

## Antimicrobial properties of Pomegranate (*Punica granatum L.*) as a Tannin rich Fruit: a review

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**Background:** Recently, agriculture by pass products has been evaluated as sources of antimicrobial agents with efficacies against a variety of microorganisms. Tannins are the secondary metabolites and can found in various species of shrubs, trees and fruits. Previous researchers have been proved which tannins have different effects e.g. nutritional, anthelmintic, immunity response, antibacterial, antimicrobial and antioxidant on human and animals. Many herb and spice extracts contained high levels of phenolics and exhibited antibacterial activity against bacteria. Gram-positive bacteria were generally more sensitive to the tested extracts than Gram-negative ones. Pomegranate (*Punica granatum L.*) is native to the region from northern India to Iran but it is also widely cultivated now in parts of Southwest America, Mexico and Africa. Pharmacological effects of pomegranate represent a long history and have been mentioned in the Greek and Egyptian documents.

**Objective:** The aim of review was to investigate the potential effects of antibacterial activities of pomegranate peel extract (rind), seed extract, juice and whole fruit on bacteria and fungi.

**Conclusion:** Food poisoning is still a concern for both consumers and the food industry despite the use of various preservation methods. Food processors, food safety researchers and regulatory agencies are continuously concerned with the high and growing number of illness outbreaks caused by some pathogenic and spoilage microorganisms in foods. The increasing antibiotic resistance of some pathogens that are associated with foodborne illness is another concern. This review suggested consumption or using tannin-containing fruits especially Pomegranate, could cure or prevent various illnesses by mentioned effects of side effects.

**Keywords:** Pomegranate, Tannin, phenolic component, Antibacterial activity

### INTRODUCTION

#### Why Herbal Antimicrobials?

The widespread use of commercially available antimicrobials led to the consequence of emergence of antimicrobial resistant pathogens that ultimately led to the threat to global public health. Since 1980 the introduction of new antimicrobials has declined due to the huge expense of developing and testing new drugs. All commercially available antibiotics with prolonged use may have negative effect on human and animal health because they kill gut flora, so they need to take probiotics to replace the killed gut flora. All the above points make a clear way for herbal antimicrobials. The use of plants for treating diseases is as old as the human civilization. There are many plants which have been in use as traditional medicine, so they are called as medicinal plants. The use of plants for curing diseases was inevitable as is already proven by seeing the problems associated with synthetic antibiotics. Peels of some plants as *Punica granatum* (having antibacterial properties) which are generally treated as wastes are true antibiotics as they are available for no cost, have no side effects and the most important benefit is that antibiotic resistant pathogens will be easily killed by these new and natural antimicrobials because they will take at least a few decades to get mutated and resistant to them.

#### Pomegranate

Pomegranate (*Punica granatum L.*) is native to the Mediterranean region and has been extensively used in the folk medicine of many countries. Pomegranate is a native fruit of Iran, one of its biggest producers and exporters, producing over 0.67MT annually. Pomegranate juice has potential anti-atherogenic effects in healthy humans and atherosclerotic effects in mice along with other nutritional and health advantages (Aviram et al., 2004; Negi et al., 2005; Turk et al., 2008). As a result, pomegranate juice has become popular worldwide. Numerous studies on antioxidant activity have shown that pomegranate juice contains higher levels of antioxidants than most fruit juices (Gil et al., 2000; Hong et al., 2008). Epidemiological studies have suggested

that the consumption of red fruit juices, such as pomegranate, berry and grape, correlates with reduced risk of coronary heart disease, stroke, certain types of cancers and aging (Hertog et al., 1997; Sumner et al., 2005). It has been reported that pomegranate juice is an important source of anthocyanins (cyanidin, delphinidin, pelargonidin), which gives the fruit and aril its red color, and phenolics and tannins (punicalin, pedunculagin, punicalagin, ellagic acid) (Kulkarni and Aradhya 2005). Pomegranate fruit contains many different kinds of polyphenolic antioxidants and commercial pomegranate juice has been shown to possess antioxidant activity three times higher than those of red wine and green tea (Gil et al., 2000).

Fruits, peels and roots of pomegranate have been commonly used in herbal remedies by local healers in many countries. Pomegranate peels have been used in traditional medicine for treating diarrhea and dysentery (Ahmad and Beg, 2001; Braga et al., 2005; Voravuthikunchai et al., 2005; Reddy et al., 2007).

### Chemistry of Phenolic components (Tannins)

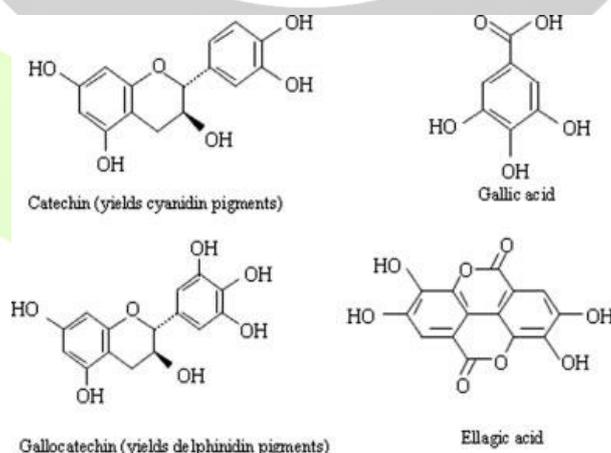
Polyphenols components are found in all fruits and vegetables and play a major role in their color, flavor, texture as well as antioxidant (Hernandez et al., 1999) and antibacterial activities (Negi and Jayaprakasha, 2003). Phenolic compounds can denature enzymes (Furneri et al., 2002) but they can also bind to substrates such as minerals, vitamins and carbohydrates making them unavailable for microorganisms (Stern et al., 1996; Shahidi and Naczki, 2004). Furthermore, phenols can be absorbed to the cell wall, resulting in a disruption of the membrane structure and function (Hugo and Bloomfield, 1971). Tannins are high molecular weight phenolic compounds which are present in many plants, including pomegranate (*Punica granatum L.*) fruit pericarp (peels). Tannins are water-soluble polyphenolic polymers of relatively high molecular weight and have capacity to form complexes mainly with proteins, to a lesser extent with carbohydrates due to the presence of a large number of phenolic hydroxyl groups. Tannins are usually divided into two major groups: Hydrolysable tannins (HTs) and Condensed tannins (CTs) (Hassanpour et al., 2011a, 2011b).

### Kinds of Tannin

Hydrolysable are gallic or ellagic acid esters of sugars. When they are consumed by human and ruminants, they can be degraded into gallic acid and be absorbed in the digestive tract (Bruneton, 1999). Because they are readily absorbed, they have been considered responsible for causing toxic effects in herbivores.

Condensed tannins are polyphenols of higher molecular weight and consist mainly of oligomers or polymers of catechin (flavan-3-ols). When CTs get depolymerized, they produce mainly cyanidin or delphinidin, and therefore have been further classified as procyanidins or prodelphinidins. Only a low degree of absorption of CTs by the digestive tract of herbivores has been reported. One of their most important chemical properties is the ability to form soluble and insoluble complexes with macromolecules, such as protein, fiber and starch. The affinity of CT for proteins is determined by the molecular mass and the molecular configuration of both the tannin and the protein (Bruneton, 1999).

Tannin–protein binding is usually reversible: acid or alkaline pH, treatment with detergents (surfactants) or phenol or other organic solvents can result in the disassociation of the complexes. Condensed tannins have a particular affinity for proline-rich proteins such as gelatin, prolamine and proteins from seed coats (Waterman, 1999). Proline-rich proteins are also produced in the saliva of certain mammals (such as rat, mouse, goat and deer).



Adapted from Patra and Saxena, 2011.

## Phytochemicals of Pomegranate

Plant Component	Constituents
Pomegranate Juice	anthocyanins, glucose, ascorbic acid, ellagic acid, gallic acid; caffeic acid; catechin, EGCG, quercetin, rutin; numerous minerals, particularly iron; aminoacids.
Pomegranate seed oil	95-percent punicalic acid; other constituents, including ellagic acid; other fatty acids; sterols.
Pomegranate pericarp (Peel, rind)	Phenolic punicalagins; gallic acid and other fatty acids; catechin, EGCG; quercetin, rutin and other flavonols; flavones, flavonones; anthocyanidins.
Pomegranate leaves	Tannins (punicalin and punicalofolin); and flavones glycosides, including luteolin and apigenin
Pomegranate flower	Gallic acid, ursolic acid; triterpenoids, including maslinic and Asiatic acid; other unidentified constituents
Pomegranate roots and bark	Ellagitannins, including punicalin and punicalagin; numerous piperidine alkaloids.

Epigallocatechin gallate (EGCG). Adapt from Dahham et al, 2010.

### Pomegranate and Functional properties

The primary phytochemicals in pomegranates are the polyphenols, including anthocyanin (ACN) pigments, flavonol glycosides, procyanidins, phenolic acids and ellagic acid derivatives (Negi and Jayaprakasha, 2003). Due to their antioxidant properties, phenolic compounds including ACNs are thought to have preventive roles in a number of chronic diseases such as cardiovascular disease and cancers (Heinonen et al., 1998). The primary antioxidative phenolics in pomegranate are punicalagins, followed by HTs, ACNs and ellagic acids (Gil et al., 2000). An attractive red color is the most important quality criteria for fruit juices containing anthocyanin, including pomegranate. ACNs are also responsible for the orange, red and blue colors of many fruits and vegetables. Unfortunately, ACNs are unstable and susceptible to degradation, leading to a brownish color during processing and storage. The primary color deterioration in fruit juices containing ACNs occurs as a result of the degradation of monomeric ACNs, polymerisation of ACNs and the subsequent formation of brown color (Somers and Evans, 1986). These color changes strongly affect consumer behavior and result in a loss of marketability of processed pomegranate products. Various factors affect the stability of ACNs, including the temperature of processing and storage, the chemical nature of ACNs (acylation or glucosylation), pH, ascorbic acid, hydrogen peroxide, sugars, light and metals. Clarification and pasteurisation during the production of fruit juices also affect the stability of ACNs.

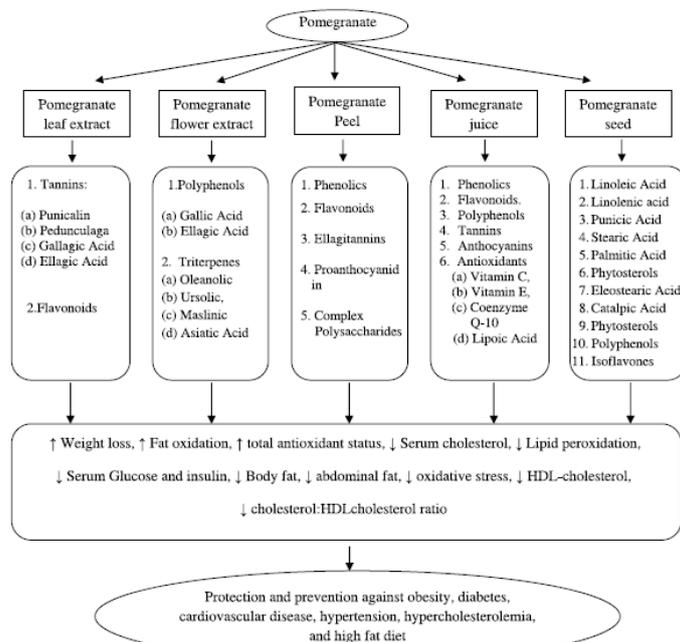
### Antimicrobial Properties

The use of chemical or synthetic agents with antimicrobial activity (as inhibitors, growth reducers, or even inactivators) is one of the oldest techniques for controlling microorganism growth. The application of preservatives to foods is fundamental if their safety is to be maintained (Viuda-Martos et al., 2008). Natural antimicrobials, whether of microbial, animal, or plant origin, which show bacteriostatic/fungistatic or bactericidal/fungicidal activity lengthen the useful life of foods and prevent, among other things, health-related problems, off-odors, unpleasant tastes, textural problems, or changes in color, which are basically caused by the enzymatic or metabolic systems of the principal microorganisms that lead to the alteration of foods (Feng and Zheng 2007).

Ahmad and Beg (2001) were reported that alcohol extracts of pomegranate fruits showed antibacterial activity when tested against *S. aureus*, *E. coli* and *Shigella dysenteriae*. Melendez and have also reported that extracts from pomegranate fruits possess in vitro antibacterial activity against many bacteria tested (*E. coli*, *Enterobacter cloacae*, *P. fluorescens*, *Proteus vulgaris*, *Alcaligenes faecalis*, *Serratia marcescens*, *E. aerogenes*, *S. aureus*, *Arthrobacter globiformis*, *M. luteus*, *B. cereus*, *B. subtilis*, *B. coagulans*, *Micrococcus roseus*, *M. phlei*, *M. rodochrus*, *M. Punicalagin* isolated from the fruit peel of pomegranate was reported to have antimicrobial activity against *Candida albicans* (Burapadaja and Bunchoo, 1995). Fungistatic activity of pomegranate peel varied with test organisms as it inhibited the growth of *Penicillium citrinum* for 8 days, *P. patulum* for 4 days and *P. roquefortii* and *Aspergillus ochraceus* for 3 days (Azzouz and Bullerman, 1982). Generally, antimicrobials have different concentration inhibition or inactivation thresholds. These thresholds depend on the specific targets of the antimicrobial substance, including cell wall, cell membrane, metabolic enzymes, protein synthesis, and genetic systems (Raybaudi-Massilia et al., 2009). The exact mechanism or target for food antimicrobials are often not known or well defined. It is difficult to identify a specific action site where many interacting reactions take place simultaneously. For example, membrane-disrupting compounds could cause leakage of cellular content, interference with active transport of metabolic enzymes, or dissipation of cellular energy in ATP form (Davidson, 2001).

### Other benefits of Pomegranate

Briefly, as illustrated in diagram we can mention to the other effects e.g. weight loss, Fat oxidation, reduction in serum LDL and cholesterol levels and lipid peroxidation and oxidative stress.



Adapt from Al-Muammar and Khan, 2012.

## Conclusion

Also it has been proved which these components have positive effects on ruminant animals e.g. improving by pass protein, N retention, decreasing N excretion, decrease methane production and totally improve animal production for human consumption. Additionally, levels of disease should be decrease by using tannin rich fruits. Also, by using this phenolic component as additionally substance for ruminant's diet we can reduce methane and controlling global worming. Although, it could be a good idea, in developing countries such as Iran to look a way to improving first circle of this chain by using this components as herbivorous feed stuffs, it seems easiest and more chipper way to improving society health. We believe it needs to more research to find a best way to use this reasonable but valuable and beneficial stuff.

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