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Mini-review

ANTIOXIDANT EFFECTS OF WINE POLYPHENOLS

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ABSTRACT

This review focuses on the antioxidant properties of wine polyphenols. In recent years, developments in food science and technology have shown the positive effects of natural compounds having functional properties on public health. Over the past several decades, many studies have been published on how alcohol consumption may be associated with reduced mortality due to heart disease in some populations. Some researchers have suggested that the benefit may be due to wine, especially the red wine. Others are examining the potential benefits of components in red wine such as flavonoids and phenolic acids in reducing heart disease risk and cancer. Some of these components may be found in other foods such as grapes or red grape juice. In this study the effects of polyphenols on the functional properties of human health will be discussed.

Key words: Antioxidant, resveratrol, anthocyanins, flavonol, ROS, hydroxycinnamates, catechins

INTRODUCTION

Reactive oxygen species (ROS) are generated in living organism due to various metabolic processes Reactive oxygen and nitrogen species produced in the human body can cause oxidative damages. The uncontrolled production of free radicals is involved in the initiation of many diseases such as cancer, rheumatoid arthritis, and atherosclerosis, as well as in degenerative processes associated with aging. (1-2). Many defence mechanisms have developed in living organisms to restrict the levels of ROS. Included among them are endogenous enzymes such as superoxide dismutase, catalase, and glutathione peroxidase. In addition to these endogenous mechanisms, much attention has been focused on the antioxidant role of some dietary compounds. These compounds are polyphenols, a class of molecules found in abundance in vegetables and red wine, vitamin C, Vitamin E etc (3).

It is known that natural polyphenols possess such physical and chemical properties that contribute to a proper and efficient protection from oxidation of important biomolecules such as lipids, proteins, and nucleic acids. Polyphenols are secondary metabolites synthesized by plants. They are synthesized during both normal development and against to stress conditions such as infection, UV radiation and wounding (4-5).

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POLYPHENOLS IN WINE

Red wines contain a range of water-soluble polyphenols that include phenolic acids, the resveratrol, the flavonols, flavanols, procyanidins, and anthocyanins. Red wine has more antioxidant capacity than white wine due to its phenolic content (6-8). **Table 1** shows the levels of the phenolic component in wine.

NON-FLAVONOIDS

This group includes hydroxycinamates, benzoic acids, hydrolyzable tannins, stilbenes.

HYDROXYCINNAMATES

Hydroxycinnamates are the major phenols in grape juice and the major class of phenolics in white wine. There are three important hydroxycinnamates in wine. These are coumaric, caffeic acid and ferulic acid. Nonflavanoids are the primary contributor to the colour in white wine. Compared to the colour in red wine, the chemical nature of the colour in white wine is not very well understood. The majority of the phenols in white wine are nonflavanoid hydroxycinamates. These include caftaric acid, coumaric acid and ferulic acid. They are commonly esterified to organic acids, sugars, alcohols, and most commonly tartaric acid (9).

Table 1. *The levels of phenolics in red and white table wine (Waterhouse, 2002)*

	White Wine		Red Wine	
Phenol Class	*Young*	*Aged*	*Young*	*Aged*
Non-flavonoids				
Hydroxycinnamates	154	130	165	60
Benzoic Acids	10	15	60	60
Hydrolyzable tannins	0	100	0	250
Resveratrol	0.5	0.5	7	7
Total mg/L	164.5	245.5	232	377
Flavonoids				
Flavanol monomers	25	15	200	100
Proantocyanidins	20	25	750	1,000
Flavonols	-	-	100	100
Anthocanins	-	-	400	90
Total mg/L	45	40	1450	1285

The deep yellow colour of white wines that have been aged most likely comes from the oxidation of phenols or galacturonic acid. The oxidation of phenols has been shown to shift its absorption spectrum to the visible range.

Caftaric acid plays an important role in phenol oxidation and oxidative browning in most. The oxidized derivatives of coutaric and caftaric acid provide the yellowish-gold colour in white wine.

Wines that are aged in oak contain elevated levels of hydroxylbenzoic acid derivatives. The most notable of these is ellagic acid, which comprises two molecules of gallic acid. Esters of ellagic acids enhance the colour of red wine by acting as co-pigments with anthocyanins (10-13).

BENZOIC ACIDS

Gallic acid is the major benzoic acid in wine. It appears from the hydrolysis of gallate esters of hydrolyzable tannins and condensed tannin after standing for at least a few months. Gallic acid is one phenolic compound readily visible by chromatographic analysis of older red wines, because it has a stable characteristic during aging. Its level in red wine is about 70mg/L, and about 10mg/L in white wines (14).

HYDROLYZABLE TANNINS

In wine hydrolyzable tannins come from oak. The levels of these are about 100mg/L for white wines aged for about 6 months in barrel, while red wines will have levels in the range of 250mg/L after aging two or more years (15). These phenols are composed of gallic acid and ellagic acid esters with glucose or other sugars. Due to the ester linkage, they are described to as “hydrolyzable.”

STILBENES

The principal stilbene in grapes, resveratrol, is produced by vines in response to *Botrytis* infection and other fungal attacks.

RESVERATROL

Resveratrol (3,4,5-trihydroxystilbene) is a common phytoalexin found in foods, such as grape skins and seeds, peanuts, mulberries, and red wine as a response to environmental stress or fungal infection (16-17). It constitutes one of the polyphenolic compounds of wine and is responsible for the beneficial effect of regular wine consumption (18). Resveratrol has possitive effects in biological systems. These effects can be summarized as a cancer chemoprevention agent, cardiovascular protection, neuroprotection, anticarcinogenesis, and anti-inflammatory effects. Resveratrol has been defined to contribute to the “French paradox” (i.e., low incidence of cardiovascular disorders in spite of diet high in saturated fat in humans in France) (19).

FLAVONOIDS

Flavonoids are the major phenolic group in red wine, and have a profound impact on wine taste. The major flavonoids in wine are flavanols, anthocyanins and cataechin. Flavonols occur in a wide range of vegetable. This class of compounds is always found in a glycoside form in plants including grape berries where it is found in grape skin. They can exist in multiple forms by themselves or polymerized with sugars, other flavonoids and or nonflavonoids (20).

CATECHINS

Catechins are produced in the stems and seeds, and are the major flavour components in red wines. There are three major types of catechins, and they polymerize with themselves, other flavonoids and nonflavonoids to form tannins. Tannins play a large role in almost every aspect of a wine.

Flavanols like quercetin absorb UV light and protect grape skins from the damaging effects of the sun. Quercetin also plays a role in human health (21).

ANTHOCYANINS

Anthocyanins are guard systems of plants and protect them from UV damage. They form complex molecules with other phenolic molecules and strongly contribute to the colour and the aging of wine. Anthocyanins contribute little to the taste of wine. However, because anthocyanins readily polymerize with tannins, they play an important role in tannin retention and in aging.

Anthocyanins are classified by the position of hydroxyl and methyl groups on the second phenyl ring. There are five basic anthocyanidins in wine: cyanidin, peonidin, delphindin, petunidin and malvidin. Colour and colour stability are mainly affected by the number of hydroxyl and methyl groups. The number of free hydroxyl groups is directly related to blueness and the number of methyl groups is directly related to redness. Anthocyanins provide the colour in red wine and the red and blue colours found in the skins of red or black grapes, but also in many other plants including other foods in the diet (22).

Anthocyanins develop in the leaves of photosynthetic plants as protection from several damage such as the photo-damage of UV and blue-green light. These pigment molecules are effectively sunscreen for plants. In addition to their primary function, they also play an anti-oxidant role, protecting plants from free radical oxidation. This is an important issue because anthocyanins are found in high concentrations in the skins of black grapes and contribute to the colour of red wine. If you kept the skins of red grapes separate from the pulp, you could make white wine red grapes (23).

THE BENEFICAL EFFECTS OF WINE ON HUMAN HEALTH

Epidemiological studies have shown that regular consumption of wine has reduced the incidences of diseases such as coronary heart disease, cancer, tumour progression, etc. The potential health benefits of red wines arose from the proposed “French Paradox” (24). In Southern France people regularly consume red wine and they eat fresh fruits. Some beneficial effects of red wines may arise from the antioxidant flavanoids, which inhibit the oxidation of human LDL in vitro and may protect against the development of atheroma. Recently, interest has focused on the potential antiatherogenic effect of resveratrol. Resveratrol reduces LDL oxidation in vitro and it is present in some red wines. The protective effects of wine on the cardiovascular system have been widely documented (25).

When LDL oxidizes, it plays a significant role in atherogenesis (26). Peroxidation of polyunsaturated (PUFA) fatty acids is one of the earliest stages of this process. This uncontrolled process induces the formation of lipid-laden foam cells, which cause the development of atherosclerotic lesions (27).

Oxidized LDL is more atherogenic than un-oxidized LDL, because it contributes to cellular accumulation of cholesterol and oxidized lipids, and to foam cell formation (28).

Aviram and Fuhrman (2002) found that red wine possesses free radical–scavenging capacity, and that quercetin is more potent in this respect than catechin. These results have shown that red wine and quercetin have decreased LDL oxidation.

Figure 1 demonstrates the researchers’ current view on the mechanisms involved in protection against foam cell formation and atherosclerosis by wine flavonoids. After wine ingestion, flavonoids bind to LDL particles. Flavonoids bound to LDL particles protect them against lipid peroxidation. The activity of the enzyme paraoxonase is preserved, resulting in a further protection of lipoproteins (LDL and HDL) from oxidative changes. Wine flavonoids protect cells in the arterial wall, including macrophages, from lipid peroxidation, thus reducing macrophage atherogenicity Wine flavonoids reduce macrophage foam cell formation and atherogenesis (28).

Fremont et al. concluded that the efficiency of resveratrol for protecting polyunsaturated fatty acids (PUFA) was higher than that of flavonoids in copper-induced oxidation and lower in AAPH (radical initiator) induced oxidation. They confirmed that resveratrol was more effective than flavonoids as a chelator of copper and less effective as a free-radical scavenger. They also showed that wine extract contains monomeric and oligomeric forms of flavonoids and phenolic acid has antioxidant effects (27).

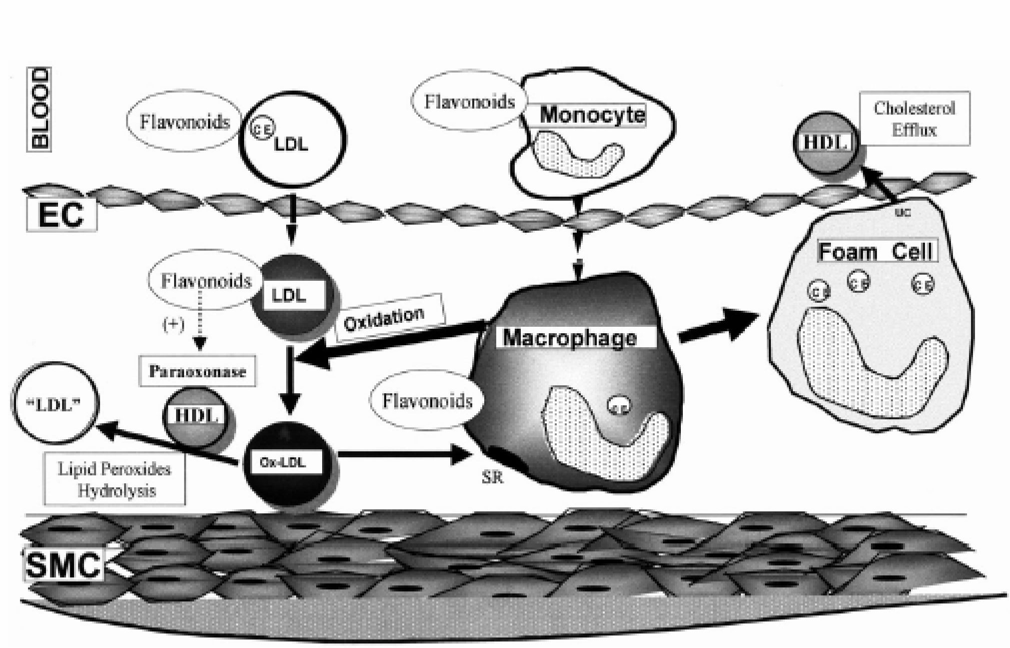

Figure 1. *Effect of wine flavonoids on LDL oxidation and foam cell formation.(Aviram and Fuhrman 2002)*

Vascular endothelial growth factor (VEGF) has contributed to intimal neovascularization in atherosclerosis. Indeed, VEGF is strongly expressed in human atherosclerotic plaques (29-31). M.-H. Oak et al. have reported that red wine polyphenolic compounds (RWPCs) strongly inhibit growth factor induced VEGF expression in vascular smooth muscle cells (VSMCs) (32).

Prostate cancer is one of the common neoplasm diagnosed in Europe. Epidemiological studies show considerable geographical variation in the age-adjusted incidence of prostate cancer. Environmental factors and especially diet are very significant in the development of prostate cancer. The nutritionist suggests Mediterranean diet, which contains low animal-fat and meat content, with a high intake of fresh fruit, vegetables, pasta and wine because it has protective effects against the endocrine cancers. Nutritional agents such as vitamin E, selenium, vitamin D, green tea and wine polyphenols have been found to inhibit proliferation or to induce apoptosis in some prostate cancer cell lines. Romero et al conclude that red wine polyphenols have important antiproliferative activity. These materials have inhibited the spread of prostate cancer (33).

Recent studies have shown that resveratrol has inhibitory effect on ribonucleotide redutase. Resveratrol is much more effective than hydroxyurea (HU) which has been used clinically against tumours. The first therapeutic agent used in the treatment of sickle cell anaemia is HU. Rodrigue et al demonstrated that resveratrol is a better erythroid inducer than HU in the bipotential K562 cell line. However, the haemoglobin synthesis was higher in resvetatrol-treated cells than in HU-treated cells (17).

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