Review Article

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Best from Waste: Therapeutic Potential of Plant Waste (Seeds, Peels, Flowers)

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Bio waste which includes fruit and vegetable peels, seeds, pomace, rind are generated in enormous amounts and discarded into the environment adding to pollution. Flowers which are generally used for decoration and religious purpose are also thrown into nature as unwanted material. They create lot of waste and are also hazardous. However, these parts of the plant are seeds, endowed with phytoconstituents and sometimes more than those present in other parts. The best was to minimize this hazard is making use of them in food, pharmaceutical and allied industries after proper extraction of bioactive compounds from them. To enumerate this idea, in this review, we have enlisted seeds, peels and flowers of 60 different plants along with their biological activity and bioactive compounds present in them. Some are used directly as crude extracts while some are used to synthesize nanoparticles which show promising biological activities. Thus, plant waste i.e. seeds, peels and flowers can be used profitably as a source of natural medicine or ingredients in many industries. Some activities are reported but other activities can be tried out. Detailed structurally analysis also should be done which may give new lead molecules or new drugs to be used as safe, natural and novel antimicrobics or antioxidants or anticancer or antiulcer agents. This review undeniably and definitely opens up the possibility for utilization of these plant waste products for therapeutic and industrial purpose.

Introduction

Medicinal plants are important sources for discovering new drugs for many diseases and disorders. From times immemorial, plants are being used to cure many ailments and recently the trend of use of this green medicine has increased. This is merely because medicinal plants are free from many side effects that are generally associated with synthetic drugs,

they are easily available and affordable by all the people. The diversity of medicinal plants is vast and there is cure for any and every ailment in them. They may be directly used as drugs or they may act as lead molecules for the discovery of new drug candidates. Many of the drugs used for deadly diseases like cancer are of plant origin (Chanda and Nagani, 2013).

Plants show various biological activities viz. antioxidant (*Punica granatum* - Kaneria *et al.*, 2012), hepatoprotective (*Abelmoschus moschatus* - Singh *et al.*, 2012), anticancer and antimicrobial and synergistic antimicrobial (*Pterocarpus santalinus* - Donga *et al.*, 2017a, 2017b), antioxidant and anti-inflammatory (*Moringa oleifera* - Xu *et al.*, 2019), anti-ulcer (*Nigella sativa* - Paseban *et al.*, 2020), antiurolithiatic (*Mangifera indica* - Iman *et al.*, 2020) etc. The therapeutic property is not isolated to any specific part of the plant. All plant parts show medicinal properties for eg. fruit and vegetable peels showed antimicrobial activity (Rakholiya *et al.*, 2014), *Embllica officinalis* fruit showed anti-inflammatory activity (Golechha *et al.*, 2014), *Mangifera indica* stem bark showed anti-viral activity (Abdel-Mageed *et al.*, 2014), *Nephelium lappaceum* peels showed antidiabetic activity (Ma *et al.*, 2017), aerial parts of *Polygonum equisetiforme* showed hepatoprotective property (El-Toumy *et al.*, 2019), *Pouteria caimito* peel showed antimicrobial and antidiarrheal activity (Abreu *et al.*, 2019), *Opuntia ficus indica* seed oil showed protection against gastric ulcer (Khemiri and Bitri, 2019); *Lawsonia inermis* and *Murraya koenigii* seed extract also showed antiulcer activity (Eggadi *et al.*, 2019). *Lavendula bipinnata* leaves showed antioxidant activity (Pande and Chanda, 2020) while *Annona squamosa* leaf showed anticancer effect (Al-Nemari *et al.*, 2020), *Carica papaya* flowers showed antioxidant and antibacterial activity (Dwivedi *et al.*, 2020), *Beta vulgaris* root showed antimicrobial and anticancer activities (El-Mesallamy *et al.*, 2020), etc.

Plant parts are enriched with phytoconstituents like alkaloids, flavonoids, phenols, tannins, saponins, glycosides, steroids, etc. But their concentration varies from part to part and hence the therapeutic efficacy of plant part also varies. The leaf of

the plant may show very good antioxidant activity but stem or seed may not show similar activity. The phytoconstituents may act individually or synergistically. Plant secondary metabolites are bioactive molecules that are not essential for plant survival, but have important role in plant growth, development, reproduction and protection from predators and environmental stresses.

Fruits and vegetables generate lot of biowaste in the form of peels and seeds which are thrown into the environment. They increase pollution and their discard is a major problem. Flowers are another part of the plant which are generally used for decoration or religious purpose. They are also discarded into the environment increasing biowaste. However, these parts can be used as a source of natural antioxidant, antimicrobial or antiulcer or antidiabetic agent. They are also rich in various phytoconstituents like any other part of the plants. The therapeutic use of these parts will reduce environmental pollution and this is the best use of the waste. The discarded peels, seeds or flowers can be used as gelling and thickening agents in the refined foods; Polysaccharides from them can be a source of gum and can be used as thickeners, gelling agents, texture modifiers and stabilizers; as a source of bio-pigments like carotenoids and colourants, as emulsifiers, essential oils, organic acids and minerals, as substrate for microbial fermentation for enzymes production, for bio-ethanol/methanol production, for production of biodegradable plastics, as bio fuels and biofertilizers, bio-pesticides, bio-preservatives, mushroom cultivation, etc (Wadhwa *et al.*, 2015).

There are many types of seeds. Some seeds are used as spices (*Cuminum cyminum*, *Trigonella foenum-graecum*, *Coriandrum sativum*, *Nigella sativa*, *Foeniculum vulgare*), some seeds are eaten along with fruits and

vegetables (*Solanum lycopersicum*, *Pisum sativum*, *Cicer arietinum*, *Psidium guajava*, *Actinidia deliciosa*) while some are thrown into the environment (*Carica papaya*, *Cucumis melo*, *Manilkara zapota*, *Citrus limon*, *Momordica dioica*). However, seeds possess various phytoconstituents and can be therapeutically used. The seeds may have extractable high value-added components. Seeds showed various biological activities like antioxidant, anti-inflammatory, antimicrobial, antidiabetic, antidiarrheal, wound healing, etc (Table 1). All these properties are because of the phytoconstituents present in them in different concentrations which act individually or synergistically. *Mesua ferrea* seed extract showed antimicrobial activity (Chanda *et al.*, 2013). *Mangifera indica* seed kernel showed inhibition of *Pseudomonas* spp (Rakholiya *et al.*, 2015). Oil extracted from seeds of *Citrus sinensis* (orange) showed antioxidant activity; they contained phenols, carotenoids, phytosterols and α -tocopherols (Jorge *et al.*, 2016). Parikh and Patel (2017) reported antioxidant activity by *Manilkara hexandra* fruit and seeds; the fruits contained phenolics like gallic acid, quercetin and kaempferol, while seeds contained quercetin, gallic acid and vanillic acid. 11 varieties of *Phoenix dactylifera* (date palm) seeds were evaluated for phenol, flavonoid and anthocyanin content and antibacterial and antioxidant properties by Metoui *et al.*, (2019) and reported a direct correlation between phenolic content and inhibitory activity. *Cucumis melo* (melon) seeds and peels showed antioxidant and anticancer activities (Rolim *et al.*, 2018). The seeds and peels contained phenols, flavonoids and tannins; they also reported was a direct correlation between phytochemical content and antioxidant and anticancer activities. *Eriobotrya japonica* (loquat) seed starch showed antioxidant activity (Barbi *et al.*, 2018). The seeds from unripe fruit had higher polyphenol content and higher antioxidant

activity. *Myrciaria dubia* (Camu-camu) seed coat showed antioxidant and antihypertensive activity (Fidelisa *et al.*, 2018). They were rich in phenolic acids and flavonoids. The aqueous extract showed higher antioxidant activity; it contained total phenolics, non-tannin phenolics, (–)-epicatechin, chlorogenic acid, 2,4-dihydroxybenzoic acid, 2,5-dihydroxybenzoic acid and gallic acid. On the other hand the propanone extract showed higher antihypertensive activity and Cu^{2+} chelating ability; it had higher levels of quercetin, quercetin-3-rutinoside (rutin), t-resveratrol, ellagic, caffeic, rosmarinic, ferulic, and p-coumaric acids. The ethanolic extract possessed only condensed tannins, syringic acid, and (–)-epicatechin. The extracting solvent plays an important role in extracting the phytoconstituents or bioactive compounds from this biowaste and in exhibiting a particular activity. *Parkia speciosa* seeds possessed phenols, flavonoids, terpenoids and alkaloids and showed antimicrobial and antioxidant activities (Ghasemzadeh *et al.*, 2018). There was a significant correlation between biological activity and flavonoid content followed by phenolic content. *Durio zibethinus* (durian) seeds showed antimicrobial, cytotoxic and photocatalytic activity (Sumitha *et al.*, 2018).

The pulp, peel and seed of four avocado varieties (*Persea americana*) were investigated for their antibacterial and antioxidant activities (Amado *et al.*, 2019). The peels and seeds showed more antioxidant activity because they possessed more antioxidant compounds, phenols and flavonoids. Similar results were found in peels and seeds of Hass and Fuerte avocado varieties (Rodriguez-Carpena *et al.*, 2011). The antibacterial activity was more in peels followed by seeds. *Datura stramonium* seed showed anti-inflammatory activity in carrageenan induced paw edema model in Wistar albino rats (Agarwal *et al.*, 2019).

Moringa oleifera leaves, seeds and roots showed antioxidant and anti-inflammatory activities (Xu *et al.*, 2019); all the parts were rich in flavonoids and phenolic acids. There was a direct correlation between phytochemical content and observed activities. *Pouteria campechiana* seed polysaccharides ultrasonic-assisted extracted showed antioxidant activity (Ma *et al.*, 2019). Wound healing activity was shown by seeds of *Chrysophyllum Albidum* (Babatunde *et al.*, 2019). *Garcinia mangostana* (mangosteen) peel and seeds are waste products that can be recycled into medical and pharmaceutical applications due to their structures and properties. They have antibiotic properties and hence are suitable as bio-fillers in natural rubber products like medical gloves, rubber transdermal patches, rubber toys, etc (Moopayak and Tangboriboon, 2020). *Garcinia kola* and *Buchholzia coriacea* seeds (Abubakar *et al.*, 2020) showed antioxidant activity; *G. kola* and *B. coriacea* seeds contained phenols, flavonoids, alkaloids, saponins and tannins.

Recently, various metal nanoparticles are being synthesized from seed extracts which showed many biological activities. Silver nanoparticles synthesized using seed extract of *Trigonella foenum-graecum* showed anticancer activity (Varghese *et al.*, 2019) while seed extract of *Pedaliium murex* showed antimicrobial activity (Ishwarya *et al.*, 2017). *Elettaria cardamomum* seed extract mediated synthesized gold nanoparticles showed antibacterial, anticancer and antioxidant activities (Rajan *et al.*, 2017). Zinc nanoparticles synthesized using *Elettaria cardamomum* seed extract showed anticancer activity (Abbasi *et al.*, 2019)

Fruit and vegetable peels are considered as one of the most waste products of food industry. They are generated in huge amounts and discarded into the environment increasing

pollution. However, they show many medicinal properties. They can be utilized for the production of value added by-products. Peels contain many important phytoconstituents which can be used for pharmacological or pharmaceutical purposes. Researchers extracted numerous components having antimicrobial, antioxidant, antidiabetic, anticancer, hepatoprotective, anti-obesity and anti-inflammatory activities from different peels (Table 1). *Actinidia deliciosa* (Kiwi) peels showed antibacterial, anti-helicobacter pylori and cytotoxic activity (Motohashi *et al.*, 2001). *Cucurbita moschata* (pumpkin) fruit peel showed antioxidant, antibacterial and wound healing properties (Bahramsoltani *et al.*, 2017). Antioxidant and anti-salmonella activities of eggplant peel was reported by Rochin-Medina *et al.*, (2019). Anticancer and antibacterial properties of *Citrus reticulata* peels were reported by (Selim *et al.*, 2019); they contained phenols, flavonoids and coumarone compounds. *Mangifera indica* peels showed antibacterial, anti-inflammatory, anti-cancer and antioxidant activities (Huang *et al.*, 2018). The bioactive compounds in the peels were polyphenols which were responsible for the observed activities. Combination of peel extracts of *Allium sativum* and *Allium cepa* showed antidiabetic effect (Lolok *et al.*, 2019).

Punica granatum (pomegranate) peels showed antibacterial activity against *Cronobacter sakazakii* (Yemis *et al.*, 2019). The peels were rich in polyphenolic compounds especially hydrolysable polyphenolics like ellagitannins α - and β -punicalagin followed by ellagic acid, ellagic acid derivatives and punicalin. Antimicrobial activity of *P. granatum* fruit peels was also reported by Al-Zoreky (2017). Anti-inflammatory activity was reported from peels of *Citrus sinensis* (Osarumwense, 2017), *Citrus grandis* (Zhao *et al.*, 2019), *Punica*

granatum (Mastrogiovanni *et al.*, 2019) and *Ziziphus jujuba* (Wang *et al.*, 2019). *Citrus grandis* peels were rich in coumarins; *Punica granatum* peels were rich in high molecular weight phenols like alpha and beta punicalagin and low molecular weight phenols like gallic acid, ellagic acid and granatin B; *Ziziphus jujuba* contained phenolics like quercetin galangin and flavonoids. All these secondary metabolites were responsible for the observed anti-inflammatory activity. *Nephelium lappaceum* (Rambutan) peel extract rich in polyphenolic content showed antidiabetic activity (Ma *et al.* 2017); antioxidant and antidiabetic activity of *Aloe vera* peel extract was reported by Christijanti *et al.*, (2019); antimicrobial activity of fruit peel extract of *Pouteria caimito* was reported by Abreu *et al.*, (2019). The genus *Pouteria* were rich in triterpenes and flavonoids; *Actinidia chinensis* (Kiwi) peels showed antioxidant, antimicrobial and anticancer activity; they contained polyphenols (catachin, quercetin and epigallocatechin) and flavonoids (Alim *et al.*, 2019).

Banana peels showed antimicrobial and antioxidant activities (Mokbel and Hashinaga 2005; Chueh *et al.*, 2019) which may be due to the bioactive compounds present in peels. The peel had abundant phenolic content, including flavan-3-ols and flavonols (Vu *et al.*, 2018) and dried peel powder had catechin, epicatechin, galocatechin and procyanidin (Rebello *et al.*, 2014). Antioxidant and antitumor activities of *Nendran* banana peels rich in phenol, flavonoid and caretonoid content was reported by Kumar *et al.*, (2019). *Litchi chinensis* (Lychee) peel powder showed hepatoprotective and anti-obesity property (Queiroz *et al.*, 2018); peels contained polyphenols, flavonoids and anthocyanins. *Citrus sinensis* (orange), *Citrus limonia* (yellow lemon) and *Musa acuminata* (banana) peels showed remarkable

antimicrobial activity against a panel of microorganisms (Saleem and Saeed, 2020). The peels were rich in trace elements zinc, magnesium and polyphenolic content.

Metal nanoparticles of silver, gold and zinc synthesized using peel extracts also showed various biological activities. For e.g. *Prunus persica* peel mediated synthesized silver nanoparticles showed antioxidant activity (Patra *et al.*, 2016). Antibacterial and antioxidant activities were reported by gold and zinc nanoparticles synthesized using *Citrullus lanatus* and *Punica granatum* peel respectively (Patra *et al.*, 2015; Sukri *et al.*, 2019)

Flowers have cosmetic or phytotherapeutical use; essential oils from flowers like lavender, orange blossom, jasminum and rose are used in aromatherapy and perfumes due to their soothing and calming effects. Flowers show a number of properties like antifungal, antibacterial, antioxidant, antimicrobial, anti-ulcer, anti-diabetic, hepatoprotective, neuroprotective, anti-cancer, anti-inflammatory, etc (Table 1). *Woodfordia fruticosa* flowers showed protective effect against acetaminophen induced hepatic toxicity in rats (Baravalia and Chanda, 2011). *Acacia saligna* flowers showed antifungal, antibacterial and antioxidant activity (Al-Huqail *et al.*, 2019). The flowers contained phenols and flavonoids like benzoic acid, caffeine and o-coumaric acid, naringenin, quercetin and kaempferol. *Agastache rugosa* flowers showed antioxidant and antimicrobial activities and these activities were attributed to bioactive molecules present in the flowers which include terpenoids, carotenoids, and phenylpropanoids (Park *et al.*, 2019). Oil extracted from *Etlingera elatior* flowers using subcritical carbon dioxide showed antibacterial activity (Anzian *et al.*, 2020). The major chemical compounds present were polyphenols, flavonoids, anthocyanins and

tannins. Flower extracts of *Vernonia amygdalina* showed antibacterial and antioxidant activity (Habtamu and Melaku, 2018); the flowers had two natural

antioxidants, isorhamnetin and luteolin, which were responsible for the observed antioxidant and antibacterial activities.

Graphical abstract

Table.1 List of plant waste i.e. seeds, peels and flowers, their family, solvent and assay used for different biological activities

SEED					
No.	Plant/Family	Solvent	Assay	Activity	References
1	<i>Chrysophyllum albidum</i> G.Don./Sapotaceae	n-HE	TTP, TTC, AC, TAC, DPPH, OH ⁻ , MIC	Antimicrobial, Antioxidant, Wound healing	Babatunde <i>et al.</i> , 2019
2	<i>Citrus sinensis</i> (L.) Osbeck/Rutaceae	-	TC, TPC, TCP	Antioxidant	Jorge <i>et al.</i> , 2016
3	<i>Cucumis melo</i> L./ Cucurbitaceae	AQ, HME, HET	TPC, TFC, TT, OH, RP, MTT	Antioxidant, Antiproliferative, Cytotoxicity	Rolim <i>et al.</i> , 2018
4	<i>Cucumis melo</i> L./ Cucurbitaceae	80% ME	TPC, DPPH, LAS, RP, TEAC	Antioxidant	Islam and Sultanaet, 2020
5	<i>Datura stramonium</i> L./ Solanaceae	PE, 70% ME	-	Anti- inflammatory	Agarwal <i>et al.</i> , 2019

6	<p><i>Durio zibethinus</i> L./ Malvaceae</p>	AQ	SEM, SAED, EDX, XRD, DLS, Zeta, MIC, MBC, Agar disc diffusion, BSCA	Antimicrobial, Cytotoxic, Photocatalytic	Sumitha <i>et al.</i> , 2018
7	<p><i>Elettaria cardamomum</i> (L.) Maton/Zingiberaceae</p>	AQ	(AuNPs) DPPH, NO, OH, Agar well diffusion, MTT	Antibacterial, Anticancer, Antioxidant	Rajan <i>et al.</i> , 2017
8	<p><i>Eriobotrya japonica</i> L./ Rosaceae</p>	AQ	SEM, XRD, TG, DTG, DLS, TPC, DPPH, FRAP, ABTS	Antioxidant	Barbi <i>et al.</i> , 2018
9	<p><i>Garcinia kola</i> Heckel/ Clusiaceae</p> <p><i>Buchholzia coriacea</i>/</p>	AQ	TPC, TFC, AC, SC, TC, DPPH, FRAP	Antioxidant	Abubakar <i>et al.</i> , 2020

	Capparidaceae				
10	<p><i>Garcinia mangostana</i> L./ Clusiaceae</p>	-	XRD, XRF, FTIR, SEM, FE-SEM, REMA	Antimicrobial, Cytotoxicity	Moopayak and Tangboriboon, 2020
11	<p><i>Manilkara hexandra</i> (Roxb.) Dubard/Sapotaceae</p>	80% AQ-ME	TPC, TFC, TAC, FRAP, DPPH, ABTS, NO, OH, RP	Antioxidant	Parikh and Patel, 2017
12	<p><i>Moringa oleifera</i> Lam./ Moringaceae</p>	90% ET	DPPH, ABTS, FRAP, TFC	Antioxidant, Anti- inflammatory	Xu <i>et al.</i> , 2019
13	<p><i>Myrciaria dubia</i> (Kunth) McVaugh/Myrtaceae</p>	AQ, EtOH , PP	TPC, SPA, PCA	Antioxidant, Antihypertensive	Fidelisa <i>et al.</i> , 2018
14	<p><i>Parkia speciosa</i> Hassk/ Fabaceae</p>	Absolute ET	TFC, TPC, PAC, DPPH, FRAP, Agar disc diffusion, MIC	Antioxidant, Antimicrobial	Ghasemzadeh <i>et al.</i> , 2018

15	<p><i>Pedalium murex</i> L./ Pedaliaceae</p>	AQ	(AgNPs) FTIR, XRD, HR-TEM, EDX, MIC, MTP, EPS, BVA, LDCA	Antibiofilm, Antimicrobial	Ishwarya <i>et al.</i> , 2017
16	<p><i>Persea americana</i> Mill./ Lauraceae</p>	ET	DPPH, ABTS, FRAP, TPC, TFC, MIC, MBC, HA	Antioxidant, Antibacterial, Toxicity testing	Amado <i>et al.</i> , 2019
17	<p><i>Phoenix dactylifera</i> L./ Arecaceae</p>	80% ME, 85% ET, AQ, ME, AC	TPC, TFC, TAC, DPPH, Agar disc diffusion	Antioxidant, Antibacterial	Metoui <i>et al.</i> , 2018
18	<p><i>Pouteria campechiana</i> (Kunth) Baehni/Sapotaceae</p>	PE, 95% ET, AQ	PSA, FTIR, SEM, NMR, DPPH, SO, ABTS, OH	Antioxidant	Ma <i>et al.</i> , 2019
19	<p><i>Silybum marianum</i> (L.) Gaernt./Asteraceae</p>	AQ	(ZnONPs) MTT, Agar disc diffusion, TAC, TRP, DPPH,	Antibacterial, Antioxidant, Cytotoxicity	Abbasi <i>et al.</i> , 2019

			α AI, BSL		
20	<p><i>Trigonella foenum-graecum</i> L./Fabaceae</p>	AQ	(AgNPs) SEM, XRD, FTIR, EDAX, MIC, MTT	Antibacterial, Antifungal, Anticancer	Varghese <i>et al.</i> , 2019
21	<p><i>Ziziphus jujube</i> Mill./ Rhamnaceae</p>	AQ	DPPH, ABTS, RP	Antioxidant, Metal chelation activity	Kanbargi <i>et al.</i> , 2016
PEEL					
22	<p><i>Ananas comosus</i> (L.) Merr./Bromeliaceae</p>	AQ	(ZnONPs) FTIR, XRD, EDX, FESEM, TEM, Agar disc diffusion	Antibacterial	Basri <i>et al.</i> , 2020
23	<p><i>Actinidia chinensis</i> Planch./Actinidiaceae</p>	ME	TPC, TFC, DPPH, ABTS, OH, Agar disc diffusion	Antioxidant, Antimicrobial, Antiproliferative	Alim <i>et al.</i> , 2019
24	<p><i>Actinidia deliciosa</i> (A.Chev.) C.F.Liang & A.R.Ferguson/Actinidiaceae</p>	HE, AC, Pure ME, 70% ME	MTT, HIV, O ₂ ⁻	Antibacterial, Anti-helicobacter pylori, Cytotoxic	Motohashi <i>et al.</i> , 2001

25	<p><i>Allium sativum</i> L./ Amaryllidaceae</p> <p><i>Allium cepa</i> L./ Amaryllidaceae</p>	96% ET	-	Anti-diabetic	Lolok <i>et al.</i> , 2019
26	<p><i>Aloe vera</i> (L.) Burm.f./ Asphodelaceae</p>	70% ET	-	Antioxidant, Antidiabetic	Christijanti <i>et al.</i> , 2019
27	<p><i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai/ Cucurbitaceae</p>	AQ	(AuNPs) FTIR, TGA, SEM, EDX, XRD, Agar disc diffusion, DPPH, ABTS	Antibacterial, Antioxidant, Inhibitory	Patra <i>et al.</i> , 2015
28	<p><i>Citrus grandis</i> Merr./ Rutaceae</p>	90% ME, Hot AQ, EA	AAIE, ASIE	Anti- inflammatory	Zhao <i>et al.</i> , 2019

29	<p><i>Citrus reticulata</i> Blanco/ Rutaceae</p>	70% ET	HEPG ₂ , HCT, MCF-7, HPLC	Anticancer, Antimicrobial	Selim <i>et al.</i> , 2019
30	<p><i>Citrus sinensis</i> (L.) Osbeck/Rutaceae</p> <p><i>Citrus limon</i> (L.) Osbeck/ Rutaceae</p> <p><i>Musa acuminata</i> Colla/ Musaceae</p>	ME, EA, ET, AQ	Agar well diffusion, MIC, GC-MS	Antimicrobial	Saleem and Saeed, 2020
31	<p><i>Citrus sinensis</i> (L.) Osbeck/Rutaceae</p>	ET, ME	-	Anti- inflammatory	Osarumwense, 2017

32	<p><i>Cucurbita moschata</i> Duchesne ex Poir./ Cucurbitaceae</p>	70% ET	DPPH, TAC, TPC, TMC, MIC	Antibacterial, Antioxidant, Wound healing	Bahramsoltani <i>et al.</i> , 2017
33	<p><i>Litchi chinensis</i> Sonn/ Sapindaceae</p>	ME	SLP, LP, HPA	Hepatoprotective	Queiroz <i>et al.</i> , 2018
34	<p><i>Mangifera indica</i> L./ Anacardiaceae</p>	95% ET, NPEE, CPEE, NPWE, CPWE	Agar disc diffusion, PPC, DPPH, ABTS, CLC, MTT	Anti inflammatory, Anti-cancer, Antioxidant, Antibacterial	Huang <i>et al.</i> , 2018
35	<p><i>Musa acuminata</i> Colla/ Musaceae</p>	-	TPC, FCC, FRAP, TEAC, DPPH, SAEA, MDA	Antioxidant	Chueh <i>et al.</i> , 2019
36	<p><i>Musa acuminata</i> Colla/ Musaceae</p>	-	TPC, TFC, DPPH, FRAP, MTT	Antioxidant, Antitumour	Kumar <i>et al.</i> , 2019

37	<p><i>Musa sapientum</i> L./ Musaceae</p> <p><i>Carica papaya</i> L./ Caricaceae</p>	AQ, Absolute, 80% ET	TPC, TFC, RP, DPPH, Agar disc diffusion	Antioxidant, Antibacterial	Siddique <i>et al.</i> , 2018
38	<p><i>Nephelium lappaceum</i> L./ Sapindaceae</p>	-	HPA, IHCA	Antidiabetic	Ma <i>et al.</i> , 2017
39	<p><i>Pouteria caimito</i> Radlk./ Sapotaceae</p>	ME, n-HE, CF, EA	MIC, MBC	Antimicrobial, Antidiarrheal	Abreu <i>et al.</i> , 2019
40	<p><i>Prunus persica</i> L./ Rosaceae</p>	AQ	(AgNPs) SEM, EDX, XRD, TGA, FTIR, Agar disc diffusion, MIC,	Antibacterial, Anticandidal, Antioxidant	Patra <i>et al.</i> , 2016

			MBC, DPPH, ABTS, NO, RP		
41	<p><i>Punica granatum</i> L./ Lythraceae</p>	AQ	Cytotoxicity	Anti-inflammatory	Mastrogiovanni <i>et al.</i> , 2019
42	<p><i>Punica granatum</i> L./ Lythraceae</p>	80% ME, 0.01% HCl, AQ	TPC, HPLC, MIC, MBC	Antibacterial	Yemis <i>et al.</i> , 2019
43	<p><i>Solanum melongena</i> L./ Solanaceae</p>	CaSO ₄ , CaCO ₃ , CaCl ₂	TPC, TFC, DPPH, ABTS, UPLC-MS	Antioxidant, Anti-salmonella	Rochín-Medina <i>et al.</i> , 2019
44	<p><i>Ziziphus jujuba</i> Mill./ Rhamnaceae</p>	ME, DMSO	TPC, TFC, MTT, NLA	Anti-inflammatory	Wang <i>et al.</i> , 2019

Flower					
45	<p><i>Acacia saligna</i> (Labill.) H.L.Wendl./Fabaceae</p>	AQ	MIC, DPPH	Antifungal, Antibacterial, Antioxidant	Al-Huqail <i>et al.</i> , 2019
46	<p><i>Agastache rugosa</i> (Fisch. & C.A.Mey.) Kuntze/ Lamiaceae</p>	ET, HE, ME	DPPH, H ₂ O ₂ , SO, Agar disc diffusion	Antioxidant, Antimicrobial	Park <i>et al.</i> , 2019
47	<p><i>Aloe barbadensis</i> (L.) Burm.f./Asphodelaceae</p>	70% ET	TPC, TFC, DPPH, ABTS, RP, NO, OH, SO	Antioxidant	Debnath <i>et al.</i> , 2018
48	<p><i>Begonia semperflorens</i> Carl Ludwig Willdenow/ Begoniaceae</p>	100% ME, 80% AQ	TFC	Hepato-protective, Neuro-protective	Kwon <i>et al.</i> , 2019
49	<p><i>Bombax ceiba</i> L./ Malvaceae</p>	ET, AQ	Phytochemical	Acute toxicity, Anti-ulcer	Barakat <i>et al.</i> , 2019

50	<p><i>Carica papaya</i> L./ Caricaceae</p>	ME, CF, n-HE, AQ	TPC, TFC, DPPH, Agar well diffusion	Antioxidant, Antibacterial	Dwivedi <i>et al.</i> , 2020
51	<p><i>Cassia fistula</i> L./Fabaceae</p>	-	-	Anti- inflammatory	Antonisamy <i>et al.</i> , 2019
52	<p><i>Ctenolepis garcini</i> (L.) C.B.Clarke/Cucurbitaceae</p>	ET	AT	Antiulcer	Kumar <i>et al.</i> , 2019
53	<p><i>Etlingera elatior</i> (Jack) R.M. Sm./Zingiberaceae</p>	ET	Agar disc diffusion, MIC, MBC	Antibacterial	Anzian <i>et al.</i> , 2020
54	<p><i>Ferulago macrocarpa</i> (Fenzl) Boiss./Apiaceae</p>	AQ	(AgNPs) DPPH, RSA, FTIR, SEM, EDX, XRF, XRD, Agar disc diffusion, Agar well	Antibacterial, Anticancer, Antifungal	Azarbani and Shiravand, 2020

			Diffusion, MTT		
55	<p><i>Ixora coccinea</i> L./ Rubiaceae</p>	80% ME	α AI, α IGE	Anti-diabetic	Anila and Hashim, 2019
56	<p><i>Mimosa pudica</i> L./ Fabaceae</p>	AQ	(AuNPs) FESEM, TEM, DLS, Zeta, XRD, FTIR	Photocatalytic	Mapala and Pattabi, 2017
57	<p><i>Peltophorum pterocarpum</i> (DC.) K. Heyne/Fabaceae</p>	AQ	(ZnONPs) Zeta, TGA, FTIR, XRD, SEM, Agar well diffusion, MTT	Antimicrobial, Cytotoxicity	Khara <i>et al.</i> , 2018
58	<p><i>Petasites japonicus</i> (Siebold & Zucc.) Maxim./Asteraceae</p>	HE, DCM, DMSO, ME, AQ, AcOH	DPPH, HPLC-DPPH	Antioxidant, DAD, ESI, HPLC, MS UPLC,	Hiemori-Kondoa and Nii, 2019

59	<p><i>Ruellia brittoniana</i> C.Wright/Acanthaceae</p>	n-HE, EA, ET	MTT	Anticancer	Tejaputri <i>et al.</i> , 2020
60	<p><i>Vernonia amygdalina</i> Delile/Asteraceae</p>	HE, CF, AC	DPPH, FTM, GC-MS	Antibacterial, Antioxidant	Habtamu and Melaku, 2018

Begonia semperflorens flowers showed hepatoprotective and neuroprotective properties (Kwon *et al.*, 2019). *Ixora coccinea* flowers were reported for antidiabetic property (Anila and Hashim, 2019). The presence of secondary metabolites like flavonoids, tannins and phenols in methanol extract were attributed for its antidiabetic property. *Bombax ceiba* flowers showed anti-ulcer property (Barakat *et al.*, 2019). They contained phytoconstituents like flavonoids (naringenin), phenols (rutin, quercetin and gallic acid), carbohydrates, tannins, sterols, coumarins and other phytoconstituents like caffeic acid, ferulic acid, syringic, cinnamic acid and mangiferin. Antiulcer activity was reported by flower extract of *Ctenolepis garcini* (Kumar *et al.*, 2019); anticancer activity against HeLa cervical cancer cell line by *Ruellia brittoniana* flowers (Tejaputri *et al.*, 2020).

Like seeds and peels, flowers are also utilized for metal nanoparticle synthesis and they showed many biological activities. For *e.g.* silver nanoparticles synthesized using flower extract of *Cassia roxburghii* and *Ferulago macrocarpa* showed antibacterial and

antifungal activities (Moteriya and Chanda, 2014; Azarbani and Shiravand, 2020). Titanium oxide nanoparticles synthesized using *Hibiscus rosasinesis* flower extract showed antibacterial activity (Kumar *et al.*, 2014). *Mimosa pudica* flower extract mediated synthesized gold nanoparticles showed dye degradation or photocatalytic activity (Mapala and Pattabi, 2017). *Peltophorum pterocarpum* flower mediated synthesized zinc oxide nanoparticles showed antimicrobial and cytotoxic activities (Khara *et al.*, 2018) while those from *Nyctanthes arbor-tristis* showed antifungal activity (Jamdagni *et al.*, 2018). Copper oxide nanoparticles synthesized using *Magnolia champaca* floral extract showed antioxidant activity (Santhoshkumar and Shanmugam, 2020).

In this review, we report the biological activity of some seeds, peels and flowers. The Seeds belonged to 17 different families like Arecaceae, Asteraceae, Capparidaceae, Clusiaceae, Cucurbitaceae, Fabaceae, Lauraceae, Malvaceae, Moringaceae, Myrtaceae, Pedaliaceae, Rhamnaceae, Rosaceae, Rutaceae, Sapotaceae, Solanaceae

and Zingiberaceae. The peels belonged to 15 families viz. Actinidiaceae, Amaryllidaceae, Anacardiaceae, Asphodelaceae, Bromeliaceae, Caricaceae, Cucurbitaceae, Lythraceae, Musaceae, Rhamnaceae, Rosaceae, Rutaceae, Sapindaceae, Sapotaceae and Solanaceae. The flowers belonged to 12 families viz. Acanthaceae, Apiaceae, Asphodelaceae, Asteraceae, Begoniaceae, Caricaceae, Cucurbitaceae, Fabaceae, Lamiaceae, Malvaceae, Rubiaceae and Zingiberaceae.

In conclusion, this review summarizes the therapeutic potential of biowaste of plants i.e. biological activities of seeds, peels and flowers. These parts which are generally thrown into the environment can be successfully exploited as a natural source for activities like antimicrobial, antioxidant, antidiabetic, anti-ulcer, hepatoprotective, anti-cancer, wound healing, etc properties. These are mostly crude extracts therefore detailed studies have to be done using various extraction techniques and their mechanism of action has to be worked out. Structural characterization of the phytochemicals involved also needs to be worked out. But definitely they are not waste and can be therapeutically useful. It has double advantage of decreasing pollution and increasing naturally occurring bioactive compounds which can be therapeutically useful.

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Abbreviation

AQ – Aqueous, **ET** – Ethanol, **HE** – Hexane, **ME** – Methanol, **CF** – Chloroform, **n-HE** – n-Hexane, **EA** – Ethyl acetate, **AC** – Acetone, **PE** – Petroleum ether, **EtOH** – Ethyl alcohol, **DCM** – Dichloro-methane,

DMSO – Di-methyl-sulfoxide, **AcOH** – Acetic acid, **CaSO₄** – Calcium sulfate, **CaCO₃** – Calcium carbonate, **CaCl₂** – Calcium chloride, **HME** – Hydro-methanolic solution, **NHET** – Hydro-ethanolic solution, **PP** – Propanone, **TPC** – Total phenolic, **PAC** – Phenolic acid content, **TFC/FC** – Total Flavonoids content, **AC** – Alkaloids content, **TTP** – Triterpenes, **TT** – Total tannins, **TCP** – Tocopherols phytosterols, **TC** – Total carotenoids, **TTC** – Tannins content, **SC** – Saponins content, **PPC** – Polyphenol content, **TMC** – Total mucilage content, **DPPH** – 2,2-diphenyl-1-picrylhydrazyl, **SO** – Superoxide anion radical scavenging activity, **ABTS** – 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid, **FRAP** – Ferric Reducing antioxidant Power, **O₂** – O₂ scavenging activity, **OH** – Hydroxyl free radical scavenging activity, **H₂O₂** – Hydrogen peroxide activity, **NO** – Nitric oxide-scavenging activity, **TRP** – Total reducing power, **TAC** – Total antioxidant capacity, **RP** – Reducing power, **RSA** – Radical scavenging activity, **TEAC** – Trolox Equivalent Antioxidant Capacity, **SAEA** – Serum antioxidant enzyme activity, **MIC** – Minimum inhibitory concentration, **MBC** – Minimum bactericidal concentration, **MTP** – Microtiter plate assay, **MTT** – 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide, **MCF-7** – Breast cancer cell line, **HCT** – Colon carcinoma cell line, **BVA** – Bacterial viability assay, **LDCA** – Live and dead cell assay, **HEPG2** – Liver carcinoma cell line, **XRD** – X-Ray Diffraction, **XRF** – X-ray fluorescence, **Zeta** – Zeta potential, **FTIR** – Fourier Transform Infrared Spectroscopy, **FESEM** – Field Emission Scanning Electron Microscope, **SEM** – Scanning electron microscope, **HR-TEM** – High-resolution transmission electron microscopy, **TEM** – Transmission electron microscopy, **SAED** – Selected area diffraction, **DLS** – Dynamic light scattering, **EDX** – Energy Dispersive X-Ray analysis, **NMR** – NMR spectrometric analysis, **TG** – Thermogravimetric analysis, **GC-MS** – Gas Chromatography Mass Spectrometry, **HPLC** – High Performance Liquid Chromatography, **UPLC-MS** – Ultra performance liquid chromatography - mass spectrometer, **NLA** – Nitrite and Luciferase assay, **PCA** – Correlation analysis by principal component analysis, **PSA** – Phenol-sulfuric acid method, **RAT** – Rhein acute toxicity, **SLP** – Serum lipid parameters, **SPA** – Spectro-photometric assay, **SICA** – Starch-iodine colour assay, **EPS** – Exopolysaccharide quantification, **FCC** – Ferrous chelating capacity, **FTM** – Ferric thiocyanate method, **αAI** – α-Amylase inhibition, **BSL** – Brine shrimp lethality, **AT** – Acute toxicity, **HA** – Hemolytic activity, **HPA** – Histopathological analysis, **HIV** – Human immunodeficiency virus, **IHCA** – Immunohistochemical analysis, **α IGE** – Inhibition of alpha-glucosidase enzyme, **LAS** – Linoleic acid

system, **LP** – Lipid peroxidation, **LTL** – Liver total lipids, **MDA** – Serum malondialdehyde concentration, **AAIE** – Anti-acute inflammation effect, **ASIE** – Anti-subacute inflammatory effect, **CLC** – Cell line culture, **BSCA** – Brine shrimp cytotoxicity assay, **REMA** – REMA assay, **AgNPs** - Silver nanoparticles, **AuNPs** - Gold nanoparticles, **ZnONPs** - Zinc oxide nanoparticles.

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