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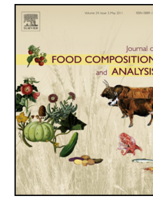

Study Review

Phytochemicals of papaya and its traditional health and culinary uses – A review

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ABSTRACT

This paper reviews the current research on phytochemical composition and non-Western traditional culinary food preparation and health uses of papaya. Only ripe papaya fruit flesh is normally eaten in Western countries. The orange or red flesh is an excellent source of pro-vitamin A and ascorbic acid. In South-East Asia, both ripe and green fruit are used and additionally leaves are popularly consumed either raw in salad or cooked as a green vegetable. The leaves contain alkaloids as well as quercetin and kaempferol as the main phenolic compounds. In contrast to Western use papaya has a reputation as a medicinal plant in tropical countries where it is grown. Different plant parts such as fruit, leaf, seed, root, bark and flowers have been used as health treatments. These have included use as topical dressings for treating ulcers and dermatitis, gastrointestinal uses such as antihelminthic and antibacterial activity treatments and traditional uses for fertility control. The differences in use for food and health illustrate potential applications and nutritional benefits of the plant which require further research. With better verification the health applications of papaya could be more widely adopted into Western culture.

1. Introduction

Carica papaya Linn., generally known as papaya or paw paw originated from the lowlands of eastern central America (Nakasone and Paull, 1998). It has been widely cultivated in tropical countries for its edible fruit for hundreds of years and has also been used in traditional ethnic health applications (O'Hare and Williams, 2014). Papaya was ranked in the top 5 nutritionally beneficial fruits (with guava, watermelon, grapefruit and kiwifruit) among 38 common fruits based on nutritional scores and the percentage Recommended Daily Allowance (RDA) for pro-vitamin A, ascorbic acid (AA), potassium, folate and fibre (CSPI, 1998).

Papaya and papaya products have a significant health profile particularly among consumers in Asia (Anuar et al., 2008; Lim, 2012; Otsuki et al., 2010). Asia has been the leading papaya producing region, accounting for 51% of the global production in 2011, followed by South America (20%), Africa (11%), the Caribbean (9%) and Central America (9%) (FAOSTAT, 2013b). Ripe fruit, as eaten by preference in most Western cultures, can be fragile with a short shelf life but have a higher content of AA and carotenoids than unripe fruit (Hernández et al., 2006; Wall, 2006). Unripe or green fruit and leaves are widely used in salads and in cooking in Asian countries, but this is not common practice in Western societies like the European Union, the USA, and Australia.

Recent scientific interest has focused on the health potential of phytochemicals from plant foods. Plants contain a large variety of secondary metabolites commonly labelled as phytochemicals. Most natural phytochemicals that occur in plant foods are presumed to be safe due to a history of consumption. Despite varied uses of the papaya plant, there is generally little information on the variation of phytochemicals (including vitamins and pro-vitamins) or specific bioactivities by cultivar, location, plant part, maturity or forms of papaya. Many literature reports have established that different cultivars of numerous different species planted in different locations, different sunlight exposure, agricultural practices, stage of ripeness and postharvest handling

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can have significant effects on the phytochemical composition of the fruits (De Rosso and Mercadante, 2005; Gayosso-García Sancho et al., 2011; Ornelas-Paz et al., 2008). This review therefore focuses on the use of papaya plants in different cultures, the variations in phytochemical content and composition due to cultivar, maturity, plant parts, cooking and other preparation methods as well as the nutritional and health potential of the whole papaya plant. Phenolic compounds (flavonoids and phenolic acids), carotenoids and ascorbic acid are the focus in the present review. However, glucosinolates and cyanogenic glucosides such as benzyl isothiocyanate (BITC), alkaloids (carpain and pseudocarpain), enzymes (papain, chymopapain, leukopapain and cystatin), saponins, triterpenoids, vitamin E, thiamine, riboflavin, niacin and nicotinic acid are also mentioned in the context of compositional aspects and cultural use of papaya as food and medicinal food.

2. Phytochemical composition and antioxidant capacity of papaya

2.1. Fruit

As mentioned previously, cultivar variation, growing location, sunlight exposure, agricultural practices, stage of ripeness and postharvest handling can all have significant effects on the chemical composition of papaya fruit (Gayosso-García Sancho et al., 2011; Wall, 2006). The progression of fruit through different maturity stages results in physiological and biochemical changes that modify fruit composition and encourages its consumption as a fresh fruit (Pereira et al., 2009). The loss of fruit firmness is a consequence of changes in plant cell wall constituents that lead to weak cell-to-cell links and thus loss of rigidity and firmness, with softening indicating ripeness (Pereira et al., 2009). For commercial production papaya fruit maturity is based on the skin colour of the fruit (Table 1).

The proximate composition of papaya (Table 2) does not show much variation from other similar eating fruits but papaya fruit is an excellent source of pro-vitamin A and AA. Papaya is ranked as one of the top fruit sources of AA (Gebhardt and Thomas, 2002) with an average AA range of between 45 and 60 mg/100 g fresh weight (FW), and reported values up to 154 mg/100 g FW (Table 3). Variation in AA and pro-vitamin A content can be due to differences in cultivar, growing location and ripeness of the fruit (Table 3). The ripening process begins when the chlorophyll is degraded, which coincides with carotenoid synthesis and results in significant colour change from green to yellow-orange colour. Moreover, during ripening, the content of esterified carotenoids increases, which allows carotenoids to integrate more quickly into the membranes. This in turn increases the colour intensity of the fruit and its accumulation in chromoplasts (Andersson et al., 2008; Yahia and Ornelas-Paz, 2010). The colour of the fruit is conferred by the carotenoid level and types, with colour intensity playing a vital role in fruit acceptability by consumers (Yahia and Ornelas-Paz, 2010). Red-fleshed cultivars often outweigh the yellow-fleshed fruit in consumer preference with red-fleshed cultivars generally having excellent flavour but very poor outer shape and appearance, whereas yellow-fleshed cultivars have very good appearance and flavour (Drew, 2005). Carotenoids like β-cryptoxanthin and β-carotene are found in all types of papaya cultivars leading to yellow and orange hues in the flesh. However lycopene, which confers red colours, is either not present or in very small amounts in yellow-fleshed fruit (Gayosso-García Sancho et al., 2011; Marelli de Souza et al., 2008; Schweiggert et al., 2011; Wall, 2006). According to Schweiggert et al. (2011), total lycopene content of red fleshed papaya was significantly higher than that of yellow fleshed fruit. Papaya is considered a good source of lycopene, with average values ranging from 0.36 to 3.4 mg/100 g FW, being ranked number 4 of overall foods in the USDA nutrient reference database, after red guava, water melon and tomatoes (Charoensiri et al., 2009; Gayosso-García Sancho et al., 2011; Schweiggert et al., 2011, 2012; USDA, 2014).

The vitamin E content of papaya has been reported as undetectable or in low concentrations (0.3 mg/100 g FW) (Charoensiri et al., 2009; Hagiwara, 2001; Tee et al., 1997; USDA, 2014).

Table 4 presents the identified polyphenols in the pulp, leaf and peel of papaya plant. The phenolic compounds of papaya vary greatly with the type of tissue, location and cultivar. However, the examination of the polyphenol composition of different types of papaya cultivars has been limited to a small number of studies. Gayosso-García Sancho et al. (2011) listed and quantified some of the major polyphenols found in papaya pulp of 'Maradol' cultivars. They were ferulic acid (187–277 mg/100 g dry weight (DW)), p-coumaric acid (136–230 mg/100 g DW), and caffeic acid (113–176 mg/100 g DW). Other researchers reported only low amounts or traces of phenolic compounds in papaya pulp or only identified compounds such as m-coumaric acid, p-coumaric acid, quercetin, apigenin, kaempherol, myricetin and luteolin without quantifying them (Franke et al., 2004; Jindal and Singh, 1975; Lako et al., 2007) (Table 4).

Total phenolic content in papaya pulp, determined using the standard Folin Ciocalteu method, was found to be generally quite low, ranging from 0.02 to 2.08 mg GAE/100 g FW (Faller and Fialho, 2010; Isabelle et al., 2010). Nevertheless, in comparison with mango cultivars, ranging from 71 to 113 mg GAE/100 g FW, the highest reported value for papaya is 75.7 mg GAE/100 g FW (Annegowda et al., 2013; Lako et al., 2007; Patthamakanokporn et al., 2008; Silva et al., 2014) (Table 4). Agricultural practices such as the use of synthetic fertilizers that offer more bioavailable sources of nitrogen can accelerate the production of polyphenols (Lima et al., 2014). Polyphenol content could also be affected by higher exposure of the plant to a stressful environment such as attack by insects or fungi which can induce the production of natural defence substances such as phenolic compounds (Winter and Davis, 2006; Woese et al., 1997). Faller and Fialho (2010) compared the polyphenol content of organic and conventional plant food and found that among fruits studied, papaya seems to be more affected by alteration in agricultural management with approximately 70% higher hydrolysable polyphenols in organic fruit compared to the conventional counterpart. This could be one of the reasons for the variation in polyphenol values between papaya cultivars. Nonetheless, polyphenol composition in plant food can also be altered by ripening, storage, location, handling, and processing conditions (Rinaldo et al., 2010).

Papaya is one of the few examples known of a plant containing both glucosinolates and cyanogenic glucosides (Williams et al., 2013). It is rich in benzyl isothiocyanate (BITC) which may provide potential for use in chemoprevention of cancer. It has been suggested that the anti-carcinogenic effects of isothiocyanates are related to their capacity to induce phase II enzymes such as glutathione *S*-transferase, nicotinamide adenine dinucleotide phosphate and quinine reductase (Cavell et al., 2011; Nakamura et al., 2000). The glucosinolates are known to be degraded into isothiocyanates by enzymatic action of plant-specific myrosinase or intestinal microbiota in the human body (Basu and Haldar, 2008). Glucosinolate (glucotropaeolin) levels of 1430 mg/100 g FW in latex, 610 mg/100 g FW in newly expanded leaves, 285 mg/100 g FW in seeds and less than 40 mg/100 g FW in the edible flesh fraction (mature and immature) and the ripe placenta were reported in the literature (reviewed by Williams et al., 2013).