

## A Review on Fruit Pericarp A Rich Source of Phytochemicals and Pharmacological Activities

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### ABSTRACT

Several phyto-chemicals possessing polyphenolic structures are advocated as nutraceutical food supplements for better health care during recent years, most of them are claimed to possess antioxidant activity. The Ayurveda and naturopathic system of medicine indigenous to India clearly states the use of medicinal plants for treating various disorders. Literature suggests that the pericarp is a rich source of active constituents. The present review has provided an over view of fruit pericarp having various pharmacological activities.

**Keywords:** Fruit pericarp, Phytochemicals, Pharmacological activities.

### INTRODUCTION

The type of fruit depends on the type of the pericarp becomes dry and hard or soft and fleshy. The pericarp consists of three layers. The outer skin may be tough and hard; the middle layer may be succulent and the inner layer may be hard or stony. Epicarp Gr. "outside" + "fruit" is a botanical term for the outermost layer of the pericarp or fruit. It is an outer skin of the fruit, which bears oil glands and pigments. It is composed by cellulostic material and contains essential oils, paraffin, waxes, steroids, triterpenoids, fatty acids, pigments carotenoids, chlorophylls, flavanoids and enzymes. Mesocarp Gr. "middle" + "fruit" is a botanical term for the succulent and fleshy middle layer of the pericarp of a fruit, which lies between the epicarp and the endocarp; it is usually the major part of the fruit. Endocarp Gr. "inside" + "fruit" is a botanical term for the inside layer of the pericarp fruit, which directly surrounds the seeds. It may be membranous as in citrus only part consumed, or thick and hard as in the stone fruits of the family Rosaceae such as peaches, cherries, plums, and apricots. In nuts, it is the stony layer that surrounds the kernel of peanuts, walnuts and that is removed prior to consumption<sup>1</sup>.

During fruit development several phases can be recognized: initially the fruit diameter increases due to cell division activities, which rapidly amplify the number of cell layers in the pericarp, followed by a growth phase caused by cell expansion. The expansion phase is accompanied by endoreduplication; that is, a multiplication of the genome without mitosis, leading to an increase in DNA content per cell, which can reach up to the end of fruit growth<sup>2</sup>.

The fruit pericarps are considered to be a rich source of phytochemicals. Some of the pericarps, their

phytochemicals and reported biological activities are described below.

*Ananas cosmosus* (Bromeliaceae)

The pericarp contains bromelin and other phytochemical constituents include fiber, phenolics, flavonoids, anthocyanins and vitamin A and C<sup>3</sup>. All these compounds were reported for its antioxidant activity<sup>4</sup>.

*Averrhoa carambola* (Oxalidaceae)

The fruit pericarp contains 96 detected volatile components namely 1-Phenyl dodecane and 1-Phenyl undecane were the major identified hydrocarbons 17% and 11% respectively, aldehydes 14%, cyclohexyl octadecanal 8%, protein content was 11%, tannin content 1.04% and small amounts of vitamin C,  $\beta$ -carotene, potassium and calcium. It has anti-inflammatory, antipyretic, analgesic, anticonvulsant, antioxidant, hypolipidemic and hypoglycemic activities and antimicrobial activities against selected bacteria and fungi<sup>5</sup>.

*Balanites aegyptiaca* (Zygophyllaceae)

The pericarp contains saponins, tannins, flavonoids, steroids, alkaloids, glycosides, phlobatannin, cardiac glycosides and phenols<sup>6</sup>. It is used traditionally to treat spleen and liver conditions<sup>7</sup>.

*Benincasa hispida* (Cucurbitaceae)

The pericarp contains flavonoids, saponins or organic acids<sup>8</sup>. These active principles responsible for diuretic activity<sup>9</sup>.

*Black rice* (Poaceae)

The pericarp contains anthocyanins namely cyanidin-3-O-glucoside, cyanidin-3-O-galactoside, peonidin-3-O-glucoside, and cyanidin-3-O-rutinoside<sup>10,11</sup>. Black rice improves serum triglyceride levels, which contributes to the suppression of atherosclerosis<sup>12,13</sup>, protects against insulin resistance<sup>14</sup>, alcoholic liver injury<sup>15</sup> and light-induced retinal damage<sup>16</sup>.

*Citrus sinensis* (Rutaceae)

The pericarp contains natural flavonoid glycosides, Polymethoxy flavones PMFs, quercetin and hesperidin<sup>17</sup>. It possesses a multitude of biological activities including anti-inflammatory<sup>18</sup>, antihyperglycemic<sup>19</sup>, antihyperlipidemic<sup>20</sup>, antioxidant<sup>21</sup> and antimutagenic<sup>22</sup> properties.

*Cucumis melo* (Cucurbitaceae)

Phytochemical investigations revealed the presence of maximum amount of steroids and steroidal glycosides, carbohydrate, flavonoids, tannins and saponins<sup>23</sup>. It is used in flatulence, leprosy, fever, jaundice, diabetes, antiobesity, cough, bronchitis, ascites, anaemia, constipation, other abdominal disorders and amentia<sup>24,25</sup>

*Eugenia Jamolana* (Myrtaceae)

The pericarp contains polyphenols, including hydrolysable tannins based on hexahydroxydiphenoyl HHDP and gallotannins or valoneoyl esters<sup>26</sup>. It has an anti-inflammatory, antiulcer, hepatoprotective and antioxidant activities.

*Euphoria longana* (Sapindaceae)

The pericarp is a rich source of polyphenols gallic acid and ellagic acid<sup>27</sup>. It has antioxidant activities like ferric reducing ability power, DPPH radical, hydroxyl radical and superoxide radical scavenging activities<sup>28</sup>.

*Feronia limonia* (Rutaceae)

Pericarp contains 2, 6-dimethoxybenzoquinone and osthonol and Three volatile flavour components like methyl hexanoate, ethyl3-hydroxyhexanoate, and butanoic acid. Free fatty acids like palmitic, oleic, linoleic, linolenic acid, palmitoleic acid, stearic acids  $\beta$ -sitosterol,  $\beta$ -amyryn<sup>29</sup> and unsaponifiable matter lupeol, stigmasterol<sup>30</sup>. In India, the fruit pericarp is used as a, stomachic, diuretic, antidiabetic<sup>31</sup>, antimicrobial<sup>32</sup>, cardiotoxic and tonic to the liver and lungs<sup>30</sup>. Some recent reports identified its use in gastrointestinal disorders<sup>28</sup>.

*Garcinia mangostana* (Clusiaceae)

Xanthones that have been isolated from the pericarp of mangosteen fruit are  $\alpha$ -mangostin,  $\gamma$ -mangostin, gartanin, gartanone D, BR-xanthone<sup>33</sup>, gartanin, 8-deoxygartanin, tannins and a flavonoid called epicatechin. The pericarp of mangosteen fruit has been used for treatment of skin infections and wounds<sup>34,35</sup>, amoebic dysentery<sup>36,37</sup>, inflammation, diarrhea<sup>38</sup>, cholera, dysentery<sup>39</sup>, anti-parasitic, antipyretic, analgesic<sup>40</sup> anti cancer<sup>41</sup> and antidiabetic activities<sup>42</sup>.

*Hypphaene thebaica* (Arecaceae)

The pericarp contains tannins, steroids, saponins, carbohydrates, flavonoids, terpenes, terpinoids and essential oils<sup>43</sup>. It had antimicrobial actions<sup>44</sup>, insect repellents, antioxidants, feeding deterrents, blood lipid regulating, antiplatelet, antithrombotic and antihypertensive properties, which provide protection from stress-induced myocardial injury, as well as anti-inflammatory, analgesic, immunomodulatory and antitumor functions<sup>45</sup>.

*Litchi chinensis* (Sapindaceae)

The pericarp contains large quantity of phenols, flavonoids, condensed tannins, cyanindin-3-glucoside and malvidin-3-glucoside may be present in these

anthocyanins and quercetin glucoside. Used for tonic to heart, brain and liver<sup>46</sup>. It is also used for antimicrobial activities<sup>47</sup>.

*Momordica chochinchinensis* (Cucurbitaceae)

The pericarp contains flavonoids like rutin, myricetin, luteolin, quercetin, apigenin and kaempferol; carotenoids like  $\alpha$ ,  $\beta$ - carotene, zeaxanthin, lycopene, lutein and phenolic compounds like gallic acid, vanillic acid, ferulic acid, caffeic acid, proto catechuic acid<sup>48</sup>. It has antimicrobial activity<sup>49</sup>, antihyperglycemic<sup>50</sup>, hypoglycemic and hypolipidemic activities<sup>51</sup>, works as a trypsin inhibitor<sup>52</sup> and inhibition of tumor growth and angiogenesis<sup>53</sup>.

*Persea americana* (Lauraceae)

High concentrations of catechins, procyanidins and hydroxycinnamic acid have recently been determined in pericarp. It reduced blood pressure, hypoglycemic effect in diabetes<sup>54,55</sup> and decreases the levels of alanine aminotransferase ALT, aspartate aminotransferase AST, albumin and creatinine<sup>56</sup>.

*Phaleria macrocarpa* (Thymelaceae)

The pericarp contains mangiferin. It had hypoglycaemic and anti-hyperglycaemic activity<sup>57,58</sup>. Used in liver diseases, vascular problems, cancer and in high blood pressure<sup>59</sup>.

*Polyalthia longifolia* (Annonaceae)

The pericarp contains flavonoids, saponins, steroids, glycosides, tannins, clerodane diterpenoids and alkaloids<sup>60</sup>. It had DPPH free radical scavenging, ferric reducing activity<sup>61</sup>, potent inhibitory activity against *Colletotrichum capsici* and drug resistant uropathogen, antibacterial, cytotoxic and insecticidal activity<sup>62</sup>.

*Punica granatum* (Punicaceae)

Pomegranate pericarp is a rich source of hydrolyzable tannins like punicalin<sup>63</sup>, pedunculagin, punicalagin<sup>64,65</sup>, gallic acid and ellagic acid<sup>66</sup> esters of glucose, casuarinin<sup>67</sup>, corilagin<sup>68</sup> flavonoids like anthocyanins, catechins like epicatechin, epicatechin 3-galate, flavan-3-ol and kaempferol, kaempferol-3-o-glucoside, kaempferol-3-o-ghammoglycoside<sup>69</sup>. The pharmacological functions of pericarp include antimicrobial<sup>70</sup>, antioxidant<sup>71</sup>, antitumor<sup>72</sup>, antihepatotoxicity<sup>73</sup>, anti-diarrhoeal, antilipoperoxidation and anti bacterial properties. In hematology, decreasing low-density lipoprotein LDL oxidation and the incidence of heart disease<sup>74</sup> also reported for cardiotoxic activity<sup>75</sup> and antimalarial activity<sup>76</sup>.

*Sapindus emarginatus* (Sapindaceae)

Pericarp has Pesticidal triterpenoid saponins<sup>77</sup> acetylated triterpene saponins, hederagenin, sweet acyclic sesquiterpene glycoside and flavonoids<sup>78</sup>. Used as anti-inflammatory, antipruritic oxytropic action, antibacterial activity<sup>79</sup>, antifertility and antiandrogenic activities<sup>80</sup>. It is also used to purify the blood.

*Sapindus mukorossi* (Sapindaceae)

The pericarp contains triterpenoids, saponins, fatty acids, flavonoids<sup>81</sup>, triterpenoids, saponins and fatty acids<sup>82</sup>. Used to relieving cough, detoxification, emetic, contraceptive, treatment of excessive salivation, epilepsy and chlorosis<sup>83</sup>.

*Sapindus trifoliatus* (Sapindaceae)

The pericarp contains glucose and saponins. It was used in hemi crania, hysteria or epilepsy and muscle relaxant activity<sup>84</sup>.

*Semecarpus anacardium* (Anacardiaceae)

Pericarp of fruit contains a bitter and astringent principle. The pericarp contains tarry oil consisting of 90% of oxy-acid anacardic acid and 10% of higher nonvolatile alcohol called cardol, also contains catechol and a mono-hydroxyphenol called as anacardol<sup>85</sup>. It acts as antiasthmatic, stimulant, digestive, escharotics, carminative, antiseptic, demulcent, rheumatism, piles and in dyspepsia<sup>86,87</sup>.

*Semecarpus anacardium* (Anacardiaceae)

Pericarp oil contains flavonoids, phenols like catachol and anacardic acid<sup>88,89</sup>. Pericarp oil obtained from nut is used in treatment of asthma and digestive disorders<sup>90,91</sup>.

*Sorghum Caryopses* (Poaceae)

The pericarp contains phenols, phenolic acids benzoic or cinnamic acid, flavonoids flavans-flavan-3-en-3-ols and tannins catechin<sup>92,93</sup>.

*Terminalia chebula* (Combretaceae)

The pericarp contains ellagic acid, gallic acid, chebulinic acid, chebugalic acid and corilagin. It was used as tonic and deobstruent in hepatic and spleen enlargements and in skin diseases, laxative, astringent, anthelmintic properties, treatment of piles and external ulcers<sup>94</sup>.

*Vitis vinifera* (Vitaceae)

Pericarp contains polyphenolics, flavonoids, oligomeric proanthocyanidins and unsaturated fatty acids. It has antioxidant, lipid lowering<sup>95</sup> and antitumor activities.

*Zanthoxylum schinifolium* (Rutaceae)

Monoterpenes namely limonene and linalool which are the major chemical components present in pericarp. The essential oils, linalyl acetate, linalool, limonene, linalool, limonene and sabinene<sup>96</sup>. It is effective for the treatment of inflammatory diseases, epigastric pain, stomachache, toothache, ascariasis, diarrhea and dysentery.

*Ziziphus rugosa* (Rhamnaceae)

The pericarp was found to possess marked antibacterial, larvicidal and free radical scavenging activity<sup>97</sup>.

**SUMMARY**

Herbal medicine also called botanical medicine or phytomedicine<sup>98</sup>, refers to using a plant's seeds, berries, roots, leaves, bark, or flowers for medicinal purposes. Herbalism has a long tradition of use outside of conventional medicine. It is becoming more mainstream as improvements in analysis and quality control along with advances in clinical research show the value of herbal medicine in the treating and preventing disease over conventional medicines. Phytochemicals plays an important role in pharmacological activity.

Apart from the above mentioned plant parts, the pericarp portion of the some of the fruits found to possesses large number of photochemicals. The photochemicals present in the pericarp are

Flavonoids enhance the effects of Vitamin C and function as antioxidants. They are also known to be biologically active against liver toxins, tumors, viruses and other

microbes<sup>99</sup>. Terpenoids are used extensively for their aromatic qualities. They play a role in traditional herbal science and are under investigation for Antibacterial, Antineoplastic and other Pharmaceutical functions<sup>100</sup>. Many of our most commonly used drugs are alkaloids from pericarp source and used as treatment for glaucoma, myasthenia gravis, muscle relaxant, analgesics, psychotropics, antihypertensives, antiarrhythmics, antimalarials, anticancer and antiseptics<sup>101</sup>. Volatile oils are complex of compounds with strong odour. And known to have antiseptic, bactericidal, virucidal and fungicidal activities<sup>102</sup>. Tannins comprise a large group of natural products widely distributed in the plant kingdom. They have a great structural diversity and used as antioxidant, antibacterial, antiviral, anticarcinogenic, cardiovascular system preventing, and antiinflammatory effects<sup>103</sup>. Many such plant glycosides present in the pericarp are used as medications for congestive cardiac failure, cardiotonics, antiarrhythmics, analgesics, antipyretics, anti-inflammatory, anticancer and synthetic glucocorticoids<sup>104</sup>. The part pericarp was a rich source of all the above mentioned phytochemicals. The present review suggests that the chemicals present in the pericarp can be developed into potential targets for many disorders.

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