



Review

Total phenolic contents, antioxidant activities, and bioactive ingredients of juices from pomegranate cultivars worldwide



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ABSTRACT

Numerous recent scientific publications investigating the health benefits of pomegranate juice have greatly increased consumer interest in this fruit. The primary cause of the positive health effect of pomegranate is the unique antioxidant activity of this fruit. As a result of the increased attention given to pomegranate, the number of countries producing pomegranate has increased and new cultivars are appearing. The purpose of this review is to quantitatively establish the antioxidant activities, the total phenolic contents which are highly correlated to antioxidant activities, and the other important ingredients of pomegranate juices obtained from cultivars of different regions. Pomegranate wine, vinegar, and sour sauce obtained directly from pomegranate juice are included in this review. Comparison of aril juices with peel and seed extracts is also given. This data could be useful to the pomegranate industry in identifying and developing cultivars having commercial value.

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1. Introduction

Fruits are rich sources of bioactive compounds. Antioxidative potentials of bioactive compounds are attributed with diverse medicinal properties and health benefit effects. Today, pomegranate (*Punica granatum* L.) is accepted as a unique fruit having considerably high antioxidant activity. The high antioxidant activity of pomegranate attracted attention by the work of Gil, Tomás-Barberán, Hess-Pierce, Holcroft, and Kader (2000), who reported the high antioxidant activity of pomegranate juice

obtained from one cultivar by different extraction methods. Anthocyanins, ellagic acid derivatives, and hydrolyzable tannins were detected in juices as responsible for this activity. The activity was higher in commercial juices extracted from whole pomegranates than from the arils only. This difference in activity was attributed to the pomegranate rind tannins in commercial juices. Commercial pomegranate juices showed an antioxidant activity three times higher than that of red wine and green tea in this study. Similarly, Tzulker et al. (2007) studied the relationships between antioxidant activity, total phenolic contents, total anthocyanin contents, and the levels of hydrolyzable tannins in the pomegranate juices obtained from 29 different accessions. The results showed that the high antioxidant activity in the aril

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juices correlated significantly to the total polyphenol and anthocyanin contents. Unlike the arils, the antioxidant level in the juices prepared from the whole fruit correlated significantly to the content of the four hydrolyzable tannins in which punicalagin is predominant. In the following years, all studies comparing the antioxidant activities of fruits consumed in different countries supported these pioneering publications. Antioxidant activity and total phenolic contents of twelve polyphenol-rich beverages in the U.S. market were compared to pomegranate juice (PJ), showing that PJ had the highest antioxidant activity (Seeram et al., 2008). Antioxidant activities and total phenolic contents of 62 fruits from the Chinese market were evaluated. The results indicated that different fruits have diverse antioxidant activities and the variation is very large. Pomegranate is one of the fruits having the highest antioxidant activity in the top seven fruits (Fu et al., 2011). Similarly, the greatest preventative antioxidant activity was found in pomegranate amongst 62 kinds of commonly consumed beverages in the Korean market (Kim et al., 2014). The high antioxidant characteristic of pomegranate made it the subject of many medicinal studies (Rahimi, Arastoo, & Ostad, 2012). Both *in vivo* and *in vitro* studies established its antibacterial, anti-inflammatory, antiviral, and anticarcinogenic activities. The beneficial effects of PJ on cardiovascular health and obesity were demonstrated. Lately these studies are reviewed in scientific publications, such as the effect of pomegranate on cancer prevention and therapy (Turrini, Ferruzzi, & Fimognari, 2015), on prostate cancer (Wang & Martins-Green, 2014), on chronic inflammatory diseases (Viladomiu, Hontecillas, Lu, & Bassaganya-Riera, 2013), on cardiovascular diseases (Vlachojannis, Erne, Schoenenberger, & Chrubasik-Hausmann, 2015), on spoilage and pathogenic microorganisms (Tanveer et al., 2015), and on obesity (Al-Muammar & Khan, 2012). The properties of PJ depend on cultivars, growing locations and climates, and maturity stages (Mphahlele, Fawole, Stander, & Opara, 2014). At the present time, considerable importance is given to the functional foods in terms of the total phenolic contents and antioxidant activities. This is particularly important for showing the medicinal and nutritional multifunctionality of the food product (Can et al., 2015; Kaygusuz et al., 2016; Malkoç, Laghari, Kolaylı, & Can, 2016). The scientific studies on the antioxidant activities, bioactive constituents, and pharmacological properties on pomegranate have increased considerably in the last decade. Fig. 1 shows the number of studies on pomegranate in WOS papers between January 2006 and December 2015.

Pomegranate is an ancient fruit originating from the Middle East. Today, the world's main producers and exporters are India, Iran, China, Turkey, United States, Spain, South Africa, Peru, Chile, and Argentina. The global pomegranate production is around 2 million tons. The European Union (EU) is prime importer of fresh

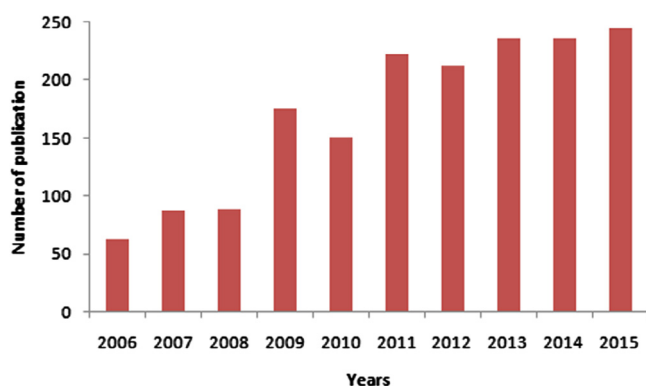


Fig. 1. Number of WOS papers on pomegranate between January 2006 and December 2015.

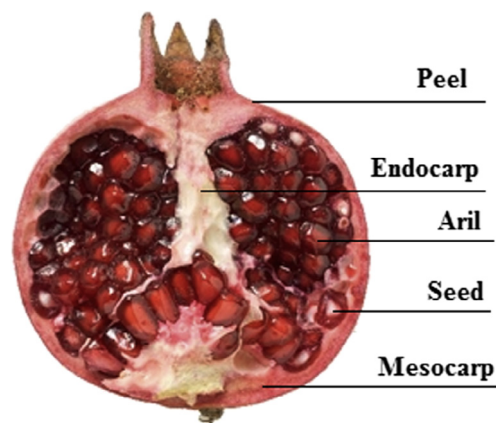


Fig. 2. Anatomical parts of the pomegranate fruit.

pomegranates. In 2013, an additional 67 thousand tons were shipped to the European market in addition to the capacity produced locally (World Pomegranate Market Supply & Forecast, 2015).

Many new cultivars have been developed worldwide. An important portion of the studies on pomegranate is on the determination of the nutrition value of cultivars from different regions. In each of these works, the total phenolic contents and the quantitative values of the antioxidant activities, obtained with different methods, of studied cultivars are necessarily reported. In addition to these two important factors, the quantitative amounts of all or some of the ingredients that affect the nutritional value and taste of pomegranate have been reported in different publications. These are the amounts of total or some individual sugars, individual organic acids, total or individual anthocyanins, total flavonoids, total tannins, ellagitannins and their derivatives, individual hydrolysable tannin, especially punicalagin, and vitamin C. Total phenolic contents, antioxidant activities, and bioactive components of different pomegranate cultivars have not been explored simultaneously. The aim of this review article is to assemble the total phenolic contents, antioxidant activities, and quantitative amounts of the important ingredients of pomegranate cultivars from different regions. This data could be useful to the pomegranate industry in identifying and developing cultivars having commercial value. Although our study may not be an exhaustive review, the data covers 14 countries and different regions of these countries. In recent years, pomegranate parts accepted as the agricultural waste product other than aril have been increasingly used, due to their antioxidant activity, as additives in the cosmetic and food industries. Studies are being published on the antioxidant activities of these products (Akhtar, Ismail, Fraternal, & Sestili, 2015). In this review, for comparison purposes, we have only included studies that report together the antioxidant activities of the aril part, mesocarp, endocarp, peel, and seed extracts of the same cultivar. These anatomical parts of pomegranate is given in Fig. 2. Furthermore, we included studies of the pomegranate based products like pomegranate wine, vinegar, and sour sauce, in order to compare the nutrition values with pomegranate juices.

2. Pomegranate aril juices

Table 1 contains data on the total phenolic contents and antioxidant activities of pomegranate aril juices taken from scientific papers published between 2006 and 2015. In order to find total phenolic contents, all researchers use Folin-Ciocalteu reagent assay (Singleton, Orthofer, & Lamuela-Raventós, 1999) and except a few report, total phenolic contents are reported as gallic acid

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