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A Study on the Determination of Mineral Elements in Jamun Fruit *(Eugenia jambolana)* Products

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Abstract: The aim of this study was to determine the mineral contents of jamun fruit (*Eugenia jambolana*) products namely jam, squash, ready-to-drink juice, pulp powder and seed powder. The products were made and stored for 24 months at various storage conditions in different packaging material since it was an essential part of doctoral study carried out in 2007-2009. About 09 mineral elements such as Cr, Cu, Mn, Zn, Fe, Mg, Ca, Na and K in all jamun products were detected through atomic absorption spectrophotometer. The minimum and maximum macronutrients of Jamun products were determined as mg/kg. Two varieties of Jamun namely improved-V1 and indigenous-V2 were used. From the results of this study it could be concluded that there is a significant difference between the products as well between the cultivars however, VI is comparatively better than V2 in containing minerals.

Key words: Jamun fruit products, minerals, atomic absorption

INTRODUCTION

Fruit and fruit products are important sources of minerals. In human diet minerals are provided mainly by fruits and vegetables puree and juices. The most valuable juices are those produced from fruit and vegetables in the form of juices or instant drinks since they offer large amounts of dry mass which contain fibers, minerals and vitamins (Black *et al.*, 2004). Minerals are unique nutrients because of their important role in metabolism. They are essential part of many impotent enzymes and they also play roles as catalysts and antioxidants. Iron and copper for example are essential in blood formation and copper is also involved normal carbohydrate and lipid metabolism (Hambidge *et al.*, 1987). Chromium regulates the action of insulin and is also essential in carbohydrate and lipid metabolism (Alam and Mahpara, 2003). Zinc for its part is a multi functional nutrient involved in glucose and lipid metabolism, hormone function and wound healing (Hambidge *et al.*, 1987) and is also associated with proper hair growth (Wang Jian and Sporns, 1999). Extracts of both, but especially the seeds, in liquid or powdered form, are freely given orally, two or three times a day to patients with diabetes mellitus or glycosuria (Dastur, 1952). In many cases, the blood sugar level reportedly is quickly reduced and there are no ill effects. Fresh seeds of jamun are considered superior to dried seeds. In India, the seed powder is administered as an antidote for strychnine poisoning. Diabetes Mellitus (DM) has been shown to be associated with abnormalities in the metabolism of zinc and chromium (Wattoo *et al.*, 2000).

Jamun (*Eugenia jambolana*) falls in underutilizing fruit species which is neither cultivated in an organized farming system nor processed by established commercial processing methods particularly in Pakistan. Jamun have almost an exotic flavor and are known for their nutritional and therapeutic values as described above. Jamun fruits although produced in considerable quantities and consumed but seldom processed in Pakistan. There is a great scope for the processed products not only because of their exotic flavor but also due to their nutra-ceutical impotence and therapeutic values. Thus, processing of jamun fruit into value-added products result in a wide variety of exotically flavored product with better nutritional and sensory qualities may unveil new market for export. Therefore, development, standardization and popularization of value-added products from jamun fruit are essential.

Jamun of good size and quality, having a sweet or sub-acid flavor and a minimum of astringency, are enjoyable raw and may be made into valuable products, sauces and jam (Kennard and Winters, 1955). Good quality jamun juice is excellent for sherbet, syrup and squash (Miller *et al.*, 1955). In India the latter is a bottled drink prepared by cooking the crushed fruits, pressing out the juice, combining it with sugar and water and adding citric acid and sodium benzoate as a preservative (Lai *et al.*, 1960).

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Keeping in view the nutritional, medicinal and delicious significance of jamun fruit, it was felt indispensable that this precious fruit should be explored by scientifically assessing its true nutritional values and extend shelf life by making commercially acceptable products to ensure its availability round the year. Apart from this, its quality is degraded till it reaches into the market therefore, as much as possible, a durable with proper size packaging material was also considered necessary to be examined during this doctoral study. Thematically, there is a big need to overcome the wastage of jamun fruit right from its production to consumption. Consequently, jamun fruit has been positively converted into different forms of products like jam, squash, ready-to-drink juice, seed powder and pulp powder etc. According to my knowledge, no scientific study has been reported in Pakistan so far particularly assessment of nutritional characteristic, making commercially viable products and evaluation of shelf life of jamun fruit altogether as “many-in-one”. After due course of time, these products were evaluated for mineral contents as essential part of this study.

MATERIALS AND METHODS

Reagents and materials: All reagents used were of A grade and calibrated. Graduated pipettes up to 0.005 ml accuracy were used and other volumetric Pyrex glass wares were also accurate in terms of quality and quantity. Deionized water was used throughout the studies.

Compilation of jamun products: Five products namely jam, squash, ready-to-drink juice, seed powder and pulp powder of each cultivar i.e. improved (V1) and indigenous (V2) were prepared and kept in various storage conditions under different packaging material were used for the analysis of minerals. Powder products of seed and pulp were dried with three different methods like freeze drying (-50°C), shade drying (32±2 C) and sun drying (40±5°C). However, jam, juice and squash were prepared through standard methods of processing as commercially applicable.

Sample preparation/digestion: Took 0.5 g jam, pulp and seed powder whereas 0.5 ml juice and squash was taken in conical flask in duplicate and added 10 ml of nitric acid (HNO_3). The mixture was heated on heat plate at 70-80°C for jam, seed and pulp powder however; mixture of juice and squash was heated at 35-40°C. On cooling a yellowish residue was obtained. 2 ml of hydrogen peroxide (H_2O_2) and 5 ml nitric acid was added into the residue and heated again. On cooling a colorless residue was obtained where 2-3 ml 2 NHNO_3 (138.5 ml HNO_3 diluted in 1000 ml in distill water) and double distilled water was used. The mixture was filtered through whattman paper No. 42. The final volume was made up to 25 ml in volumetric flask by adding double distilled water.

Analysis through atomic absorption spectrophotometer: The digested samples were analyzed by using air-acetylene flame in combination with single element hollow cathode lamps into an atomic absorption spectrophotometer (Hitachi model A-1800). Calibration of the instrument was repeated periodically during operation. Mineral contents were calculated by comparison of their standards solutions. The blanks were used for zeroing the instrument before each analysis to avoid matrix interference. All standard used were of ultrahigh purity (certified >99.9%) procured from E-Merck, Germany, or British Drug House Chemicals Ltd., Poole, UK (BDH). Duplicate sub-samples of each sample were run separately in order to record average mineral concentrations. The elementary composition was determined to the procedure of Ecrements and Burell (1973) by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

The concentration of the mineral elements in the jamun products namely jam, squash, ready-to-drink juice, seed powder and pulp powder were thoroughly investigated. All data are the results of average of three measurements on each sample with a relative standard deviation of less than 5%. The results showed a similar pattern for all the mineral elements of jamun products. About 09 mineral elements such as Cr, Cu, Mn, Zn, Fe, Mg, Ca, Na and K in all jamun products were detected (Table 1 and 2). The fresh pulp of jamun V1 and V2 contained 3.50 and 3.44 mg/kg Cr respectively. These findings are in agreement with the findings of (Indrayan *et al*., 2005). Besides, these results can also be compared with other fruits such as (Tirmizi *et al*., 2007) reported that apple, banana and carrot contain 1.71, 2.20 and 1.47 mg/kg Cr respectively. The amount of Cr in seed powder of V1 with the strength of 5.25 mg/kg remained high which is followed by seed powder of V2 contained 5.15 mg/kg. The minimum content of Cr was observed in pulp powder i.e. 2.96 and 3.00 mg/kg in V2 and V1 respectively. The other products like jam, squash and ready-to-drink juice ranged in between seed and pulp powder in decreasing order. Although, there is not a significant difference between the cultivars of jamum however, V1 is somehow superior to V2. Chromium plays a vital role in metabolism of carbohydrates and its deficiency leads to diabetes in human body (Jamal *et al*., 1986). Deficiency of chromium results in hyperglycemia, growth failure, neuropathy, cataract and atherosclerosis (Saner *et al*., 1980).

Copper competency was recorded as 68.76 and 69.89 mg/kg in fresh pulp of V1 and V2 respectively. It was followed by ready-to-drink juice with a value of 68.49 and 69.75 mg/kg in V1 and V2 respectively. Results indicate that fresh pulp of jamun is abundant in Cu followed by ready to drink juice, jam and squash in decreasing order respectively. There was a significant difference between the products whereas slight differences were observed among the cultivars. For instance, squash with a capacity of 9.35 and 7.94 mg/kg in V1 and V2 respectively ranked the lowest barrier whereas fresh pulp contained Cu with grate difference than the former. As far as cultivar is concerned, V1 is superior to V2 in containing Cu. These results are highly significant as compare to other studies which found less amount of Cr in jamun fruit. For example Indrayan *et al.* (2005) reported 0.0018% Cu in jamun aqueous extraction which is comparatively low than we found in jamun. Cu is a component of many enzyme systems such as cytochrome oxidase, lysyl oxidase and ceruloplasmin, an iron-oxidizing enzyme in blood (Mills, 1981). Cu deficiency may probably be related to its role in facilitating iron absorption and in the incorporation of iron into hemoglobin (FAO/WHO, 1974).

The level of calcium in fresh pulp of jamun was ranged from 620.98 and 661.13 followed by squash 614.59 and ready-to-drink juice 653.8 mg/kg as the highest value to 160.21 and 156.56 mg/kg as lowest value in pulp powder of V1 and V2 respectively. However, in jam product Ca was found 252.37 and 245.07 mg/kg and ranked medium to high level content. The increased amount of calcium in jamun jam, squash and ready-to-drink juice may be due to the use of acidity regulators during production and preservation process e.g. citric acid and sodium benzoate. These substances resultantly increase calcium strength (Guz *et al.*, 2007; Mao *et al.*, 2007; Zhu *et al.*, 2007). The lowest amount of calcium in seed and pulp powder was probably because of its typical composition. Findings of Ca during this study were significantly higher than other studies as claimed 0.54% by Indrayan *et al.* (2005) in jamun seed. There is no significant difference between cultivars however, significant difference was observed between the products. Seeds of jamun have less calcium than squash, juice and jam. In spite of having no significant difference between the cultivars but still V1 is superior to V2. Calcium makes the major elements of bones and teeth. It also participates in muscle contractions and conductions of nerves impulses and cell membrane permeability, blood coagulation (Szotowa *et al.*, 1996). Calcium bioavailability with food is 25-50% and is depressed by anti-nutrient substances (oxalic acid, phytic acid) but raised by some amino acids, lactose and vitamin D (Waine, 2001; Lynch and Stoltzfus, 2003). In children, pregnant women and during lactation the level of absorption rises (Waine, 2001) and shortage of calcium in children is manifested by rickets and inadequate growth.

Manganese was reasonably equal in all jamun products except jam of V2 which was significantly different. While, no significant difference between all other products of

Table 1: Determination of mean values of minerals in various products of Jamun fruit (mg/kg) V1

Sa.	Cr	Cu	Mn	Zn	Fe	Mg	Ca	Na	K
SP	5.256449±0.053504	22.77596±0.025082	13.26402±0.008382	6.958763±0.60748	9.419431±0.837804	98.58193±0.742759	214.9635±1.290341	2200.03±487.0003	17051.01±520.748
PP	3.006845±0.008231	14.4048±0.075245	13.00915±0.050294	10.82474±1.21496	14.45498±0.418902	109.0861±0.742759	160.219±1.290341	1667.835±531.2731	13601.97±190.941
J	3.821708±0.008231	55.9414±0.0752450	13.24624±0.016765	11.68385±2.42992	10.90047±0.418902	94.38025±2.228278	252.3723±2.580682	1886.974±398.4548	21837.93±104.1497
S	4.037065±0.024694	9.35017±0.100327	13.10992±0.025147	7.388316±1.21496	9.419431±0.837804	71.0084±0.37138	614.5985±6.451704	4673.17±265.6365	9072.81±347.1655
R	3.478301±0.016463	68.49816±0.075245	13.29936±0.016765	14.26117±1.21496	16.82464±1.256706	92.80462±1.485518	610.9489±3.871023	1949.586±115.1092	8950.069±520.7483
FP	3.501583±0.008231	68.76419±0.050164	13.34108±0.016765	21.13402±1.21496	20.08294±0.837804	95.43067±0.742759	620.9854±2.580682	1417.391±177.091	17910.2±1041.497

Sa. = Sample, SP = Seed Powder, PP = Pulp Powder, J = Jam, S = Squash, R = Ready-to-drink juice, FP = Fresh Pulp

Table 2: Determination of mean values o minerals in various products of jamun fruit (mg/kg) V2

Sa.	Cr	Cu	Mn	Zn	Fe	Mg	Ca	Na	K
SP	5.157501±0.020578	22.43899±0.050164	13.31737±0.016765	5.670103±1.21496	8.530806±0.418902	103.3088±2.228278	210.4015±2.580682	2397.255±500.2822	12386.83±173.5828
PP	2.966102±0.016463	15.30931±0.200655	12.96173±0.016765	12.1134±0.60748	12.97393±0.837804	107.2479±1.114139	156.5693±1.290341	1943.324±371.8912	20340.49±381.8821
J	3.46375±0.02881	45.74347±0.00	16.69591±5.381509	12.1134±0.60748	11.19668±0.837804	87.28992±1.114139	245.073±5.161363	2356.558±354.1821	16928.27±347.1655
S	4.063257±0.004116	7.949064±0.075245	12.82541±0.041912	6.958763±0.60748	7.938389±0.418902	71.27101±0.742759	580.8394±5.161363	5080.142±44.27276	18558.28±465.2018
R	3.431738±0.008231	69.75738±0.100327	13.06842±0.03353	13.83162±0.60748	15.63981±1.256706	88.34034±1.856898	653.8321±5.161363	2575.697±575.5459	10300.23±694.3311
FP	3.440468±0.004116	69.89926±0.050164	13.1277±0.016765	15.54983±0.60748	17.71327±0.837804	88.60294±0.742759	661.1314±2.580682	1996.544±376.3184	19683.82±685.652

Sa. = Sample, SP = Seed Powder, PP = Pulp Powder, J = Jam, S = Squash, R = Ready-to-drink juice, FP = Fresh Pulp both the jamun varieties, V1 and V2 was recorded. Results shows that seed powder contained 13.26 and 13.31, pulp powder 13.00 and 12.96, jam 13.24 and 16.69, squash 13.10 and 12.82, ready-to-drink juice 13.29 and 13.06 mg/kg. From the results, it can be said no significant affect of processing and storage could occurred on Mn. For instance, aqueous extraction of jamun contained 13.34 and 13.12 mg/kg in V1 and V2 respectively. Hence, the amount in aqueous extraction remained the same even after processing and storage. These results are comparable with the findings of Indrayan *et al.* (2005) who reported about 0.14% in jamun seed. Manganese is essential for hemoglobin formation (Verma *et al.*, 1982). Manganese plays a number of essential roles in cellular function and human metabolism. At the biochemical level, manganese can function both as a constituent of metallo-enzymes and as an enzyme activator. The enzymes involved in urea production, carbohydrate synthesis and preventing lipid per-oxidation all contain manganese. A large number of enzymes with broad functions affecting multiple processes central to cellular metabolism, growth, replication and differentiation, require manganese for their activation. It is also now known that manganese-activated enzymes are involved in the synthesis of proteoglycan molecules, which add structural integrity to bone and joint cartilage (Ken and Zidenberg-Cher, 1982). Manganese may play a further role in bone development and remodeling (Strause, 1987).

The magnesium content was ranged from 98.58 and 103.30 to 95.43 and 88.60 mg/kg in seed powder and aqueous extraction of jamun V1 and V2 respectively. The highest level of Mg was observed in pulp powder of V1 i.e. (109.08, followed by V2 107.24 mg/kg), whereas the lowest value of Mg was determined in squash of V1 (71.00 mg/kg). The main constituent of Mg was found pulp powder followed by aqueous extraction of jamun. Jam and ready-to-drink juice remained modest with a range of 94.38 to 87.28 and 92.80 to 88.34mg/kg in V1 and V2 respectively. These findings of Mg for aqueous extraction of jamun are in agreement with the research outcomes of (Indrayan *et al.*, 2005) for jamun seed. Moreover, these results can be compared with other fruits like pumpkin which contain 14 m/100 g of the raw product (Kunachowicz *et al.*, 1998). The author's own studies revealed that squash from both cultivars had the lowest amount of magnesium among all other products. This result revealed that less amount of jamun mash has been used in squash product than jam and ready-to-drink juice. From the results we may say that the beverages made from jamun are not only meet the standard of edible juices available in the market rather supplying much better amount of Mg. In humans, Mg is required in the plasma and extra cellular fluid, where it helps to maintain osmotic equilibrium. It is required in many enzyme-catalyzed reactions, especially those in which nucleotides participate where the reactive species is the magnesium salt. Lack of Mg is associated with abnormal irritability of muscle and convulsions (Janani and Sondhi, 1995).

The highest content of iron in the form Fe was revealed in aqueous extraction 20.08 and 17.71 mg/kg of V1 and V2 respectively. Slightly lower values were determined in ready-to-drink juice 16.82 and 15.63 mg/kg followed by pulp powder 14.45 and 12.97 mg/kg of V1 and V2 respectively. The lowest amount of Fe was found in squash 9.41 and 7.93 mg/kg of V1 and V2 respectively. Whereas, jam and seed powder was ranked moderate with a value of 10.90 and 11.19 and 9.41 and 8.53 mg/kg of V1 and V2 respectively. From the results, we may say that aqueous extraction of jamun is significantly high among others. There was although not much significant difference between the cultivars but V1 was standstill slightly high than V1. This difference might be due to less amalgamation of raw jamun composition in the products. The past studies are also agreed with the same viewpoint and stated that iron content in beverages depends on percent composition of raw material. Studies of Marzec *et al.* (2007) revealed that fruit juices for infants contained from 0.76-2.92 µg of Fe in 1 g. About 10% of iron is absorbed from an average food ration. The presence of calcium reduces the absorption of iron, whereas, the presence of copper increase its absorption (Hallberg *et al.*, 1993; Szotowa *et al.*, 1996; Bread and Tobin, 2000). Iron absorption is also stimulated by ascorbic acid (Carpenter and Mohoney, 1992; Davis *et al.*, 1992). As far as iron's importance is concerned, iron is a trace mineral that is essential for our health. Forming a part of the red pigment called hemoglobin in the blood; it gives blood the dark red color and helps transport oxygen to our cells. Apart from that, iron is also important for muscle protein and traces of it can be found in liver, spleen, bone marrow and in our muscles (Davidson and Lonnerdal, 1989).

Zinc in aqueous extraction of jamun was higher e.g. (21.13 and 15.54 mg/kg) in V1 and V2 respectively which was followed by ready-to-drink juice 14.26 and 13.83 mg/kg in V1 and V2 respectively. Seed powder was found to have the least value of Zn among other products i.e. (6.95 and 5.67 mg/kg) followed by squash in decreasing order (7.38 and 6.95 mg/kg) of V1 and V2 respectively. Almost Zn was in equilibrium position in pulp powder and jam. For instance, pulp powder retained 10.82 and 12.11, whereas jam contained 11.68 and 12.11 mg/kg of V1 and V2 respectively. The results are slightly different among the products. As far as varietals difference is concerned, V1 was superior to V2. The content of Zn in the author's own studies was significantly higher than those reported by Marzec and Zareba (2005) where its average content in fruit juices was 0.51 μg^{-1}. Zinc is a component of many metalenzymes, including some enzymes which play a central role in nucleic acid metabolism (Lai *et al*., 1960). In addition, Zn is a membrane stabilizer and a stimulator of the immune response (Hambidge *et al*., 1987). Its deficiency leads to impaired growth and malnutrition (Prasad, 1981). Zinc insufficiency may also lead to inhibiting the growth in children and to changes in their appetite, taste, smell and body weight loss (Brandao-Neto *et al*., 1995; Black *et al*., 2004).

The highest level of sodium was determined in squash i.e. 4673.17 and 5080.14 mg/kg of V1 and V2 respectively which is followed by seed powder 2200.03 and 2397.25 mg/kg of V1 and V2 respectively, whereas, least presence of Na was found in aqueous extraction of V1 1417.391 and V2 1996.544 mg/kg respectively. The jam products also contained a great composition of Na such as jam of V1 contained 1886.97 mg/kg whereas jam of V2 contained 2356.55 mg/kg. Moreover, a gigantic variance in aqueous extraction among both the cultivars was determined. Aqueous extraction of V2 showed a highest value i.e. 1996.54 mg/kg whereas aqueous extraction of V1 showed the lowest value i.e. 1417.39 mg/kg. High content of sodium probably meant a high share of raw mash in the product yet there seemed no logic concerning the high variance of content composition among the products otherwise. Concentration of sodium in seed powder of this study are in agreement with the findings of Indrayan *et al.* (2005) who reported that jamun seed contained about 1.82% Na on dry weight basis. The other products having highest values of Na can be compared with other fruits like carrot which contained 82 mg of sodium per 100 g of the raw products (Kunachowicz *et al*., 1998). Indrayan *et al.* (2005) reported that Na take part in ionic balance of the human body and maintain tissue excitability. Because of the solubility of salts, Na plays an important role in the transport of metabolites.

The highest amount of potassium was detected in jam of V1 and V2 i.e. 21837.93 mg/kg and 16928.27 mg/kg respectively whereas aqueous extraction of V2 is ranked just after the former product as the highest barrier of K i.e. 19683.82 mg/kg. On the other hand, the lowest value of K was found in ready-to-drink juice of both V1 and V2 e.g. 8950.06 and 10300.23 mg/kg. The squash product made from V1 and V2 showed almost variable quantities of K 9072.81 and 18558.28 mg/kg. It means that inconsistent amount of raw material may be used during product preparation hence; there was a significant difference among the squashes. Pulp powders of V1 and V2 also showed great difference being having 13601.97 and 20340.49 mg/kg. Overall, there is significant difference between product and cultivars. V1 is superior to V2 in containing K. These results can be compared with other fruits as reported by Kunachowicz *et al.* (1998) that potassium content was 282 mg/100 g in carrot and from 118 mg/100 g (pears) to 395 mg/100 g (bananas) in other fruits. Potassium is the principal intracellular caution and with sodium helps regulate osmotic pressure and pH equilibrium. It also is involved with cellular enzyme function. Potassium is essential for life but rarely is limiting even in the most meager diets (Goldberg, 1994; Guthrie, 1986; Whitney and Hamilton, 1987).

Conclusion: In pursuance of the results, it is concluded that jamun fruit and its products contained a considerable amount of mineral elements. Sodium and potassium are found to be abundant in quantity particularly in jamun seed. No large reduction of minerals during storage was found once the product is prepared through processing. It may be therefore recommended that jamun fruit can be utilized in beverage or even baby foods for the supplementation of essential mineral elements to malnourished.

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