provide several benefits for stored grains, including color preservation, growth of microbiological organisms reduction, and enhanced storage stability, there is a great amount of potential for their use as preservatives in the cereal grain business. Extensive research is also required to establish the safest dose that may be used in a range of healthy meals without creating unintended side effects.

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Conflicts of interest statement

Authors declare no conflict of interest.

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