Fruits: A potential source of vitamin C as essential human nutrition and immunity development: A review

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Introduction

The chemical name for the vitamin C is ascorbic acid. Ascorbic acid is a simple compound containing six carbon atoms, related to the monosaccharide glucose. It is stable to acid but easily destroyed by oxidation, light, alkali and heat especially in the presence of iron and copper. Most mammals can synthesize vitamin C from glucose but few including human lack of the liver enzyme gluconolactone oxidase, which is required to catalyse one step of this process. It is the lack of this enzyme that forces humans to depend on supplies of vitamin C. Ascorbic acid is a compound containing six carbon atoms, related to the structure of monosaccharide glucose. It is stable to acid but easily destroyed by oxidation, light, alkali and heat especially in the presence of iron or copper. Vitamin C is an essential nutrient in many multicellular organisms, especially in humans. Ascorbic acid is a water-soluble vitamin and is found in variable quantities in fruits and vegetables and organ meats (Devaki and Reshma, 2017) [35]. The fruits guava, kiwifruit, longan and strawberry were rich in vitamin C content per gram (Isabelle et al., 2010) [65]. Wall (2006) [149], stated that it is an important source of nutrition for human. Vitamin C was an additive for processed foods according to Rios & Penteado (2003) [148]. L- ascorbic acid (AA), is the main biologically active form of Vitamin C and dehydroascorbic acid (DHA) is its reversibly oxidised form.

In the present review discussed about,

1. Biological function and metabolic pathways requiring vitamin C
2. Natural source of Vitamin C from tropical, sub-tropical, arid zone and temperate fruit as a source of natural vitamin C
3. Vitamin C effects on health and as human Immunity development

4. Retention of Vitamin C content by advances Processing Methods

Metabolic pathways requiring vitamin C

- Hydroxyltion of proline and lysine for collagen synthesis
- Synthesis of noradrenaline from dopamine
- Synthesis of carnitine from lysine
- Activation of neuropepties
- Catabolism of tyrosine
- General antioxidant function

Recommended daily allowance

National Research Council recommends that children have to take as much as 35 mg. Males and females need 45mg. pregnant and lactating women requires 60-80mg.

The recommended Dietary Allowances of ICMR for ascorbic acid are given in table 1.

Table 1: Recommended dietary allowance of Vitamin C

| Group                     | mg/day |
|---------------------------|--------|
| Man                       | 40     |
| Women                     | 40     |
| Pregnant Women            | 40     |
| Lactation                 | 80     |
| Infants (0-12 months)     | 25     |
| Children (Boys and girls) | 40     |

Deficiency disorders

- Scurvy- weight loss, weakness, heart palpitations, redness and swelling of gums, loosening of teeth, haemorrhage into the skin and mucous membrane, odema, hyperirritability, etc.,
- Metabolism of tyrosine and cholesterol is partially affected.
- Absorption and utilization of iron are affected.

Natural source of Vitamin C from tropical, sub-tropical, arid zone and temperate fruit

Vitamin C content in fruits

Among all the fruits, West Indian Cherry (Asenjo & Freire De Guzman. A.R., 1946) [8], one of the subtropical fruits has the highest Vitamin C content of 2963 mg/100g of the pulp. Aonla (Jain &D.S.Khurdiya., 2004) [69] has the second highest Vitamin C content of 478.56 mg/100ml of the juice. Carissa (Pewlong et al, 2014) [126] occupies the next position having an ascorbic acid content of 300.75 mg/100 g of the unripe pulp and 180.4 mg/100g of the fully ripe pulp. Guava (Golberg et al, 1941) [52] also has a higher ascorbic acid content of 300 mg/100g. The other fruits occupy the consecutive position in the vitamin C content order with their respective values as follows: Rose Apple (Minh, 2014) [103] has 292.59 mg of ascorbic acid/100g of pulp. Mango (Ribeiro et al, 2007) [86] and bilimbi (Yan et al, 2013) [175] contains 182mg of AA/100 g of pulp. Pomegranate (Opara et al, 2008) [123] contains 118.4 mg AA/100g of peel and 72 mg/100 g of aril. These seven fruits have the highest Vitamin C content. Next to that, higher content of AA is found in the following fruits: Carambola (Yan et al., 2013) [175] has 120.74 mg AA/100 g of DW and persimmon (Yaqub et al, 2016) [178] has 70 mg AA/100g. Chestnut (Baros et al, 2011) contains 69.3 mg of AA/100g of DW. Bael (Sharma et al, 2007) [150] has 66 mg of AA/100g of pulp, apricot (Munzuroglu et al, 2003) [118] has 62 mg AA/g, strawberry (Moore et al, 2005) [105] has 62 mg /100 g, sweet orange (Okwa & Emeneke., 2006) [122] has 61.6 mg AA/100g, blackberry (Guedes et al,2013) has 55.78 mg AA/100g, papaya (Wall, 006) has 51.2 mg AA/100g.

The fruits having medium vitamin C content are as follows: Custard apple (Amoo et al, 2008) [106] has 50 mg AA/100g, kiwi (Esch et al.,2010) [37] has 46.8 mg of AA/100g, mandarin orange (Navarro et al,2011) [113] has 41.9 mg AA/100 ml, passion fruit (Suntornruk et al, 2002) [159] has 39.1 mg AA/100 g, rambutan (Wall, 2006) [169] has 36.4 mg AA/100 g, olive (Lopez et al, 2005) [89] has 36.1 mg AA/100 g, jackfruit (Ibrahim et al, 2013) [64] has 31.55 mg of AA/100g, litchi (Wall, 2006) [169] has 27.6 mg AA/100g, raspberry (Ancos et al,2000) [7] has 26.2 mg AA/100g, durian (Ashraf et al,2010) [9] has 25.13 mg AA/100g, ber (Tembo et al, 2008) [160] has 23 mg AA/100 g, sour cherry (Wojdylo et al,2014) has 22.11 mg AA/100 g, avocado (Palab et al., 2016) [158] has 21.3 mg AA/100 g, acid lime (Rangel et al, 2011) [134] and bread fruit (Huang et al, 2000) [62] has 20 mg of AA/100 g, jamun (Shahmawaz et al, 2009) [149] has 19.14 mg AA/100g, walnut (Gunnamoyole & Kade &Korodele 2011) [121] has 18.22mg AA/g, fig (Guvecn., 2009) [55] has 17.6 mg AA/100 g, date Palm (Chaira et al,2009) [26] with 17.5 mg AA/100 g, sweet tamarind (Lal &Vishal Nath,2017) [82] has 13.8 mg AA/100 g, loquat (Ghasemnezhad et al,2011) [40] has 12.8 mg AA/100 g, peach (Gill et al,2002) [51] has 12.6 mg AA/100 g, sweet cherry (Gundogdu & Ugur Bilge, 2012) [54] with 11.4 mg AA/100 g. Following this, the fruits having a lower Vitamin C content ranging from 1.0 to 10 mg of AA/100 g of the pulp are as follows: plum (Gill et al, 2002) [51] contains 9.5 mg AA/100, sapota (Ahmed et al,2011) [4] and pear (Sanchez et al,2003) [148] have 8 mg AA/100 g, blackcurrant (Milivojevic et al, 2010) has 7.6 mg AA/g, mangosteen (Manurakchinakorn et al, 2004) [94] has 6.75 mg AA/100 g, pineapple (Nweze., 2015) [119] with 6.14 mg AA/100 ml, pistachio nut (Bullo et al, 2015) [19] has 5.6 mg AA/100g, phalsa (Sinha et al,2015) [151] and grapes (Daniel et al, 1932) [53] approximately have 4 mg AA/100 g, banana (Wall, 2006) [169] has 3.3 mg AA/100 g, hazel nut (Koksal et al,2006) has 2.45 mg AA/100 g. Least value of Vitamin C are found in fruits like macadamia nut (Munro & Manohar L.Garg.,2006) and pecan nut (Wakeling et al,2005) [149] which has a content of approximately 1 mg of AA/100 g. Apple (Jacob et al,2011) [68] has 0.46 mg AA/I and almond (Christian &Mark E.Ukhun.,2006) has most least content of Vitamin C of 0.03 μg of AA g of pulp. Natural source of Vitamin C content of tropical, sub-tropical, arid zone and temperate fruit in Table 2.
| S. No | Common Name of The Fruit | Botanical Name | Family | Vitamin- C /Ascorbic Acid Content (mg/100g) | Reference |
|-------|--------------------------|----------------|--------|------------------------------------------|-----------|
| 1. | Mango | Mangifera indica L. | Anacardiaceae | 0.56 mg(seed) 25.3-182.55mg pulp | Fowomola.,2010 Ribeiro et al,2007 [46] |
| 2. | Banana | Musa sp. | Musaceae | 3.3mg | Wall, 2006 [169] |
| 3. | Guava | Psidium guajava | Myrtaceae | 300mg | Golberg et al,1941 [52] |
| 4. | Papaya | Carica papaya | Caricaceae | 51.2mg | Wall, 2006 [169] |
| 5. | Sapota | Achras sapota | Sapotaceae | 8.90mg | Ahmed et al, 2011 [4] |
| 6. | Grape | Vitis vinifera | Vitaceae | 4mg | Daniel et al,1932 [53] |
| 7. | Acid lime | Citrus aurantifolia | Rutaceae | 20mg | Rangel et al, 2011 [134] |
| 8. | Sweet orange | Citrus sinensis | Rutaceae | 19.36-61.60mg | Okwa & Ememike, 2006 [122] |
| 9. | Mandarin orange | Citrus reticulata | Rutaceae | 419mg/l | Navarro et al, 2011 [113] |
| 10. | Jack fruit | Artocarpus heterophyllus | Moraceae | 17.82-31.55mg | Ibrahim et al,2013 [64] |
| 11. | Avocado | Persea americana | Lauraceae | 14.63mg(ripe seed) 4.5-21.3mg(pulp) | Talabi et al., 2016 [158] |
| 12. | Pineapple | Ananas comosus | Bromeliaceae | 6.44±0.18mg/100ml | Nweze, 2015 [119] |
| 13. | Mango | Garcinia mangostana L. | Clusiaceae | 6.75±0.05mg(fresh cut) 4.1±1.2mg(ripe) | Manurakchinakorn et al,2004 [94] |
| 14. | Litchi | Litchi chinensis | Sapindaceae | 27.6mg | Wall, 2006 [169] |
| 15. | Loquat | Eriobotrya japonica | Rosaceae | 12.8mg | Ghasemnezhad et al,2011 [49] |
| 16. | Rambutan | Nephelium lappaceum | Sapindaceae | 36.4mg | Wall, 2006 [169] |
| 17. | Carambola | Averrhoa carambola L. | Oxalidaceae | 120.74±0.46mg /100g DW | Yan et al., 2013 [175] |
| 18. | Durian | Durio zibethinus | Malvaceae | 18.87-25.13mg | Ashraf et al,2010 [99] |
| 19. | Bilimbi | Averrhoa bilimbi | Oxalidaceae | 182.98±0.42mg /100g DW | Yan et al., 2013 [175] |
| 20. | Passion fruit | Passiflora edulis | Passifloraceae | 39.1mg | Suntornsuk et al,2002 [155] |
| 21. | Bread fruit | Artocarpus altilis | Moraceae | 20mg | Huang et al,2000 [62] |
| 22. | Rose apple | Syzygium jambos | Myrtaceae | 292.59mg | Minh., 2014 [103] |
| 23. | Aonla | Phyllanthus emblica | Phyllanthaceae | 478.56mg/100ml | Jain & D.S.Khuriya, 2004 [69] |
| 24. | Ber | Ziziphus mauritania | Rhamnaceae | 18-23mg | Tembo et al,2008 [160] |
| 25. | Pomegranate | Punica granatum | Punicaceae | 52.8-72 mg(aril) 118.4mg(peels) | Opara et al, 2008 [123] |
| 26. | Carissa | Carissa carandas | Apocynaceae | 300.75±57.65mg (unripe) 180.40±3.09mg (fully ripe) | Pewlong et al,2014 [126] |
| 27. | Custard apple | Annona squamosa | Annonaceae | 50mg(ripe fruit) 43.38mg(juice) | Amoo et al,2006 [106] |
| 28. | Fig | Ficus carica | Moraceae | 12.2-17.6mg(fresh) | Guvenc., 2009 [55] |
| 29. | Date palm | Phoenix dactylifera | Arecaceae | 2.4-17.5mg | Chaira et al,2009 [126] |
| 30. | Phalsa | Grewia asiatica | Malvaceae | 4.385mg | Sinha et al,2015 [151] |
| 31. | Jamun | Syzygium cumini | Myrtaceae | 19.14mg | Shahnawaz et al,2009 [149] |
| 32. | Bael | Aegle marmelos(L.) | Rutaceae | 66mg | Sharma et al,2007 [156] |
| 33. | West Indian Cherry | Malpighia marginata | Malpighiaceae | 1707-2963mg | Asenjo &Freire DeGuzman,A.R.,1946 [48] |
| 34. | Sweet tamarind | Tamarindus indica | Fabaceae | 13.8mg | Lal&Vishal Nath.,2017 [62] |
| 35. | Apple | Malus domestica | Rosaceae | 0.46±0.01mg/l | Jacobo et al,2011 [168] |
| 36. | Pear | Pyrus communis | Rosaceae | 5.5-8.4mg | Sanchez et al,2003 [143] |
| 37. | Peach | Prunus persica | Rosaceae | 3.6-12.6mg | Gill et al,2002 [51] |
| 38. | Plum | Prunus domestica | Rosaceae | 9.5mg | Gill et al, 2002 [51] |
| 39. | Strawberry | Fragaria'cananassa | Rosaceae | 54-62mg | Moor et al,2005 [105] |
| 40. | Sweet cherry | Prunus saviun | Rosaceae | 6.01-11.448mg | Gundogdu & Ugrur Bilge.,2012 [54] |
| 41. | Sour cherry | Prunus cerasus | Rosaceae | 5.45-22.11mg | Wotjydlo et al,2014 |
| 42. | Blackberry | Rubus armeniac | Rosaceae | 42.69-55.78mg | Guedes et al,2013 |
| 43. | Raspberry | Rubus idaeus | Rosaceae | 220.67- 310.89mg/kg | Ancos et al,2000 [7] |
| 44. | Blackcurrants | Ribes nigrum L. | Grossulariaceae | 7.60mg/g FW | Milivojevic et al,2010 |
| 45. | Apricot | Prunus armeniaca | Rosaceae | 62mg/g | Munzuroglu et al,2003 [110] |
| 46. | Kiwi | Actinidia delicosa | Actinidiaceae | 46.8mg(conventional) 51.4mg(organic) | Esch et al,2010 [177] |
| 47. | Persimmon | Diospyros kaki | Ebenaceae | 7.5-70mg | Yaqub et al,2016 [176] |
| 48. | Olive | Olea europaea | Oleaceae | 36.1mg | Lopez et al,2005 [159] |
| 49. | Almond | Prunus dulcis | Rosaceae | 0.030µg/g | Christian &Mark E.Ukhn.,2006 |
| 50. | Walnut | Juglans regia | Juglandaceae | 18.22±0.45mg/l | Ogunmoyole &Kade I.,2011 &Korodele B.,2011 [212] |
| 51. | Pecan nut | Carya illinoinensis | Juglandaceae | 1.1mg | Wakeling et al,2001 [168] |
| 52. | Pistachio nut | Pistacia vera L. | Anacardiaceae | 5.6,3mg(raw,roasted) | Bullo et al,2015 [19] |
| 53. | Macadamia nut | Macadamia integrifolia | Proteaceae | 1.2mg | Munro&Manohar L.Garg., 2008 |
| 54. | Chest nut | Castanea ohtsulip | Fagaceae | 400-693mg/kg DW | Baros et al,2011 |
| 55. | Hazel nut | Corylus avellana | Corylaceae | 2.45mg | Koskal et al,2006 |
Vitamin C effects on health and as human Immunity development: Mechanism of actions of Vitamin C

Vitamin C is a biological reducing agent especially during hydroxylations reactions and it is an antioxidant that protects the body against damaging oxidizing agents (Raman, 2009) [132].

Collagen synthesis

Collagen synthesis is essential for maintaining normal vascular function. It is a major structural protein of connective tissue (which binds cells and tissues together), bone, teeth, cartilage, skin and scar tissue. Vitamin C is specifically required by the fibroblast cells of connective tissue (responsible for collagen synthesis) and the bone forming osteoblasts within bone. Vitamin C acts as a cofactor non-heme iron α-ketoglutarate- dependent dioxygenases such as prolyl 4-hydroxylase by keeping in a catalytically active reduced state which is required for the action of specific hydroxylase enzymes required for the synthesis of collagens (Libby & Aikawa, 2002) [87]. Vitamin C deficiency may result in improper dentin layer formation in tooth (Srirlakshmi, 2011) [155]. The dentin layer of tooth does not form normally during vitamin C deficiency. This results in teeth that are structurally weak and more prone to mechanical injury and decay. Skin grafts to repair burned tissue have been found to heal more quickly when adequate vitamin C is present (Srirlakshmi, 2011) [154].

Carnitine synthesis

Vitamin C is required for the synthesis of carnitine. Carnitine is small nitrogen containing organic compounds involved in the transport of fatty acids into mitochondria to be oxidised to release energy for use by cells.

Regulation of hypoxia – inducible factor 1α

Ascorbate assists in the hydroxylation of Hypoxia Inducible Factor 1α (HIF-1α) which is responsible for the cellular response to low oxygen conditions (Semenza, 2001; Schofield and Ratcliffe, 2004) [146, 23]. When certain fast growing tumors create a hypoxic environment HIF - 1α hydroxylation is repressed which in turn promotes angiogenesis & tumour growth (Flashman et al, 2010) [43].

Activation of hormones

Many peptide hormones and hormone releasing factors are synthesised as precursor molecules that are enzymatically modified into their active forms. Vitamin C is essential for the activation of bombesin (human gastrin-releasing peptide) calcitonin, gastrin, oxytocin, thrythropin, corticotrophin, vasopressin, growth hormone- releasing factor.

Drug detoxification

Vitamin C is required for the optimal activity of various drug detoxifying metabolic systems within the body. These include the mixed function oxidase system and the flavin monooxygenase system in the liver.

Anti-oxidant action

In all of its known functions, vitamin C functions as a potent reducing agent that efficiently quenches potentially damaging free radicals produced by normal metabolic respiration of the body. At physiological concentrations, vitamin C is a potent free radical scavenger in the plasma, protecting cells against oxidative damage caused by ROS. The antioxidant property of ascorbic acid is attributed to its ability to reduce potentially damaging ROS, forming, instead, resonance-stabilized and relatively stable ascorbate free radical (AFR) serving as a one-electron donor. Within cells, NADH- and NADPH-dependent reductases have affinity for lesser radical concentrations and AFR is reduced to ascorbate. If the AFR significantly accumulates in areas not accessible to these enzymes, or if its concentration exceeds their capacity, two molecules of the AFR reactor dismutate to form one molecule each of ascorbate and DHA. This shows the cytoprotective functions such as prevention of oxidation induced DNA mutation, lipid protection against peroxidative damage and oxidized amino acid residue repair for protein integration. Since oxidative stress is involved in the pathogenesis of many morbid conditions, vitamin C (frequently administered in combination with other antioxidants) have been often used to prevent or treat several diseases due to its antioxidant properties.

A variety of damaging oxidizing agents occur in the body, as a result of normal metabolic processes and exposure to drug and environmental pollutants. Arrange of enzymes and antioxidant reducing agents (including vitamin E, Beta carotene and vitamin C) are able to convert these oxidising agents to harmless substances that can be excreted. It can also regenerate the reduced from of vitamin E converting that vitamin back into the form in which it can act as an antioxidant. Vitamin C is known to be involved in regulating cholesterol metabolism and in maintain the structure of blood vessels and the antioxidants affects of the vitamin might prevent tissue damage that leads to cardiovascular disease. Vitamin C is a reducing agent which acts against free radical produced by normal metabolic respiration. It is a free radical scavenger which protects cells against oxidative damage cause by ROS (Carr & B Frei, 1999; Iuzzi et al, 2012; Iuzzi et al, 2012; Marzocchella et al, 2011) [66, 67, 25, 78].

The anti-oxidant action of vitamin C accounts accounts for so many of in cytoprotective functions such as,

- Prevention of DNA mutation induced by oxidation (Lutsenko et al, 2002; Noroozí et al, 1998; Pflaum et al, 1998; Sweetman et al, 1997) [90, 117, 127, 156].
- Protection of lipids from peroxidative damage (Barja et al, 1994; Kimura et al, 1992) [12, 72].
- Maintaining protein integrity (Barja et al, 1994; Cadenas et al, 1998; Hoey & Butler, 1984; Heitger et al, 2001) [12, 61].

This makes vitamin C suitable to prevent or treat several diseases.

Iron Metabolism

Vitamin C acts as reducing agent that is able to keep ferric ions in ferrous form and facilitate absorption. Vitamin C forms soluble complexes with ferric ions, which preserve the iron solubility on the more alkaline duodenal pH. Vitamin C also assists in the transfer of iron from blood plasma into ferritin for storage in the liver as well as the release of iron from ferritin when required. The role of ascorbate in iron metabolism is related not only to enhanced absorption but also to intracellular metabolism of iron binding protein (Srirlakshmi, 2011) [154]. Vitamin C also aids calcium absorption by preventing the incorporation of calcium into insoluble complexes. Vitamin C converts inactive form of folic acid inot its active form dihydrofolic acid and tetra hydro follic acid and also stabilises the active form. Vitamin C
alleviates allergic reactions, enhances immune function, stimulates formation of bile and facilitates the release of some steroid hormones. Vitamin C is necessary for the conversion of cholesterol to bile acids and has been reported to be involved in the detoxification of many chemical carcinogens.

**Pro – oxidant action**
In conditions such as low concentration acid or in the presence of free transition metals, such as copper and iron, Vitamin acts as function as a pro-oxidant. vitamin c acts as a pro-oxidants (Buettnet & Jurkiewicz, 1996) [18]. Metal ions are indeed reduced by ascorbate and, in turn, may react with hydrogen peroxide leading to the formation of highly reactive and damaging hydroxyl radicals. The pro-oxidant activity of vitamin C leads to the formation of ROS or glycated proteins. On the other hand, in vitro model suggested that certain prooxidant effects of ascorbate such as the capacity to promote protein thiol oxidation in rat liver microsomes can also be advantageous.

The activity leads to the formation of ROS or glycated proteins (Barja et al., 1994; 51 Kimura et al., 1992) [12, 72]. But researcher also suggest that in some cases the pro – oxidant action of vitamin C can be advantageous.

**Anti-carcinogenic effects of vitamin c**
Since the mid 90’s, it has been theorized that vitamin c might reduce the incidence of malignancies. High therapeutic dose of vitamin c administered intravenously has been found to increase the average survival of advanced cancer patients in addition to the benefit of increased wellbeing and reduced pain. This is due to the anti – inflammatory action of vitamin c which prevents DNA mutation induced by oxidation. High plasma concentrations of vitamin c neutralizes mutagenic ROS and decreases oxidative stress-induced damage to the cellular DNA.

The pro-oxidant function of vitamin C makes it cancer cell killer given it is administered intravenously. This action is achieved by the formation of H$_2$O$_2$ diffuses into tumor cells and causes damage to the DNA and mitochondria, killing the cells rapidly (Hyslop et al., 1998; Ahmad et al., 2005; Comelli et al., 2003; Renis et al., 2008; Mc Cormick, 1959) [63, 3, 30, 92, 101].

Vitamin C’s role in increasing collagen synthesis and decreasing hyaluronidase (Cameron & Rotman, 1972) [23] is also hypothesized to prevent cancer spread by increasing the extracellular matrix and mechanically blocking metastasis (Cameron et al., 1979; Bei et al., 2012; Bei et al., 2009) [24].

Despite all of this, there still exists a controversy in the therapeutic action of vitamin C in cancer patients due to failure of studies and inconsistent results which was only be solved by further researchers (Creagan et al., 1979; Moertel et al., 1985) [34].

**Vitamin C and cardiovascular diseases**
Vitamin C, being a free radical scavenger, prevents ROS mediated cardiovascular diseases (Izzi et al., 2012; Izzi et al., 2012; Taniyama & K K Griending, 2003; Bei et al., 2011; Fiaccavento et al, 2006; Masuelli et al., 2008) [66, 67, 159, 42, 100].

The collagen synthesis property helps from proper folding of triple helical collagen which strengthens extracellular matrix without which blood vessels and especially capillaries become prone to rupture (Sotiriou et al., 2002) [153]. Vitamin C also prevents apoptosis in endothelial cells in addition to prevention of potent endothelial dysfunction (Nakata & Maeda, 2002) [112].

**Role of Vitamin C in critically ill patients**
Vitamin C concentration in plasma and leukocytes in critically ill patients have given the impression that it is inversely related to multiple organ failure and directly to survival. Vitamin C and other anti – oxidants are shown to increase speed of recovery in patients with sepsis (Recchioni et al., 2002; Rossig et al, 2001; Saeed et al, 2003; Schor et al, 1983) [139, 141, 142, 147]. Vitamin C also Improves receptiveness to norepinephrine, angiotensin and vasopressin (vasoconstrictors) which is of great use in patients with CVD (Ferlitsch et al., 2005; Pleiner et al, 2003) [41, 130]. Ascorbate also prevents edema by restricting endothelial permeability (Kirsch & de, 2000) [73].

**Vitamin C effects on nervous system**
**Neurotransmitter synthesis:** Vitamin C is required to sustain the activity of the copper containing enzyme dopamine oxygenase, which catalyses the oxidation of dopamine to form the neurotransmitter norepinephrine. Vitamin C also appears to be involved in the hydroxylation of tryptophan during the biosynthesis of serotonin. The involvement of vitamin C in the synthesis of neurotransmitters probably explains the presence of high concentration of vitamin C in brain and adrenal tissues.

Vitamin C seems to have improved neurotransmission this enhancing processes such as learning, memory and locomotion (Grunewald, 1993; Rebec & Pierce, 1994) [2, 138]. Oral intake of vitamin C has been observed to reduce fear in animal experiments (Parle & Dhinra, 2003; De & Furlan, 1995) [125, 134]. Adequate dietary intake of vitamin C has shown reduced incidence of Alzheimer’s disease (Morris et al, 1998; Engelhart et al) [106]. It can also use to protecting against parkinson’s disease by increasing the bio availability of levodopa (Nagayama et al, 2004) [111].

**Vitamin C in ocular diseases**
The combination of ascorbate with certain other anti – oxidant vitamins and minerals slows down the progression of cataract, macular degeneration and other causes which lead to loss of visual acuity (Fan et al, 2006; Evans,2008; Evans & Henshaw,2008; Jesus et al, 2008) [40, 38, 39, 88].

**Effect of processing on retention of Vitamin C content in fruits**
Fruits are the major source of natural vitamin C and is present in reduced (L-ascorbic acid, AsA) and oxidized (L-dehydroascorbic acid monomer, DHA) form. Both AsA and DHA exhibit vitamin C activity and the AsA could transform into DHA by enzymatic and nonezymatic oxidation during processing and storage (Martí et al., 2009; Wechtersbach et al., 2011) [97, 171].

Vitamin C is also essential for the synthesis of collagen, radical scavenger activity and NO-sparing function and has been widely applied in the cosmetic industry (Phillips et al., 2016) [128]. With so many important roles, the retention of vitamin C in products has been regarded as a reliable and representative index during their processing (Giannakourou and Taoukis, 2003; Xiao et al., 2014) [50, 174].

Thermal processing is frequently used for vegetables and fruits preservation processes, such as blanching, drying, and cooking etc. However, vitamin C can be easily degraded and very sensitive to various external factors, especially high
Factors influencing the degradation of Vitamin C

The vitamin C has the least stability among all kinds of vitamins and is easily destroyed during processing and storage, depending on many variables such as pH (Munyaka et al., 2010; Wechtersbach et al., 2011) \[171\], temperature (Rattanathanalert et al., 2005; Tiwari et al., 2009) \[124\], light (Zhan et al., 2012; Noichinda et al., 2007) \[177, 116\], and the presence of enzymes (Munyaka et al., 2010), oxygen (Martínez-Sánchez et al., 2011) \[98\], hydrogen peroxide (Ozkam et al., 2004) \[152\], and metallic catalysts (Santos and Silva, 2008; Santos and Silva, 2009; Lee and Kader, 2000) \[84, 167\]. It is illustrated in Fig. 1.

Effect of oxygen

The vitamin C degradation is closely associated with oxygen. Blanching is frequently employed to slow down or hinder the production of water and dehydroascorbic acid (Nishikawa et al., 2004) \[93\]. It has been demonstrated that ascorbic acid degradation is closely related to ascorbic acid oxidase (AAO) and ascorbic acid peroxidases (APx) by facilitating oxidation of vitamin C (Nishikawa et al., 2003; Munyaka et al., 2010) \[114\]. AAO catalyses the oxidation of ascorbic acid in the presence of molecular oxygen resulting in dehydroascorbic acid and water, while APx catalyses the reduction of hydrogen peroxide by ascorbic acid, leading to the production of water and dehydroascorbic acid (Nishikawa et al., 2003; D’ébrowska et al., 2007) \[114, 32\]. Therefore, blanching is frequently employed to slow down or hinder the vitamin C degradation by destroying the AAO, PPO and POD enzymes.

Effect of temperature

Vitamin C belongs to the heat sensitive substance. It is believed that the higher processing temperature the higher losses of vitamin C in the products (Munyaka et al., 2010; Leong and Oey, 2012; Wawire et al., 2011; Phillips et al., 2016) \[85, 86, 170, 128\]. Kuljarachanan et al. (2009) \[75\] reported that drying temperature was the major factor controlling the degradation of vitamin C in lime residues and the higher drying temperature results in lower vitamin C content. Processing at lower temperatures, such as by freeze-drying, is more effective in preserving vitamin C. Barbosa et al. (2015) \[11\] compared the influence of spray drying, freeze drying and convective hot air drying on vitamin C content of orange powder. The result showed that total vitamin C content for freeze and convective dried sample was 22.2±1.4 mg/100mL and 14.0±1.9 mg/100mL, respectively. Higher vitamin C retention was obtained with high temperature due to the short processing time consumed. For example, the use of ultra-high temperature (UHT, 135-140 oC, 3-4 s) for juice to prevent microorganism spoilage and contamination of pathogens, results in higher nutrition (including vitamin C) retention than lower temperature long time (LTLT, 60 oC, 30 min) pasteurization and high temperature short time (HTST, 72-75 oC 20 s or 82-85 o C, 15 s) pasteurization (Chavan et al., 2016) \[28\]. During hot air drying at 40, 50, 60, and 70 o C, the highest ascorbic acid degradation of papaya at the lowest temperature (40 oC) was found by Kurozawa et al. (2014) \[76\], who attributed this phenomenon to the longest drying time. Similar findings have also been reported by Marfil et al. (2008) \[80\], Kaya et al. (2010), and Mrad et al. (2012) \[107\].

Effect of Light

During the growing season of vegetables and fruits, the amount and intensity of light have a definite influence on the quantity of vitamin C formed, which is related to synthesis from sugars supplied through photosynthesis in plants. Generally, the higher the light intensity during growth, the higher the ascorbic acid content in plant tissues (Lee and Kader, 2000) \[84, 167\].

Effect of enzymes

Enzymes, such as ascorbic acid oxidase (AAO), polyphenol oxidase (PPO) and peroxidase (POD) present in almost all fruits, not only causes loss of organoleptic qualities including color and off-flavor by enzymatic reactions but also degradation of nutrients though redox reactions during processing, transportation and storage (Mai and Glomb, 2013; Altunkaya and Gökmen, 2008) \[93, 5\]. It has been demonstrated that ascorbic acid degradation is closely related to ascorbic acid oxidase (AAO) and ascorbic acid peroxidases (APx) by facilitating oxidation of vitamin C (Nishikawa et al., 2003; Munyaka et al., 2010) \[114\]. AAO catalyses the oxidation of ascorbic acid in the presence of molecular oxygen resulting in dehydroascorbic acid and water, while APx catalyses the reduction of hydrogen peroxide by ascorbic acid, leading to the production of water and dehydroascorbic acid (Nishikawa et al., 2003; D’ébrowska et al., 2007) \[114, 32\]. Therefore, blanching is frequently employed to slow down or hinder the vitamin C degradation by destroying the AAO, PPO and POD enzymes.

Fig 1: Factors influencing the degradation of Vitamin C

Effect on pH

The pH influences not only ascorbic acid accumulation during plants’ growth but also the stability during post-harvest storage. It is well known that low pH could enhance the stability of vitamin C, especially for DHAA. On the other hand, acid such as hydroxyl acid, citric and malic can dissociate a large number of hydrogen ions (H+) which in turn stabilize vitamin C by chelating prooxidant metals. On the other hand, low pH inactivate enzymes (such as ascorbic acid oxidase, ascorbic acid peroxidases) can hinder the degradation of vitamin C.

Effect of temperature

Vitamin C belongs to the heat sensitive substance. It is believed that the higher processing temperature the higher...
very useful protective atmosphere to prevent oxidation of vitamin C (Ramesh et al., 1999) [133]. The vitamin C retention of papaya and guava in inert gas heat pump dryer was higher than the product dried under normal air (Hawlader et al., 2006) [58]. The most commonly used inert gases are nitrogen, carbon dioxide, superheated steam. Furthermore, decreasing the area exposed to the oxygen can also reduce the degradation of vitamin C.

**Effect of water activity**

Vitamin C destruction rates increased with increased water activity, and vitamin C was more rapidly destroyed in desorption system than in the adsorption system due to decrease in viscosity and possible dilution in the aqueous phase (Lee and Labuza, 1975; Laing et al., 1978) [83, 81]. The effect of water content on vitamin C degradation is more complex compared with other factors as water content brings both negative and positive effect at the same time (Santos and Silva, 2008). High water content brings negative effect on vitamin C degradation by diluting the ascorbic acid concentration, which results to a lower degradation rate.

**Retention of Vitamin C content by advances Processing Methods**

In the area of advanced processing technologies covers technology for both preparation and preservation of foods and biomaterials. These include high-pressure processing and use of various electric methods such as microwave, pulsed electric fields and between electric fields, ohmic processing. One tremendous advantage of these advanced methods is the uniform application of pressure or electric fields to the product as a whole, rather than needing to rely on heat or freezing temperature penetration from the external surface to the container. During pressurization, the heating of the material is generally less than if temperature was the only means of preservation. Electric field processing generates heat locally, which also minimizes the amount of heat required. Advanced processes therefore minimize the temperature (and hence the quality) gradient in the product and shorten the process time required. (Diane et al.,2011) [36].

**High Pressure processing (HPP)**

Somya Tewari et al. (2016) [152] stated that High pressure processed foods have a better stability of AA during refrigeration storage as compared to thermally processed ones. These studies establish the positive implications of HPP and justify its potential use as a promising preservation technique to safeguard AA in food products. Sanchez-Moreno et al. (2009) [144] summarized a number of recent manuscripts on a variety of fruit and vegetable pieces, purees and juices in which vitamin C retention after HPP processing was generally above 80%.

**Microwave processing**

Picouet et al. (2009) [129] found that total vitamin C content in apple puree was similar before and after the microwave process, however, ascorbic acid content decreased (43% retention) and dehydroascorbic acid increased (57%). As mentioned above, vitamin C content in microwaved apricots was reported to increase 260% (Karatas and Kamsli, 2007) [71]. In a comparison of vitamin C content in tomatoes, Begum and Brewer (2001) [14] found that the content of this vitamin decreased after boiling-water blanching (65% retention), but there was only 10% loss after the microwave blanching method. Wojdylo et al. (2009) [172] studied the effect of microwave vacuum drying on strawberries, in a very thorough manuscript which reported results on a dry weight basis. Microwave energy levels of 240, 360 and 480 W were utilized, and vitamin C losses were only 13–40%, with the highest losses occurring under the 480 W conditions.

**Freeze drying**

Freezing drying is considered as one of the best methods to keep the quality attributes of the materials submitted to drying processes since the combination between absence of liquid water and low temperature stop most degradation reactions (Ratti, 2001) [137], Nogueira et al. (1978) [115] freeze-dried red guava pulp and its ascorbic acid content was retained by 92%. Guava was also freeze-dried by Marques et al.(2006) [96]. Chang et al.(2006) [27] carried out drying experiments with two different tomato varieties was large. Considering both varieties, the retention of ascorbic acid in freeze-dried tomato cubes was higher than 90% without any sample pre-treatments. During the freeze-drying process, the temperature of the product is pretty low, which reduces degradation reactions and does not make the drying time crucial.

To obtain the maximum vitamin C retention, many innovative technologies have been explored, such as vacuum, freeze-drying, microwave and High pressure processing etc. With high-quality demand for processed food, determination of vitamin C degradation during processing should give more priorities in the future research and for optimization of the processing for vitamin C preservation.

**Conclusion**

The paper is a quintessence of developments in the inclusion of diet which will fortify human immune system amidst the pandemic cloudiness that has bordered the world and individual’s biological system. Already known activity of ascorbic acid as potential antioxidant, also plays a role in drug detoxification, iron metabolism and many metabolic pathways involved in immune system are always in need of Vitamin C. There has been presented a fruit sources of vitamin C in a capsule form which are of wide habitats and readily available at our vicinity. The spotlight on per daily requirements imposes the need of regular uptake of the same so as to get enhanced results. Second important highlight of the paper in the attempts made to preserve Vitamin C while processing which is otherwise degraded due to multiple factors. Sensitivity of Vitamin C even to light shows the importance of improved processing techniques. Finally the promising nature of the High pressure processing than thermal processing; potential reduction in degradation loss of Vitamin C by microwave vaccum drying and freeze drying has widened the roads towards improved immunity of the human biological system.

**References**

1. Munro Irene A, Manohar L Garg. Nutrient Composition and Health Beneficial Effects of Macadamia Nuts. Nutraceutical Science and Technology (tree nuts), 2008, 249-257.
2. Grunewald RA. Ascorbic acid in the brain. Brain Res Brain Res Rev. 1993; 18:123-133 207-220.
3. Ahmad IM, Aykin-Burns N, Sim JE, Walsh SA, Higashikubo R, Buettnr GR et al. Mitochondrial O2*- and H2O2 mediate glucose deprivation-induced stress in human cancer cells. J Biol Chem. 2005; 280:4254-4263
4. Ahmed T, Burhanuddin M, Haque MA, Hossain MA. Preparation of Jam from Sapota (Achras zapota). A Scientific Journal of Krishi Foundation. The Agriculturists. 2011; 9(1&2):1-7

5. Altunkaya A, Gökmén V. Effect of various inhibitors on enzymatic browning, antioxidant activity and total phenol content of fresh lettuce (Lactuca sativa). Food Chemistry. 2008; 107(3):1173-1179.

6. Amoo IA, Emenike AE, Akpambang VOE. Compositional Evaluation of Annona cherimoya (Custard Apple) Fruit. Trends in Applied Science Research. 2008; 3(2):216-220.

7. Ancos Begona de, Eva Gonza’lez M, Pilar Cano M, Ellagic Acid, Vitamin C, and Total Phenolic Contents and Radical Scavenging Capacity Affected by Freezing and Frozen Storage in Raspberry Fruit. Journal of Agriculture and Food Chemistry. 2000; 48:4565–4570.

8. Asenjo CF and Freire De Guzman AR. The High Ascorbic Acid Content in West Indian Cherr. Science (Washington). 1946; 103:219.

9. Ashraf Muhammad Aqeel, Mohd. Jamil Maah and Ismail Yusuf. Estimation of Antioxidant Phytochemicals in Four Different Varities of Durian (Durio zibethinus murray) Fruit. Middle-East Journal of Scientific Research. 2010; 6(5):465-471

10. Bielski BH, Allen AO, Schwarz H A. Mechanism of disproportionation of ascorbate radicals. J Am Chem Soc. 1981; 103:3516-3518.

11. Barbosa J, Borges S, Amorim M, Pereira MJ, Oliveira A, Pintado ME, Teixeira P. Comparison of spray drying, freeze drying and convective hot air drying for theproduction of a probiotic orange powder. Journal of Functional Foods. 2015; 17:340-351.

12. Barja G Lopez-Lorez M, Perez-Campo R, Rojas C, Cadenas S, Prat J et al. Dietary vitamin C decreases endogenous protein oxidative damage, malondialdehyde, and lipid peroxidation and maintains fatty acid unsaturation in the guinea pig liver. Free Radic Biol Med. 1994; 17:105-115.

13. Barros Ana IRNA, Ferando M, Nunes, Berta Gonçalves, Richard N. Bennett, Ana Paula Silva. Effect of cooking on total vitamin C contents and antioxidant activity of sweet chestnuts (Castanea sativa Mill.). Food Chemistry. 2011; 128:165-172.

14. Begum S, Brewer MS. Chemical, nutritive and sensory characteristics of tomatoes before and after conventional andmicrowave blanching and during frozen storage. J Food Qual. 2001; 24:1–15.

15. Bei RC, Palumbo L, Masuelli M, Turriziani GV, Frajese G, Li Volti M, Malaguarnera F, Galvano: Impaired expression and function of cancer-related enzymes by anthocyanins: an update. Curr Enzyme Inhib. 2012; 8:2-21

16. Bei RL, Masuelli M, Turriziani G, Li Volti M, Malaguarnera F, Galvano: Impaired expression and function of signaling pathway enzymes by anthocyanins: role on cancer prevention and progression. Curr Enzyme Inhib. 2009; 5:184-197

17. Birlouez-Aragon FJ Tessler: Antioxidant vitamins and degenerative pathologies. A review of vitamin C. J Nutr Health Aging. 2003; 7:103-109.

18. Buettner GR, Jurkiewicz BA. Catalytic metals, ascorbate and free radicals: combinations to avoid. Radiat Res. 1996; 145:532-541

19. Bullo M, Juanola-Falgarona M, Hernañdez-Alonso P and Salas-Salvadó J. Nutrition attributes and health effects of pistachio nuts. British Journal of Nutrition. 2015; 113:S79–S93

20. Buring: Vitamins E and C in the prevention of prostate and total cancer in men: the Physicians' Health Study II randomized controlled trial JAMA. 2009; 301:52-62.

21. Schofield CJ, Ratcliffe PJ. Oxygen sensing by HIF hydroxylases. Nat Rev Mol Cell Biol. 2004; 5:343-354.

22. Cadenas C, Rojas G, Barja. Endotoxin increases oxidative injury to proteins in guinea pig liver: protection by dietary vitamin C. Pharmacol Toxicol. 1998; 82:11-18.

23. Cameron ED, Rotman: Ascorbic acid, cell proliferation, and cancer. Lancet. 1972; 1:1542.

24. Cameron EL, Paulung B, Leibovitz. Ascorbic acid and cancer: a review. Cancer Res. 1979; 39:663-681.

25. Carr AB Frei. Does vitamin C act as a pro-oxidant under physiological conditions? FASEB J. 1999; 13:1007-1024

26. Chaira Nizra, Abdesselam Mrabet An Ferchichi. Evaluation of Antioxidant Activity, phenolics, Sugar and Mineral contents in Date palm fruits. Journal of Food Biochemistry. 2009; 33(3):390-403.

27. Chang C, Lin H, Chang C, Liu Y. Comparisons on the antioxidant properties of fresh, freeze-dried and hot-air-dried tomatoes. Journal of Food Engineering. 2006; 77:478–485.

28. Chavan RS, Sehrawat R, Mishra V, Bhatt S. Milk: processing of milk. Encyclopedia of Food and Health, 2016; 729-735.

29. Christian Agatemor, Mark E Ukhn. Nutritional Potential of the Nut of Tropical almond (Terminalia Catappia L.). Pakistan Journal of Nutrition. 2006; 5(4):334-336

30. Comelli M, Di PF, Mavelli I. Apoptosis is induced by decline of mitochondrial ATP synthesis in erythroleukemia cells. Free Radic Biol Med. 2003; 34:1190-1199.

31. Creagan E, Moertel TCG, O'Fallon JR, Schutt AJ, O'Connell MJ, Rubin J et al. Failure of high-dose vitamin C (ascorbic acid) therapy to benefit patients with advanced cancer. A controlled trial. N Engl J Med. 1979; 301:687-690.

32. D'hrowska G, Kata A, Goc A, Szychynska M, Skrzypek E. Characteristics of the plant ascorbate peroxidase family. Acta Biologica Craciensia Series Botanica. 2007; 49(1):7-17.

33. Daniel Esther Peterson, Hazel E. Munsell. The vitamin A, B, C and G content of Sultanina and Malaga grapes and two brands of commercial grape juice. Journal of Agricultural Research. 1932; 1(44):63-66.

34. De AL, Furlan C. The effects of ascorbic acid and oxiracetam on scopolamine-induced amnesia in a habituation test in aged mice. Neurobiol Learn Mem. 1995; 64:119-124.

35. Devaki SJ, Reshma LR. Vitamin C: Sources, Functions, Sensing and Analysis, book vitamin C http://dx.doi.org/10.5772/intechopen.70162. 2017, 1-20.

36. Diane M, Barrettd Bate Lloyd. Advanced preservation methods and nutrient dopaminergic and glutamatergic transmission. Prog Neurobiol 1994; 43:537-565.

37. Esch Julia R, Jeffrey R. Friend, James K. Kariuki. Determination of the Vitamin C Content of Conventionally and Organically Grown Fruits by Cyclic Voltammetry. International Journal of Electrochemical Science. 2010; 5:1464–1474.

http://www.thepharmajournal.com
38. Evans JR, Henshaw K. Antioxidant vitamin and mineral supplements for preventing age-related macular degeneration. Cochrane Database Syst Rev, 2008, CD000253.

39. Evans J. Antioxidant supplements to prevent or slow down the progression of AMD: a systematic review and metaanalysis. Eye (Lond). 2008; 22:751-760.

40. Fan X, Reneker LW, Obrenovich ME, Strauch C, Cheng R, Jarvis SM et al. Vitamin C mediates chemical aging of lens crystallins by the Maillard reaction in a humanized mouse model, Proc Natl Acad Sci USA. 2006; 103:16912-16917.

41. Fellerth A, Pleiner F, Mittermayer G, Schaller M, Honomick M, Peck-Radosavljevic M, Wolzt Vasoconstrictor hyporeactivity can be reversed by antioxidants in patients with advanced alcoholic cirrhosis of the liver and ascites. Crit Care Med. 2005; 33:2028-2033.

42. Fiaccavento RF, Carotenuto M, Minieri L, Masuelli A, Vecchini R, Bei A et al. Alpha-linolenic acid-enriched diet prevents myocardial damage and expands longevity in cardiomypathic hamsters. Am J Pathol. 2006; 169:1913-1924.

43. Flashman E, Davies SL, Yeoh KK, Schofield CJ. Investigating the dependence of the hypoxia-inducible factor hydroxylases (factor inhibiting HIF and prolyl hydroxylase domain 2) on ascorbate and other reducing agents. Biochem J. 2010; 427:135-142.

44. Food and Nutrition Board. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, Carotenoids. Washington, DC: National Academy Press, 2000.

45. Fowomola MA. Some nutrients and antinutrients contents of mango (Mangifera indica) seed. African Journal of Food Science. 2010; 4(8):472-476.

46. Ribeiro Sonia Machado Rocha, Jose Humberto de Queiroz, Maria Eliana Lopes Ribeiro de Queiroz, Flavia Milagres Campos and Helena Maria Pinheiro Santana. Antioxidant in Mango (Mangifera indica L.) Pulp. Plant Foods for Human Nutrition. 2007; 62:13–17.

47. Buettner GR, Jurkiewicz WA. Catalytic metals, ascorbate and free radicals: combinations to avoid. Radiat Res. 1996; 145:532-541.

48. Buettner GR. The pecking order of free radicals and antioxidants: lipid peroxidation, alpha-tocopherol, and ascorbate. Arch Biochem Biophys. 1993; 300:535-543.

49. Ghasemnezhad Mahmoud, Mostafa Ashour Nezhad, Somayeh Geralloo. Changes in Postharvest Quality of Loquat (Eriobotrya japonica) Fruits Influenced by Chitosan. Horticulture, Environment, Biotechnology. 2011; 52(1):40-45.

50. Giannakourou MC, Taoukis PS. Kinetic modelling of vitamin C loss in frozen green vegetables under variable storage conditions. Food Chemistry. 2003; 83(1):33–41.

51. Gill Maria I, Francisco A. Tomas-Barberan, Betty Hess-Pierce, Adel A Kader. Antioxidant Capacities, Phenolic Compounds, Carotenoids, and Vitamin C Contents of Nectarine, Peach, and Plum Cultivars from California. Journal of Agricultural and Food Chemistry. 2002; 50:4976–4982.

52. Golberg Leon, Leopold Levy. Sep Vitamin C Content of Fresh, Canned and Dried Guavas. Nature. 1941; 148:286.

53. Guedes Mayara Neves Santos, Celeste Maria Patto de Abreu, Luana Aparecida Castilho Maro, Rafael Pio José Renato de Abreuand João Otávio de Oliveira. Chemical characterization and mineral levels in the fruits of blackberry cultivars grown in a tropical climate at an elevation. Acta Sciitarium Agronomy. 2013; 35(2):191-196.

54. Gundogdu Muttalip, Ugur Bilge. Determination of Organics, Phenolics, Sugars and Vitamin C Contents of some Cherry Cultivars (Prumus avium). International Journal of Agriculture & Biology. 2012; 14(4):595-599.

55. Guvenc Mehmet, Mehmet Tczu and Okkes Yilmaz. Analysis of fatty acid and some lipophilic vitamins found in the fruits of the Ficus carica variety picked from the Aydyanman District. Research Journal of Biological Sciences. 2009; 4(3):320–323.

56. Stich HF, Karim J, Koropatnick J, Lo L. Mutogenic action of ascorbic acid. Nature. 1976; 260:722-724.

57. Ughr, catak J, Mizrak OF, Cebi N, Yaman M. Determination and evaluation of in vitro bioaccessibility of added vitamin C in commercially available fruit-, vegetable-, and cereal-based baby foods, Food chemistry, 2020, 122:

58. Hawlader MNA, Perera CO, Tian M, Yeo KL. Drying of guava and papaya: Impact of different drying methods. Drying Technology. 2006; 24:77–87.

59. Heitzer T T, Schlinzing K, Krohn T, Meieritz T, Munzel Endothelial dysfunction, oxidative stress, and risk of cardiovascular events in patients with coronary artery disease. Circulation. 2001; 104:2673-2678.

60. Hernández Y, Lobo MG, Gonzalez M. Determination of vitamin C in tropical fruits: A comparative evaluation of methods. Food Chemistry. 2006; 96(4):654–664.

61. Hoey BM, Butler J. The repair of oxidized amino acids by antioxidants. Biochim Biophys Acta. 1984; 791:212–218.

62. Huang AS, Titchenal CA, Meilleur BA. Nutrient Composition of Taro Corms and Breadfruit. Journal of Food Composition and Analysis. 2000; 13:859-864.

63. Hysslop PA, Hinshaw DB, Halsey WA, Jr., Schraufstatter IU, Sauerheber RD, Spragg RG et al. Mechanisms of oxidant-mediated cell injury. The glycolytic and mitochondrial pathways of ADP phosphorylation are major intracellular targets inactivated by hydrogen peroxide. J Biol Chem. 1988; 263:1665-1675.

64. Ibrahim M Islam MS, Helali MOH, Alam AKMS, Shafique MZ. Morphological fruit characters and nutritional food value of different jackfruit (Areacarpus heterophyllus Lam.) cultivars in Rajshahi region of Bangladesh. Bangladesh Journal of Scientific and Industrial Research. 2013; 48(4):287-292.

65. Isabelle M, Lee LB, Lim TM, Koh PW, Huang D, Ong NC. Antioxidant activity and profiles of common fruits in Singapore. Food Chemistry. 2010; 123:77–84.

66. Izzi V L, Masuelli I, Tresoldi C, Foti A, Modesti R, Bei. Immunity and malignant mesothelioma: from mesothelial cell damage to tumor development and immune response-based therapies. Cancer Lett. 2012; 322:18-34.

67. Izzi VL, Masuelli I, Tresoldi P, Sacchetti A, Modesti F, Galvano R, Bei. The effects of dietary flavonoids on the action of ascorbic acid. Nature. 1976; 260:722-724.

68. Jacobo Angela Suárez, Corinna E. Rüfer, Ramón Gervilla, Buenaventura Guaman, Artur X. Roig-Sagués, Jordi Saldo. Influence of ultra-highpressure homogenisation on antioxidant capacity, polyphenol and vitamin content of clear apple juice. Food Chemistry.
The Pharma Innovation Journal

2011; 127(2):447-454.

69. Jain Shashi Kumar, Khurdiya DS. Vitamin C Enrichment of Fruit Juice Based Ready-to-Serve Beverages through Blending of Indian Gooseberry (Embilica officinalis Gaertn.) Juice. Plant Foods for Human Nutrition. 2004; 59:63-66.

70. Jun Wang, Chung-Lim Law AS, Mujumdar and Hong-Wei Xiao. The Degradation Mechanism and Kinetics of Vitamin C in Fruits and Vegetables During Thermal Processing. Drying Technologies for Foods, 2017, 276-301. https://www.researchgate.net/publication/319527724.

71. Karatas F, Kamsl F. Variations of vitamins (A, C and E) and MDA in apricots dried in IR and microwave. J Food Eng. 2007; 78:662–668.

72. Kimura HY, Yamada Y, Morita H, Ikeda T. Matsuo: Dietary ascorbic acid depresses plasma and low density lipoprotein lipid peroxidation in genetically scorbritic rats. J Nutr. 1992; 122:1904-1909.

73. Kirsch M, de GH. Ascorbate is a potent antioxidant against peroxynitrite-induced oxidation reactions. Evidence that ascorbate acts by re-reducing substrate radicals produced by peroxynitrite. J Biol Chem 2000; 275:16702-16708.

74. Koksal A Ilhami, Nevzat Artik, Atilla Simsek, Nurdan Gunes. Nutrient composition of hazelnut (Corylus avellana L.) varieties cultivated in Turkey. Food Chemistry. 2006; 99:509–515.

75. Kutlarachanan T, Devahastin S, Chiewchan N. Evolution of antioxidant compounds in lime residues during drying. Food Chemistry. 2009; 113(4):944-949.

76. Kurozawa LE, Terng I, Hubinger MD, Park KJ. Ascorbic acid degradation of papaya during drying: Effect of process conditions and glass transition phenomenon. Journal of Food Engineering. 2014; 123:157-164.

77. Kyle RA, Shampo MA. Albert Szent-Gyorgyi-Nobel laureate. Mayo Clinic Proceedings. 2000; 75(7):722.

78. Marzocchella L, Fantini M, Benvenuto M, Masueli L, Tresoldi I, Modesti A et al. Dietary flavonoids: molecular mechanism of action as anti-inflammatory agents. Recent Pat Inflamm Allergy Drug Discov. 2011; 5:200-220.

79. Wakefield LM, Cass AE, Radda GK. Electron transfer across the chromaffin granule membrane. Use of EPR to demonstrate reduction of intravesicular ascorbate adical by the extravesicular mitochondrial NADH: ascorbate radical oxido-reductase. J Biol Chem. 1986; 261:9746-9752

80. Schulze HR, Gallenkamp H, Staudinger H Microsomal NADH-dependent electron transport). Hoppe Seylers Z Physiol Chem. 1970; 51:809-817.

81. Laing BM, Schlüeter DL, Labuza TP. Degradation kinetics of ascorbic acid athigh temperature and water activity. Journal of Food Science. 1978; 43(5):1440-1443.

82. Lal Narayan, Vishal Nath. Sweet Tamarind, 2017, 901-909

83. Lee SH, Labuza TP. Destruction of ascorbic acid as a function of water activity. Journal of Food Science. 1975; 40(2):370-373.

84. Lee SK, Kader AA. Preharvest and postharvest factors influencing, 2000.

85. Leong SY, Oey I Effect of endogenous ascorbic acid oxidase activity and stability on vitamin C in carrots (Daucus carota subsp. sativus) during thermal treatment. Food Chemistry. 2012; 134(4):2075-2085.

86. Leong SY, Oey I. Effects of processing on anthocyanins, carotenoids and vitamin C in summer fruits and vegetables. Food Chemistry, 2012; 133(4):1577-1587.

87. Libby PM. Aikawa Vitamin C, collagen, and cracks in the plaque. Circulation. 2002; 105:1396-1398.

88. Lopes de Jesus CC, Atallah AN, Valente O, Moca Traversini VF. Vitamin C and superoxide dismutase (SOD) for diabetic retinopathy. Cochrane Database Syst Rev, 2008, CD006695.

89. Lopez A, Montano A, Garrido A. Quantification of Ascorbic Acid and Dehydroascorbic Acid in Fresh Olives and in Commercial Presentations of Table Olives. Food Science and technology International, 2005, 11(3):

90. Lutsenko EA, Carcano DW, Golde Vitamin C prevents DNA mutation induced by oxidative stress. J Biol Chem. 2002; 277:16895-16899

91. Csala M, Braun L, Mile V, Kardon T, Szarka A, Kupcsulik P et al. Ascorbate-mediated electron transfer in protein thiol oxidation in the endoplasmic reticulum. FEBS Lett. 1999; 460:539-543.

92. Renis M, Calandra L, Scifo C, Tomaselbo B, Cardile V, Vanella L et al. Response of cell cycle/stress-related protein expression and DNA damage upon treatment of CaCo2 cells with anthocyanins. Br J Nutr. 2008; 100:27-35.

93. Mai F, Glomb MA. Isolation of phenolic compounds from iceberg lettuce andimpact on enzymatic browning. Journal of Agricultural and Food Chemistry, 2013; 61(11):2868-2874.

94. Manurakchinakorn Supranee, Pattama Intavong, Pilapa Yuemnan, Salisa Tonwattana, Amonrat Pankong. Changes in Ascorbic Acid Content, Antioxidant Capacity and Sensory Quality of Fresh-cut Mangosteens during Storage. Walailak Journal of Science & Technology. 2004; 1(2):87-95.

95. Marfil PHM, Santos EM, Telis VRN. Ascorbic acid degradation kinetics intimatoes at different drying conditions. LWT-Food Science and Technology. 2008; 41(9):1642-1647.

96. Marques LG, Silveira AM, Freire JT. Freeze-drying characteristics of tropical fruits. Drying Technology. 2006; 24(4):457–463.

97. Martí N, Mena P, Cánovas VA, Micol V, Saura D. Vitamin C and the role of citrus juices as functional food. Natural Product Communications. 2009; 4(5):677-700.

98. Martínez-Sánchez A, Tudela JA, Luna C, Allende A, Gil MI. Low oxygen levels and light exposure affect quality of fresh-cut Romaine lettuce. Postharvest Biology and Technology. 2011; 59(1):34-42.

99. Marzocchella LM, Fantini M, Benvenuto L, Masueli I, Tresoldi A, Modesti R. flavonoids: molecular mechanisms of action as anti-inflammatory agents. Recent Pat Inflamm Allergy Drug Discov. 2011; 5:200-220.

100. Masueli LP, Trono L, Marzocchella MA, Mrozek C, Palumbo M, Minieri F et al. Be: Intercalated disk remodeling in delta-sarcoglycan-deficient hamsters fed with an alpha-linolenic acid-enriched diet. Int J Mol Med. 2008; 21:41-48.

101. Mc Cormick WJ. Cancer: a collagen disease, secondary to a nutritional deficiency. Arch Pediatr. 1959; 76:166-171.
102. Milivojević Jasmina, Jelena Bogdanović-Prstov, Vuk Maksimović. Phenolic compounds and vitamin C as sources of antioxidant activity in black currant fruit (Ribes nigrum L.). Acta Agriculturae Serbica. 2010; 15(29):3-10.

103. Minh Nguyen Phuoc. Enzymatic pectinase application in extraction and purification of juice turbidity from red rose apple pulp (Syzgium malaccensis). International Journal of Multidisciplinary Research and Development. 2014; 1(4):45-51.

104. Moertel CG, Fleming TR, Creagan ET, Rubin J, O'Connell MJ, Ames MM. High-dose vitamin C versus placebo in the treatment of patients with advanced cancer who have had no prior chemotherapy. A randomized double-blind comparison. N Engl J Med. 1985; 312:137-141.

105. Moor U, Karp K, Pöldma P, Pae A. Cultural Systems Affect Content of Anthocyanins and Vitamin C in Strawberry Fruits. European Journal of Horticultural Science. 2005; 70(4):195–201.

106. Morris MC, Beckett LA, Scherr PA, Hebert LE, Bennett DA, Field TS et al. Vitamin E and vitamin C supplement use and risk of incident Alzheimer disease. Alzheimer Dis Assoc Disord. 1998; 12: 21-126.

107. Mrad ND, Boudhrioua N, Kechaou N, Courtous F, Bonazzi C. Influence of air-drying temperature on kinetics, physicochemical properties, total phenolic content and ascorbic acid of pears. Food and bioproducts processing, 90(3):433-444.

108. Munyaka AW, Oey I, Van Loey A, Hendrickx M. Application of thermal inactivation of enzymes during vitamin C analysis to study the influence of acidification, crushing and blanching on vitamin C stability in Broccoli (Brassica oleracea L var. italica). Food Chemistry. 2010b; 120(2):591-598.

109. Munyaka AW, Makule EE, Oey I, Van Loey A, Hendrickx M. Thermal stability of L-ascorbic acid and ascorbic acid oxidase in broccoli (Brassica oleracea var. italica). Journal of Food Science. 2010a; 75(4):C336-C340.

110. Munzurogluha Omer, Fikret Karatasb, Hikmet Geckil. The vitamin and selenium contents of apricot fruit of different varieties cultivated in different geographical regions. Food Chemistry. 2003; 83:205–212.

111. Nagayama H, Hamamoto M, Ueda C, Nito H, Yamaguchi Y, Katayama: The effect of ascorbic acid on the pharmacokinetics of levodopa in elderly patients with Parkinson disease. Clin Neuropharmacol. 2004; 27:270-273.

112. Nakata YN, Maeda: Vulnerable atherosclerotic plaque morphology in apolipoprotein E-deficient mice unable to make ascorbic Acid. Circulation. 2002; 105:1485-1490.

113. Navarro P, Pérez-López AJ, Mercader MT, Carbonell-Barrachina AA, Gabaldon JA. Antioxidant Activity, Color, Carotenoids Composition, Minerals, Vitamin C and Sensory Quality of Organic and Conventional Mandarin Juice, cv. Orogrende. Food Science and Technology International. 2011; 17(3):241-247.

114. Nishikawa F, Kato M, Wang R, Hyodo H, Ikoma Y, Sugiura M et al. Two ascorbate peroxidases from broccoli: identification, expression and characterization of their recombinant proteins. Postharvest Biology and Technology. 2003b; 27(2):147-156.

115. Nogueira JN, Sobrinho JS, Vencovsksy R, Fonseca H. Effects of storage on the content of ascorbic acid and beta-carotene in freeze dried guava. Archives Latinoamerica-nos de Nutricion. 1978; 28(4):363–377.

116. Noichinda S, Bodhipadma K, Mahamontri C, Narongruk T, Ketsa S. Light during storage prevents loss of ascorbic acid, and increases glucose and fructose levels in Chinese kale (Brassica oleracea var. alboflabaga). Postharvest Biology and Technology. 2007; 44(3):312-315.

117. Noroozi MWI, Angerson ME: Lean: Effects of flavonoids and vitamin C on oxidative DNA damage to human lymphocytes. Am J Clin Nutr. 1998; 67:1210-1218.

118. Nutrient Data Laboratory, USDA National Nutrient Database for Standard Reference. Release 24 [Internet]. Available from http://www.ars.usda.gov/ba/bhnrc/nib).

119. Nwee CC, Abdulguniyu MG, Erhabor OG, Comparative analysis of Vitamin C in fresh fruit juice of Malus domestica, Citrus sinensis, Ananascomosus and Citrullus lanatus by iodometric titration. International Journal of Science, Environment and Technology. 2015; 4(1):17-22.

120. Odrizio-Serrano I, Hernández-Jover T, Martín-Belloso O. Comparative evaluation of UV-HPLC methods and reducing agents to determine vitamin C in fruits. Food Chemistry. 2007; 105:1151–1158.

121. Ogunmoyole T, Kade IJ, Korodele B. In vitro antioxidant properties of aqueous and ethanolic extracts of walnut (Juglans regia). Journal of Medicinal Plants Research. 2011; 5(31):6839-6848.

122. Okwu DE, Emenike IN. Evaluation of the phytonutrients and vitamins content of citrus fruits. International Journal of Molecular Medicine and Advance Sciences. 2006; 2(1):1-3.

123. Opara Linus U, Majeed R Al-Ani, Yusra S, Al-Shuabii. Physico-chemical Properties, Vitamin C Content, and Antimicrobial Properties of Pomegranate Fruit (Punica granatum L.). Food and bioprocess Technology. 2008; 2:315-321.

124. Özkem M, Kýrca A, Cemeroğlu B. Effects of hydrogen peroxide on the stability of ascorbic acid during storage in various fruit juices. Food Chemistry. 2004; 88(4):591-597.

125. Parle MD. Dhingra: Ascorbic Acid: a promising memory-enhancer in mice. J Pharmaco! Sci. 2003; 93:129-135.

126. Powlong Wachiraporn, Surasak Saajbut, Jaruratan Eamsiri, Sirilik Chookaew. Evaluation of Antioxidant activities, Anthocyanins, Total Phenolic Content, Vitamin C Content and Cytotoxicity of Carissa carandas Linn. CMUJ NS Special Issue on Food and Applied Bioscience. 2014; 13(1):509-517.

127. Pflaum MC, Kielbassa M, Garmyn B. Epe: Oxidative DNA damage induced by visible light in mammalian cells: extent, inhibition by antioxidants and genotoxic effects. Mutat Res. 1998; 408:137-146.

128. Phillips KM, Council-Troche M, McGinty RC, Rasar AS, Tarrago-Trani MT. Stability of vitamin C in fruit and vegetable homogenates stored at different temperatures. Journal of Food Composition and Analysis. 2016; 45:147-162.

129. Picouet PA, Landl A, Abadías M, Castellari M, Vinas I. Minimal processing of a Granny Smith apple puree by microwave heating. Innov Food Sci Emerg Technol. 2009; 10:545–550.

130. Pleiner JF, Mittermayer G, Schaller C, Marsik RJ,
MacAllister M. Wolzt: Inflammation-induced vasoconstrictor hyporeactivity is caused by oxidative stress. J Am Coll Cardiol. 2003; 42:1656-1662.

131. Bei R, Frigioala A, Masuellii L, Marzocchellia I, Tresoldi A, Modestif F, Galvant: Effects of omega-3 polyunsaturated fatty acids on cardiac myocyte protection. Front Biosci. 2011; 16:1833-1843.

132. Ramani AV. Food chemistry, MJP publishers, Chennai, 2009, 12-128.

133. Ramesh MN, Wolf W, Tevini D, Jung GS. Studies on inerst gas processing of vegetables. Journal of Food Engineering. 1999; 40:199–205.

134. Rangel Carolina Netto, Lucia Maria Jaeger de Carvalho, Renata Borchetta Fernandes Fonseca, Antonio Gomes Soares, Edgar Oliveira de Jesus. Nutritional value of organic acid lime juice. Food Science and Technology. 2011; 31(4):919-92.

135. Rassis D, Saguy IS. Oxygen effect on nonenzymatic browning and vitamin C incitrus products. Lebensmittel Wissenschaft und Technologie. 2000; 33(3):146-148.

136. Santos PHS, Silva MA. Retention of vitamin C in drying processes of fruits and vegetables-A review. Drying Technology. 2008; 26(12):1421-1437.

137. Schor AM, Schor SL, Allen TD. Effects of culture conditions on the proliferation, morphology and migration of bovine aortic endothelial cells. J Cell Sci. 1983; 62:267-285.

140. Semenza GL. HIF-1, O (2), and the 3 PHDs: how animal cells signal hypoxia; the nucleus 2001. Cell 107, 1-3

141. Shahnawaz Muhammad, Saghir Ahmed Sheikh, Nizamani SM. Determination of Nutritive Values of Jamun Fruit (Eugenia jambolana) Products. Pakistan Journal of Nutrition. 2009; 8(8):1275-1280.

145. Sharma Prabodh Chander, Vivek Bhatia, Nitin Bansal, Archana Sharma. A Review on Bael Tree. Natural Product Radiance. 2007; 6(2):171-178.

146. Sinha Jyoti, Shalini Purwar, Satya Kumar Chuhan, Gyanendra Rai. Nutritional and medicinal potential of Grewia subinaequalis DC. (syn. G. asiatica.) (Phalsa). Journal of Medicinal Plants Research. 2015; 9(19):595-611.

150. Somya Tewari, Rachna Sehrawat, Prabhat K Nema, Barjinder Pal Kaur. Preservation effect of high pressure processing on ascorbic acid of fruits and vegetables: A review. Journal of biochemistry, 2016, 1-14. wileyonlinelibrary.com/journal/jbce

155. Sotiriou SS, Gispert J, Cheng Y, Wang A, Chen S, Hoogstratten-Miller GF et al. Nussbaum: Ascorbic-acid transporter Slc23a1 is essential for vitamin C transport into the brain and for perinatal survival. Nat Med. 2002; 8:514-517.

161. Srilakshmi B. Human Nutrition, New age international (p) limited, Publisher, New Delhi, 2nd Edition, 2011, 191-196.

165. Suntronsuk Leena, Wandee Gritsanapun, Suchada Nilkhamhank, Anocha Paochom. Quantitation of Vitamin C content in herbal juice using direct titration. Journal of Pharmaceutical and Biomedical Analysis. 2002; 28(5):849-855.

166. Sweetman SF, Strain JJ, Mckelvey-Martin VJ. Effect of antioxidant vitamin supplementation on DNA damage and repair in human lymphoblastoid cells. Nutr Cancer. 1997; 27:122-130.

170. Duarte TL, Lune J. Review: When is an antioxidant not an antioxidant? A review of novel actions and reactions of vitamin C. Free Radic Res. 2005; 39:671-686.

175. Talabi Justina Y, Olukemi AO. Effect of antioxidant vitamin supplementation on DNA damage and repair in human lymphoblastoid cells. Asian Journal of Plant Science and Research. 2016; 6(2):6-12.

180. Taniyama Y, Griendling KK. Reactive oxygen species in the vasculature: molecular and cellular mechanisms. Hypertension. 2003; 42:1075-1081.

185. Tembo Lovejoy ZA Chiteka, Irene Kadzere, Festus K Akiniffesi, Fanuel Tagwira. Blanching and drying period affect moisture loss and vitamin C content in Ziziphus mauritiana (Lamk.). African Journal of Biotechnology. 2008; 7(8):3100-3106.

190. Tiwari BK, O’donnell CP, Patras A, Brunton N, Cullen PJ. Stability of anthocyanins and ascorbic acid in sonicated strawberry juice during storage. European Food Research and Technology. 2009a; 228(5):717-724.

195. Tiwari BK, O’Donnell CP, Muthukumarappan K, Cullen PJ. Ascorbic acid degradation kinetics of sonicated orange juice during storage and comparison with thermally pasteurised juice. LWT-Food Science and Technology. 2009b; 42(3):700-704.
163. Topcu Y, Dogan A, Kasimoglu Z, Sahin-Nadeem H, Polat E, Erkan M. The effects of UV radiation during the vegetative period on antioxidant compounds and postharvest quality of broccoli (Brassica oleracea L.). Plant Physiology and Biochemistry. 2015; 93:56-65.

164. Izza V, Masueli L, Tresoldi I, Foli C, Modiesti A, Bei R. Immunity and malignant mesothelioma: from mesothelial cell damage to tumor development and immune response-based therapies. Cancer Lett. 2012; 322:18-34.

165. Izza VL, Masueli I, Tresoldi P, Sacchetti A, Modiesti F, Galvano R. Bei: The effects of dietary flavonoids on the regulation of redox inflammatory networks. Front Biosci. 2012; 17:2396-2418.

166. Marisa M. Ascorbic acid and mineral composition of longan (Dimocarpus longan), lychee (Litchi chinensis) and rambutan (Nephelium lappaceum) cultivars grown in Hawaii. Journal of Food Composition and Analysis, 2006, 655–663.

167. Lee SK, Kader AA. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology. 2000; 20(3):207-220.

168. Wakeling Lara T, Richard L Mason, Bruce R D'Arc, Nola A Caffin. Composition of Pecan Cultivars Wichita and Western Schley [Carya illinoinsis (Wangenh.) K. Koch] Grown in Australia. Journal of Agriculture and Food Chemistry. 2001; 49(3):1277–1281.

169. Wall Marisa M. Ascorbic acid, vitamin A, and mineral composition of banana (Musa sp.) and papaya (Carica papaya) cultivars grown in Hawaii. Journal of Food Composition and Analysis, 2006; 19:434–445.

170. Wawire M, Oey I, Mathooko F, Njoroge C, Shibata D, Hendrickx M. Thermal stability of ascorbic acid and ascorbic acid oxidase in African cowpea leaves (Vigna unguiculata) of different maturities. Journal of Agricultural and Food Chemistry. 2011; 59(5):1774-1783.

171. Wechtersbach L, Polak T, Ulrih NP, Cigiæ B. Stability and transformation of products formed from dimeric dehydroascorbic acid at low pH. Food Chemistry. 2011; 129(3):965-973.

172. Wojdylo A, Figiel A, Oszmianski J. Effect of drying methods with the application of vacuum microwaves on the bioactive compounds, color, and antioxidant activity of strawberry fruits. J Agric Food Chem. 2009; 57:1337–1343.

173. Wojdylo Aneta, Paulina Nowicka, Piotr Laskowski, Jan Oszmianski. Evaluation of Sour Cherry (Prunus cerasus L.) Fruits for Their Polyphenol Content, Antioxidant Properties, and Nutritional Components. Journal of Agricultural and Food Chemistry. 2014; 62:12332–12345.

174. Xiao HW, Bai JW, Sun DW, Gao ZJ. The application of superheated steam impingement blanching (SSIB) in agricultural products processing—a review. Journal of Food Engineering. 2014; 132:39-47.

175. Yan SW, Rajesh Ramasamy, Noorjahan Banu Mohamed Alitheen, Asmah Rahmat. A Comparative Assessment of Nutritional Composition, Total Phenolic, Total Flavonoid, Antioxidant Capacity, and Antioxidant Vitamins of Two Types of Malaysian Underutilized Fruits (Averrhoa Bilimbi and Averrhoa Carambola). International Journal of Food Properties. 2013; 16(6):1231-1244.