Research in Pharmacy 3(5): 01-09, 2013 ISSN: 2231-539X
www.researchinpharmacy.com

Regular Article

Some compositional and biochemical attributes of jaman fruit (*Syzygium cumini* L.) from Potowar region of Pakistan

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Jaman (*syzygium cumini* L.) is among the neglected fruits of tropical and sub-tropical regions having certain food and pharmaceutical values. Numerous studies are available world over on the compositional potentials of this fruit; however, very limited work has been done in Pakistan. The present investigation was therefore undertaken to assess some compositional properties and antioxidant potentials of jaman fruit parts. Proximate composition in terms of crude protein, fat, fiber and ash content were estimated in pulp, skin and seed portions and found in the range of 3.57-5.05%, 1.60-8.00%, 3.09-3.33%, 4.51-6.21% respectively. Seed was leading in protein, fat, ash and crude fiber, whereas varying levels were found in pulp and skin. Among the chemical attributes, total sugars, titratable acidity and ascorbic acid were assessed only in fruit pulp on dry weight basis that were 52.48%, 5.66% and 187.63 mg. 100g^{-1}, while total soluble solids (9.11^{o}Brix) were estimated in fresh pulp. Bioactive composition revealed that jaman fruit parts were rich in phenolics (4812.03-5103.03 mg GAE. 100g^{-1}), flavonoids (2380-3920 mg QE. 100g^{-1}), anthocyanins (272.26-384.32 mg Cya.3-rut E. 100g^{-1}) and antioxidant activity (82.52-90.66%). Fruit skin had higher amounts of bioactive components and antioxidant capacity followed by pulp and seed. All fruit parts were rich in mineral composition; however, seed had higher contents followed by skin and pulp. Among the individual minerals, potassium, phosphorus and calcium were abundant followed by magnesium, sodium and iron respectively. These findings revealed that *Syzygium cumini* fruit is a junction of health promoting phytochemicals and major mineral elements.

Keywords: Jaman fruit, phenolics, flavonoids, anthocyanin, antioxidant activity, mineral contents

Euginia jambosa (*Syzygium cumini* L.) is a large evergreen fruit tree which is commonly grown in the plains of Pakistan. Jaman is the common name given to this tree in Indo-Pakistan. It belongs to the family Myrtaceae, having about 90 genera and 2800 species around the globe

(Noomrio and Dahot, 1996). It has a wide adaptability, well grown in the tropical regions and thought to be native to Asia (Steward *et al*., 1972).

Two varieties are common in Pakistan, the one with large oblong shaped deep purple or bluish fruit with sweet juicy flesh, while the other variety has small round fruit with sour flesh and small seeds (Jabbar *et al*., 1994). The large oblong shaped fruit variety is common in Potowar region and the fruit is available in the local markets during mid spring. Although the fruit was not popular among the consumers in this region, however, it is getting importance due to its nutritional and health benefits. The fruit is reported to be a good source of minerals, vitamin C, sugars, phenolic compounds (Gallic acid, tannins, flavonoids, anthocyanins) and other antioxidant components (Martinez and Del Valle, 1981; CSIR, 1976; Prabhakaran *et al*., 2011).

Plant flavonoids, anthocyanins, tannins and other phenolic constituents are excellent antioxidant and have a high biological value (Saskia *et al*., 1996). Antioxidants are important in eliminating the effect of free radicals which cause oxidative damage to bioactive molecules like carbohydrates, proteins, lipids and DNA in foods and other living systems (Wiseman and Halliwell, 1996). Free radicals are responsible for accelerating aging, cancer, cardiovascular diseases, Neuro-degenerative diseases and inflammations (Stadtman, 1992; Sun, 1990). Utilization of foods from plant origin has been shown to lower the risk of chronic diseases such as cancer and cardiovascular diseases (Yeum *et al*., 2003). The positive health effects may be attributed to the high contents of certain phenolic compounds in these foods (You *et al*., 2007). Phytochemicals have recently been studied for their positive health benefits and has attracted great attention researchers and consumers (Ruan *et al*., 2008). These compounds play a crucial role in preventing chronic diseases (Diplock *et al*., 1998). Foods containing high concentration of antioxidants are effective in prevention of cardiovascular diseases, cancers (Gerber *et al*., 2002) and neurodegenerative diseases (Serafini *et al*., 2002) as well as inflammation and problems caused by cell and cutaneous aging (Ames *et al*., 1993).

Jaman has a long history of medicinal as well as culinary uses in Asia and currently has a vast market for different products of the fruit. It is used especially for diabetics, chronic diarrhea, enteric disorders and as an antimicrobial (Migliato, 2005; Benherlal and Arumughan, 2007). A variety of products are made from the ripe fruit i.e. juice, squashes, jam, jellies, vinegar and wines (CSIR, 1976). Different parts of the plant like seed, barks and leaves are also used in therapeutics and feeds (Ayyanar and Subash-Babu, 2012). The leaf and seed extracts are reported to be beneficial for treatment of diabetics, hypoglycemic action, preventing radiation induced DNA damage and have antioxidant properties (Prince, 1998).

The chemical composition of Jaman fruit has been studied in Pakistan but there is no information regarding antioxidant composition (phenolics, flavonoids, anthocyanins and free radical scavenging activity) of *S. cumini*. The present study was therefore undertaken to explore some nutraceutical potentials of the fruit commonly found in the Potowar region and thus enable the consumers and processors to use this local source for nutraceuticals or antioxidant supplements for food and feed purposes.

Materials and methods

Materials

Fresh and fully ripened jaman fruit was harvested from different locations of Potowar and campus plantation of Pir Mehr Ali Shah, Arid Agriculture University Rawalpindi. The fruit was immediately shifted to the Postharvest Research Laboratory, Department of Food

Technology, where the investigations were conducted. Chemicals and reagents used were procured from sole distributors of Merck (Germany) and Sigma Aldrich (St. Louis MO).

Proximate composition

The fruits were cleaned, graded and equal portions of harvested samples from different locations were combined to make a representative whole. Randomly selected 40 fruits were used for all determinations. The pulp portion, skin and seed were separated manually using a stainless steel knife. Moisture, dry matter, crude fiber and ash content (pulp, skin, and seed) were determined according to the standard procedures of AOAC (2000). Soluble solid content (TSS) expressed as ^{o}Brix was determined in the pulp of each sample using a digital hand refractometer PL-3 (ATAGO™, Japan) at 29±1^{o}C and temperature corrections were made accordingly. Total sugars were determined by the Lane - Eynon method (James, 1995).

Chemical and bioactive composition

The pH values were measured by using a pH-meter (Inolab. WTW Series, Germany), while, titratable acidity was estimated by titrating 5 ml of juice with 0.1N NaOH and results were expressed as percentage of citric acid. Ascorbic acid in fruit sample was determined using 2, 6-dichlorophenolindophenol titration method (AOAC, 2000).

Total phenolic compounds were measured by using Folin-Ciocalteu (FC) reagent and expressed as Gallic acid equivalent (GAE) (Jayasinghe *et al.,* 2003). Content was calculated from the standard curve made from different concentrations of Gallic acid. Fruit parts were crushed and extracted with 80% methanol, centrifuged at 10, 000 rpm for 15 minutes and filtered through a 0.45 mm membrane filter. From the above filtrate 0.1 ml was taken in a test tube, 7 ml distilled water and 2.0 ml of 2 N FC reagent was added, mixed well, kept for 5 min and another addition of 2.0 ml of 7.5% sodium carbonate was made. Total volume of the mixture was then made up to 10 ml and incubated at room temperature for one hour. The mixture was taken in quartz cavetts and absorbance of the developed blue color was read at 760 nm in spectrophotometer (CE-2021, 2000 series CECIL Instruments™ Cambridge, England) against a reagent blank.

Total flavonoid estimation was performed colorimetrically according to aluminum chloride method described by Benherlal and Arumughan, (2007). Extraction of total flavonoids in pulp, skin and seed portions of Jaman fruit was performed in 80% ethanol according to Chang *et al.* (2002). Quercetin standard of different concentrations (10-100 µg. L^{-1}) was prepared and properly diluted in 80% ethanol and 0.5 ml from each concentration was taken in different test tubes. The volume of standard and samples were made up to 2 ml with 95% ethanol followed by the addition of 0.1 ml of 10% aluminum chloride, 0.1 ml of 1 mol.L^{-1} potassium acetate and 2.8 ml of distilled water, incubated at room temperature (30-34^{o}C) for 30 min. The intensity of color developed was read at 415 nm (CE-2021, 2000 series CECIL Instruments™ Cambridge, England) against a reagent blank. The results were presented as quercetin equivalents 100g^{-1} of dry weight.

Anthocyanin determination was carried out according to the method described by Viskelis *et al*. (2009). Fifty grams of frozen berries were homogenized; the pigments were extracted from 5g homogenate with 95% (v/v) food grade ethanol containing 0.1 M HCl (acidified ethanol). The berries were ground in dark with quartz sand and the extraction was continued with 20 ml portions of solvent until the sample became colorless. The extract was diluted with acidified ethanol until 100 ml; the pH of the extracts was 1.2. The absorption was measured on a spectrophotometer (CE-2021, 2000 series CECIL Instruments Cambridge,

England) at 544 nm and the concentration of anthocyanins was determined from the calibration curve, which was constructed by measuring the absorption of cyanidin-3-rutinoside (MW 595.2, ε = 28.800) reference solutions. The concentration of anthocyanins was calculated using the following formula and expressed in mg cyd-3-rut in 100g of different fruit parts:

$$C = c \times V \times k / m \times 10$$

Where C is the concentration of anthocyanins in mg. L^{-1} obtained from the calibration curve; V is the volume of the extract in milliliters; k is the dilution factor; and m is the amount of berries used for the extraction in grams.

The antioxidant activities of the methanolic extracts were measured on the basis of the free radical scavenging activity of the stable 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical, following the method described by Braca *et al*. (2001). Sample extract of 0.1 ml was added to 3 ml of a 0.004% of DPPH and the mixture was let stand for 30 min. Absorbance at 517 nm (CE-2021, 2000 series CECIL Instruments™ Cambridge, England) was determined after 30 min incubation and the percent inhibition activity was calculated as:

$$\% \text{ Antioxidant activity} = [(A_B - A_S) / A_B] \times 100$$

Where A_B is absorbance blank, while A_S is absorbance of sample tested.

Mineral contents

Mineral composition (Ca, Fe, Zn, Mn, Cu, Ni, Mg), was determined by dry ashing method (incineration of sample at 500^{o}C in a furnace) through an Atomic Absorption Spectrophotometer (GBC-932 Australlia), according to Ecrements and Burell (1973). Whereas Na and K by Flame Photometer (PFP 7 Jenway™, England) and Phosphorus by using UNICO 2100 Series™, UV-Spectrophotometer (Watanabe and Olsen, 1965). The amount of minerals was calculated against the standard.

Statistical analysis

Statistical analysis of the obtained data was performed using one-way ANOVA and all experiments were conducted in triplicates. The results were reported as mean ± SD (standard deviation of the estimates) according to Steel *et al*. (1997) using MSTAT-C Software.

Results

Compositional characteristics of jaman fruit have been illustrated in Table 1. The moisture content in pulp, skin and seed was established around 86.24±1.45, 74.60±1.22 and 52.91±1.48%, whereas total soluble solids and total sugars were found in the range of 9.11±0.45 ^{o}Brix and 52.48±1.34 g/100g respectively in fruit pulp where sugar values are based dry matter content. Crude proteins were found in the range of 4.37±0.04, 3.57±0.05 and 5.05±0.07%, crude fat 1.60±0.02, 1.97±0.03 and 8.00±0.10%, crude fiber 2.09±0.03, 2.89±0.04 and 3.33±0.03%, while ash content was found in the range of 4.51.72±0.12, 5.49±0.21 and 6.21±0.20% respectively in pulp, skin and seed portion of the fruit.

The data pertaining to the chemical and bioactive composition is presented in Table 2. pH, titratable acidity and ascorbic acid were assessed only in pulp portion and found as 3.10±0.02, 5.66±0.04% and 30.46±2.18 mg. $100g^{-1}$, where pH was determined in fresh juice while the other parameters were determined on dry matter basis. Total phenolic compounds in jaman revealed significantly ($p < 0.05$) higher contents in skin (5990.39±12.67 mg GAE. $100g^{-1}$) followed by pulp (5103.03±10.82 mg GAE. $100g^{-1}$) and seed (4812.03±10.67 mg GAE. $100g^{-1}$) on dry weight basis. Similarly, total flavonoid contents were found in the range of 3110±6.06, 3920±8.12 and 2380±5.08 g. $100g^{-1}$ dw respectively in pulp, skin and seed. A similar pattern was observed in

anthocyanin composition that demonstrated higher amounts in skin (384.32±4.02 mg. $100g^{-1}$) followed by pulp (349.40±5.06 mg. $100g^{-1}$) and seed (272.26±6.04 mg. $100g^{-1}$) on dry weight basis. Furthermore, antioxidant activity in terms of DPPH free radical scavenging capacity was found in the range of 90.66±2.56, 82.52±1.02 and 85.22±1.22% in skin, pulp and seed respectively. The differences in the above parameters were statistically significant ($p < 0.05$).

The amount of mineral constituents from different parts of jaman fruit are presented in Table 3. Among the individual minerals examined, potassium was in higher concentration (87.90±5.20, 133.07±7.10 and 190.61±10.11 mg. $100g^{-1}$) followed by phosphorus (39.14±4.12, 40.32±5.03, 46.21±5.32 mg. $100g^{-1}$), magnesium (24.31±1.03, 33.12±3.45, 36.10±3.22 mg. $100g^{-1}$) calcium (10.05±2.00, 16.40±1.12, 17.67±1.94 mg. $100g^{-1}$) sodium (8.61±0.73, 12.10±1.65, 16.34±2.00 mg. $100g^{-1}$) and iron (3.04±0.32, 4.60±0.42, 6.12±0.84 mg. $100g^{-1}$) in pulp, skin and seed respectively.

Table 1. Proximate composition of jaman fruit from Potowar region of Pakistan

Components	Fruit part		
	Pulp	Skin	Seed
Moisture content (%)	86.24±1.45	74.60±1.22	52.91±1.48
Total soluble solids (^{o}Brix)	9.11±0.45	ND	ND
Total sugars (%DW)	52.48±1.34	ND	ND
Crude protein (%DW)	4.37±0.04b	3.57±0.05c	5.05±0.07a
Crude fat (%DW)	1.60±0.02c	1.97±0.03b	8.00±0.10a
Crude fiber (%DW)	2.09±0.03c	2.89±0.04b	3.33±0.03a
Ash (%DW)	4.51±0.12c	5.49±0.21b	6.21±0.20a

ND: not determined, DW: dry weight; All the values are mean ± standard deviation of triplicate samples and the means with different letters in the same row are statistically significant (p 0.05)

Table 2. Biochemical composition of jaman fruit (DW) from Potowar region of Pakistan

Components	Fruit parts		
	Pulp	Skin	Seed
pH	3.10±.01	ND	ND
Titratable acidity (%)	5.66±0.04	ND	ND
Ascorbic acid (mg. $100g^{-1}$)	30.46±2.18	ND	ND
Total phenolics (mg GAE. $100g^{-1}$)	5103.03±10.82c	5990.39±12.67a	4812.03±10.67b
Total flavonoids (mg QE. $100g^{-1}$)	3110±6.06b	3920±8.12a	2380±5.08c
Anthocyanin (mg Cya.3-rut. E.$100g^{-1}$)	349.40±5.06b	384.32±4.02a	272.26±6.04c
Free radical scavenging capacity (%)	85.22±1.22b	90.66±2.56a	82.52±1.02c

ND = not determined, DW = dry weight, GAE = gallic acid equivalent, QE = quercetin equivalent, Cya.3-rut. E = cyanidin 3-rutinoside equivalent; All the values are mean ± standard deviation of triplicate samples and the means with different letters in the same row are statistically significant (p 0.05)

Table 3. Mineral contents of jaman fruit (mg. 100g^{-1} DW) from Potowar region Pakistan

Mineral	Fruit part		
	Pulp	Skin	Seed
Na	8.61±0.73c	12.10±1.65b	16.34±2.00a
K	87.90±5.20c	133.07±7.10b	190.61±10.11a
P	39.14±4.12c	40.32±5.03b	46.21±5.32a
Ca	24.31±1.03c	33.12±3.45b	36.10±3.22a
Mg	10.05±2.00c	16.40±1.12b	17.67±1.94a
Iron	3.04±0.32c	4.60±0.42b	6.12±0.84a

All the values are mean ± standard deviation of triplicate samples on dry weight basis and the means with different letters in the same row are statistically significant (p 0.05)

Discussion

According to our knowledge this is the ever first study on overall composition of jaman fruit parts from Pakistan. The data was recorded on dry weight basis since moisture content of a commodity affect the concentration of individual components (Ali *et al*., 2011). Proximate analysis in terms of total sugars, crude protein, fat, fiber and ash content showed that fruit parts were rich in the above components (Table 1). A fairly good amount of sugars in the tested samples indicate the energy potential of jaman fruit produced in this region. The obtained results revealed nutritional significance of jaman fruit. Seed part of the fruit was possessing higher contents of protein, fats, crude fiber and ash contents as compared to skin and pulp portion. These results were in agreement with those of Jabbar *et al*. (1994) and Noomrio and Dahot (1996) who determined compositional attributes of jaman fruit from Peshawar and the tropical Sindh province of Pakistan respectively. Our findings regarding proximate composition of fruit parts were also in line with the reports of Benherlal and Arumugan (2007).

Among different biochemical parameters, pH, titratable acidity and ascorbic acid were estimated in fruit pulp only (Table 2). The lower pH values indicate acidic nature of the fruit. The data revealed that titratable acidity and ascorbic acid were higher in jaman fruit. Both the acid content and sugars play an important role in determining the taste of fruit. The higher levels of TA and ascorbic acid suggest that jaman fruit carries good contents of organic acids. Ascorbic acid as an antioxidant vitamin has a greater biological valve. It has many health benefits and improves the defense mechanism in living systems. The appreciable content of ascorbic acid in jaman fruit signifies it as a healthy food.

Among the important plant chemicals; phenolics, flavonoids and anthocyanins are the most important antioxidant components which possess health promoting effects (Chaudhary and Mukhopadhyay, 2012). The findings of the present study demonstrated that skin of fruit was rich in phenolics, flavonoids and anthocyanins as well as antioxidant activity. The data revealed that phenolic content was higher in the skin followed by pulp and seed. It has been established that the fruit parts exposed to environmental stresses result in to higher accumulation of phenolics (Gliszczynska-Swiglo *et al*., 2007). The difference in composition was statistically significant ($p < 0.05$) for all of the above parameters in the skin, pulp and seed portions of the fruit. These studies have shown that jaman fruit has a rich composition of phytochemicals and hence indicates the pharmaceutical potential of the fruit. Our results are in line with Sagrawat *et al*. (2006) who reported diverse contents of flavonoids, anthocyanins and

terpens of pharmaceutical importance. Many reports have suggested jaman fruit as chemopreventive (Parmar, 2010), radioprotective (Jagetia *et al*., 2008) and carrying antineoplastic effects which are important cancer preventive measures (Li *et al*., 2009). The findings of the present study indicate the significance of jaman fruit as a potential nutraceutical source as previously opined by Chaudhary and Mukhopadhyay, (2012). Total antioxidant activity showed a direct relationship with the phenolic content of different fruit parts and was high in skin, pulp and seed respectively. These results are in accordance with the findings of Benherlal and Arumughan (2007), who found a linear relationship between the phenolic contents and free radical reducing activity in different parts of jaman fruit (pulp, seed and seed coat extracts). Similarly, Banerjee *et al*. (2005) have shown high antioxidant activity of jaman fruit that is in agreement with our results. Ali *et al*. (2011) have also reported that phenolic concentration is highly correlated with free radical scavenging capacity in apricot fruit. The variations in compositional properties may be related to the fact that these characteristics are affected by genotype, agro-climatic conditions and geography (Haciseferogullari *et al*., 2007).

The higher mineral contents in seed and skin indicate their significance to be used in food supplementations and animal feeds. Furthermore, minerals play very crucial role in different physiological functions as part of skeleton, body fluids and enzyme systems. The results showed a rich mineral concentration in all the three portions, however, higher amounts were found in seed followed by skin and pulp. Among different mineral elements potassium, phosphorus, calcium, magnesium and sodium followed by iron were found in higher concentrations, while sodium content was low as compared to other minerals, hence, jaman is considered as a low sodium food (Bhutani *et al*., 1989). Mineral contents like the other constituents may vary with the stage of maturity and ripening and reports from previous findings indicate that iron accumulates in the fruit up to 52 days after fruit set and a decline occur thereafter (Waheed *et al*., 2003).

Conclusions

The present investigation with regards to physico-chemical and mineral composition of jaman fruit parts suggests high food and pharmaceutical potentials of the fruit grown in Potowar region of Pakistan. The rich phyto-nutrient composition of fruit parts (skin, pulp, seed) provide better prospects for the use of fruit in value added products and as a health food. Furthermore, based on the functional components of the fruit, intensive and in-depth biological studies are recommended to further authenticate the traditional health uses of this neglected natural resource.

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