CHAPTER 2
REVIEW OF LITERATURE
In India, a large quantity of waste is generated by fruit and vegetable processing industries. These waste has been recognized previously for possessing a high antioxidant potential and are a rich source of sugars, minerals and organic acids dietary fibers and phenolics which have a wide range of actions which includes antioxidants, antimutagenic, antibacterial, antifungal and antiviral activities (Adams et al., 2006; Balasundram et al., 2006). Available literature regarding previous researches on selected plants were studied and all relevant information was compiled as a patronage for the present work.

2.1 Allium cepa L. (Onion)

According to Waldron (2001), more than 500,000 tonnes of onion by-products are produced annually in the European Union, mainly from Spain, UK and Holland. Onion is one of the most consumed spices in the world due to its health benefits. Mainly it is known for its flavonoid content, which is one of the reasons for its considerable dietary consumption (Santas et al., 2008). Onion by-products may also possess some of the bioactive compound. Several studies have been carried out in search of them so that the waste can be utilized in some other way.

Proximate analysis of onion peel indicated that it is rich in carbohydrates, dietary fibre ranged in 7.78% to 26.84% and ash content 5.93% to 14.12% but contains lower amount of protein i.e. 2.64 to 3.06% (Bello et al., 2013; Sayed et al., 2014). It is also found to be a good source of phenols and flavonoids ranged between 52.7 mg GAE/g to 384.7 mg GAE/g and 43.1±1.8 mg QE/g to 183.95 mg QE/g extract accordingly (Suh et al., 1999; Beníteza et al., 2011). Phytochemical evaluation revealed the presence of tannins, saponins, flavonoids, terpenoids and cardiac glycosides in onion peel. However, it was negative for phlobatannins or reducing sugars (Chiew et al., 2014).

Quercetin 4’-O-β-glucopyranoside is found to be present as the major flavonoid in onion peels and decreases from the outer to inner rings. In general, it contains
flavonoids, such as anthocyanins, flavanols (quercetin and its derivatives) and alk(en)yl cysteine sulfoxides (ACSOs), which can be developed as complementary and alternative healthcare products that benefit human health (Orhan et al., 2010; Arung et al., 2011; Russo et al., 2012). The phenolic compounds which are present in onion peel are reportedly 3 to 5 times higher than edible inner parts (Skerget et al., 2009).

Flavonoids have been verified to have antibacterial, antifungal, antiviral, anti-oxidant and anti-inflammatory properties (Russo et al., 2012). Due to the presence of phenolics and flavonoids, onion peel also shows high antioxidant capacity evaluated by various methods like DPPH radical scavenging activity, ferric thiocyanate assay, anti-radical power and reducing power assay. Its HPLC and MS analysis showed the presence of ferulic, gallic, protocatechuic acids, quercetin and kaempferol (Beníteza et al., 2011; Lee et al., 2014). Onion peel extract also exhibited antimicrobial activity against *E. coli, P. aeruginosa, S. Flexner, P. fluorescens, B. cereus* and *A. niger* (Skerget et al., 2009; Chiew et al., 2014).

### 2.2 Allium sativum L. (Garlic)

Garlic (*Allium sativum* L.), belonging to the Alliaceae family which possesses an important dietary and medicinal role for centuries. In the past, garlic has been utilized as a remedy for the various diseases such as typhus, dysentery, cholera, influenza, worm infestation and whenever an epidemic has emerged, garlic has been the first preventive and curative remedy. Its therapeutic uses include beneficial effects on the cardiovascular system, antibiotic, anticancer, anti-inflammatory, hypoglycemic, and hormone-like effects (Jonkers et al., 1999; Banerjee and Maulik, 2002; Toplak, 2005). Garlic also possess a wide range of bioactive effects, including antioxidant, antimicrobial, anticancer, antihypertensive, hepatoprotective, and insecticidal properties (Corzo-Martínez et al., 2003; Rahman and Lowe, 2006).

Garlic cloves are generally used as a remedy for infections, digestive disorders, and fungal infections such as thrush (Lemar et al., 2005; Shuford et al., 2005). Allicin, a compound produced by enzymatic (alliin lyase) hydrolysis of alliin after cutting and crushing of the cloves is found to be responsible for its pungent odor and antibacterial
activity (Ellmore and Feldberg, 1994). However, there has been no report on the garlic peel. Garlic peel has been treated as waste and may constitute nuisance.

Proximate analysis of garlic showed that it contained moisture content in between 4.26% to 66.57%, crude protein 6.39% to 17.35 %, crude fat 0.52% to 0.83%, crude fiber 0.73% to 3.05%, ash content 1.33% to 5.00%, dry matter 33.43% to 35.42% and total carbohydrate content 33.06% to 73.22% (Nwinuka et al., 2005; Odebunmi et al., 2009; Otunola et al., 2010; Okolo et al., 2012; Belemkar et al., 2013). When the proximate analysis of garlic peel was compared with garlic clove, it has been recorded that garlic peel contains 93.26% carbohydrates which is higher than clove and rest of the parameters were recorded lower than clove i.e. Ash 0.49 ± 0.04%, Crude fibre 0.13 ± 0.01%, Fat 0.05 ± 0.01%, Moisture content 5.50 ±0.00% and Protein 0.57 ± 0.02% (Ifesan et al., 2014).

Only a few reports are available for the chemical composition of garlic skin. It has been reported that garlic peel contains fair concentration of total phenolic, flavonoid (Ifesan et al., 2014) and pectin is the characteristic component (Abdel-Fattah and Edrees, 1972; Alexander and Sulebele, 1973). Also, p-coumaric acid, ferulic acid, and sinapic acid were reported from the enzymatic hydrolysate of garlic skins (Schmidtlein and Herrmann, 1975; Ra et al., 1998; Suh et al., 1999). Ichikawa et al. (2003) identified six important phenyl propanoid derivatives as primary antioxidant constituents from garlic skin and also reported strong DPPH radical scavenging activity of the extract.

Garlic peel also reported to inhibit the growth of several microorganisms such as E.coli, P. vulgaricus, B. cereus, B, subtilis and S. aureus (Ifesan et al., 2014). Tsao and Yin (2001) isolated the active antibacterial element, llicin-derived organo-sulphur compound. It has been also reported that the antibacterial activity of garlic is the result of interaction between sulphur compounds, allicin with sulphur groups of microbial enzymes (Bakri and Douglas, 2005).

2.3 Solanum tuberosum L. (Potato)

Potato (Solanum tuberosum L.) is one of the main components of human diet and grown in more than 100 countries. With world annual production of 367.75 million
tons, it ranks fourth among worldwide grown crops (Leo et al., 2008; FAO, 2013). Peels contain up to 3% - 5% part of potato tuber and are the main by-product of potato processing which causes many environmental problems (Habeebullah et al., 2010).

The proximate analysis of potato peel showed presence of 3.73 to 7.85 % moisture, 5.31 to 7.73% ash, 0.92 to 1.40% total soluble sugar, 70 to 86% carbohydrates, 45 to 66.8% starch, 6.47 to 18.55% crude protein, 3.4% pectin, 0.1% to 2.2% Cellulose, 1.17 % fat and 76.40 % dietary fiber (Camire et al., 1997; Dhingra et al., 2012; Amado et al., 2014).

Potato peel is a good source of phenolic compounds which are natural antioxidants and dietary fibers (Mohdaly et al., 2010; Mohagheghi et al., 2012; Wu et al., 2012; Albishi et al., 2013; Amado et al., 2014). Potato peel contains many free form and bound phenolic acids. Some of these compounds were identified as chlorogenic acid, gallic acid, protocatechuic acid and caffeic acid (Sotillo et al., 1994). Due to the presence to such compounds, potato peel exhibited good antioxidant activity which was found to be comparable to butylated hydroxytoluene (Kanatt et al., 2005). Major part of phenolic compounds are distributed between the potato cortex and skin (peel) tissues (Friedman, 1997). About 50% of the phenolic compounds are located in the potato peel and adjoining tissues, while the rest decrease in concentration from the outside toward the centre of potato tubers (Hasegawa et al., 1966).

Potato peel was found to be effective against different types of bacteria and fungi like P. aeruginosa, C. michigenensis, S. typhimurium and E. coli. Peel extract gave good results in higher concentration (Sotillo et al., 1998; Prasad and Pushpa, 2007).

2.4 Mangifera indica L. (Mango)
Mango (Mangifera indica L.), a member of the family Anacardiaceae, is among the most cultivated fruits in the world and India is the largest producer of mangoes with 44.14 per cent of the total world production (Kusuma and Basavaraja, 2014). Approximate 20% of world’s total mango production is utilized for making frozen mango products, canned products, dehydrated products, and ready-to-serve beverages along with using as a common ingredient for the development of functional foods as a
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flavor, colorant etc. (Ramteke and Eipeson, 1997; Ajila et al., 2007). Several million tons of mango wastes (peels and seeds) are produced annually from consumption or industrial processing (Puravankara et al., 2000; Ashoush and Gadallah, 2011). Peel contributes about 15-20% of the fruit and seeds account for 35%–55% of the fruit (Beerh et al., 1976; Bhalerao et al., 1989) depending on the variety. Seeds and peels are generally discarded as waste and becomes a source of pollution. The utilization of mango by-products may be an economical way to reduce the problem of waste disposal from mango production.

Mango seed kernel contains 38.55 to 45.2% moisture content, 1.43 to 10.06% crude protein, 4.92 to 14.80 % fats/oil, 1.65 to 10.60 % crude fiber, 0.83% to 3.2% ash content and 32.24 to 70.12 % carbohydrates (Arogba, 2002; Nzikou et al., 2010; Fowomola, 2010; Ashifat et al., 2012). Mango seed kernel is also reported high in potassium, magnesium, phosphorus, calcium and sodium. It also contains vitamin A, vitamin E, vitamin K, vitamin B1, vitamin B2, vitamin B6, vitamin B12 and vitamin C (WHO, 1985; Fowomola, 2010).

Mango seed kernel was reported rich in phenolic content and potent antioxidant activity. It is also a good source of phytosterols, tannins, gallic acid, coumarin, ellagic acid, vanillin, mangiferin, ferulic acid, cinamnic acid and unknown compounds (Soong et al., 2004; Abdalla et al., 2007; Ashoush and Gadallah, 2011; Deng et al., 2012). High content of polyphenols, sesquiterpenoids, phytosterols and microelements like selenium, copper and zinc is probable reason for the antioxidant activity of seed kernel (Schiber et al., 2003; Nunez-Selles, 2005). Reports are also available on the presence of glutamate, methionine, arginine, leucine, triterpene, unsaturated sterols, cardiac glycosides, alkaloid, tannins, phytate, cyanide, saponin and oxalate (Fowomola, 2010; Talba et al., 2014).

Mango peel contain 4.92 to 9.96% Moisture, 3.88 % Ash, 1.23 to 4.80% Fat, 3.6 to 4.32% Protein, 9.33 to 16.50% Crude fiber and 57.92% Carbohydrate (Ashoush and Gadallah, 2011; Ashifat et al., 2012). Peel has been found to be a good source of phytochemicals, such as flavonoids, xathones, carotenoids, phenolic acids, gallotannins, vitamin E, dietary fibre, homogentisic acid and vitamin C and it also exhibited very high antioxidant activity, a fact attributed to its high phytochemical
content (Soong and Barlow 2006; Abdalla et al., 2007; Ajila et al., 2007; Barreto et al., 2008; Kim et al., 2010; Souza et al., 2011; Deng et al., 2012).

It is a source of pectin, which is considered a high quality dietary fiber containing high amount of extractable polyphenolics. Polyphenolics in mango peel are responsible for its higher values of anticancer properties (Tandon et al., 1991; Pedroza-Islas and Aguilar-Esperanza, 1994; Tandon and Garg, 1999; Ojokoh, 2007; Noratto, 2010).

Mango peel extract showed activity against microbes like C. rubrum, M. flavus, S. albus, S. aureus, B. cereus, M. flavus, C. freundii, E. coli and P. vulgaris (Oliveira et al., 2011; Rakholiya et al., 2013). M. indica seeds kernel extract shows antibacterial activity against strains like B. subtilis, S. aureus, S. pyogens, E. coli, P. vulgaris, K. pneumonia, S. dysenteriae and P. aeruginosa (Sowmiya et al., 2009; Latha et al., 2011; Rajan et al., 2011; Sahu et al., 2013).

2.5 *Cajanus cajan* (L.) Millsp. (Pegion pea)

*Cajanus cajan* (L.) Millsp. belongs to family fabaceae and it is widely consumed as an excellent source of protein in developing tropical countries. India is a principal pigeon pea-growing country contributing nearly 90% of the total world production. Currently, it occupies an area of 3.85 million hectares with an annual production of 2.68 million tonnes (Kumar et al., 2010). It is a multipurpose plant as all parts of this plant are reported to be very useful. The seeds and the pods are rich in proteins and eaten as vegetables and additives in soups. Its leaves are rich in carotene and other essential nutrients and used as fodder in replacement of alfalfa. They are also used for rearing silkworms. The pod shells after removing the seed is a useful feed for ruminant cattle as it contains high level of digestible crude protein. But, low levels of digestible energy and sulphur. It also used as green manure (Kurien and Parpia, 1968; Ambasta, 2004; Ahsan and Islam, 2009).

Proximate composition of green seeds of pegion pea is 0.24 to 3.61% moisture, 3.17 to 9.93% Ash, 48.4% starch, 4.11 to 25.83% protein, 5.14 to 8.4% soluble sugars, 50.08 carbohydrate, 5.54 to 8.2% crude fiber and 2.17 to 3.68% Fat (Tiwari et al., 2008; Saxena et al., 2010; Balogun, 2013; Adamu and Oyetunde, 2013). The leaves
and seed coat of pigeon pea are also rich in nutrients (Mohanty et al., 2011). Kong et al. (2010) isolated a new natural coumarin, cajanulactone and two phyto alexins: pinostrobin, cajaninstilbene acid from the leaves of pigeon pea.

As far as the antinutrient profile of pigeon pea is concerned, it contains phenols, flavonoids, tannins, phytate, cyanide, saponin and oxalate. The minerals and trace elements in the green seed and mature seed are calcium, magnesium, copper, iron, zinc, respectively (Singh, 1988; Balogun, 2013; Florence et al., 2014).

Cajanus cajan seeds shows effective antioxidant activity when analysed with different methods like DPPH free radical scavenging activity, Hydroxyl (OH-) free radical scavenging, ABTS analysis and ferric reducing antioxidant power. Good ascorbic acid content was also reported from pigeon pea. Cajaninstilbene acid (3-hydroxy-4-prenylmethoxystilbene-2-carboxylic acid), pinostrobin, vitexin and orientin were found to be responsible for the antioxidant activity of C. cajan leaves (Pal et al., 2006; Wu et al., 2009; Pal and Mitra, 2010).

Cajanus cajan seed extract showed remarkable inhibitory action against microbial strains like S. epidermidis, S. aureus and B. subtilis. (Yuan-gang et al., 2010; Kong et al., 2010). All parts of C. cajan plant had potential antibacterial activity against S. aureus and E. coli and may be used for production of drugs commercially to treat diseases caused by the respective pathogens (Banala et al., 2015).

Pigeon pea pod shells are the major residual part of the plant. Though several research reports are available about seed and leaves, pod shells are still not explored much for their phytochemical importance.

2.6 Pisum sativum L. (Pea)

Pisum sativum, pea is the second most consumed and important food legume in the world. It is an annual plant of cool season belonging to the family leguminosae. It is being cultivated on approximately 5.9 million hectares of land with 11.7 million tons of annual production. In India, its annual production is about 0.6 million tons with the cultivation on 0.7 million hectares (Sharma et al., 2006; Ahmad et al., 2010). Green peas (Pisum sativum) is one of the most important vegetable processing crop and its
Peel is the main by-product. It is lignocellulosic by-product which can be used as raw material for cellulose production (Choi and Han, 2001).

Pea peel waste contains 90.33±1.85% Total Sugar, 32.36±1.14% Glucose, 18.85±1.18% Xylose, 61.35±4.96% Holocellulose, 6.93±0.44 to 22.12±3.18% Lignin, 4.80+1.76 to 7.18+0.34% ash, 1.34+0.03% total fat, 13.27+0.51% total protein, 71.3% total dietary fiber, 51.48+1.34% Insoluble fibre, 19.82+1.36% soluble fibre and 3.53+0.67 to 5.77±0.46% Moisture (Mishra et al., 2010; Verma et al., 2011; Sharoba et al., 2013; Rehman et al., 2015).

*Pisum sativum* peel has also been reported effective for absorption of toxic common dye, Methylene blue (MB) in waste water treatment (Dod et al., 2012). Bioactive compounds detected in pea grains and peel are Butoxyacetic acid, Sedoheptulosan, Sucrose, Fructose, 1, 3, 6-trideoxy, 3, 6-epitio, Lactose, Hexanoic acid, 5, oxo- trimethyl silyl ester, Mannosamine, 2-thiozolamine,4,5-di hydro, Goitrin, Sucrose, Inositol, Lactose, Mannitol 1-thio heptyl -1-deoxy and Methionine. Pea pod and grain also contain various amino acids and sterically hindered ring compounds which are responsible for the antioxidant value. It also contain a good amount of phenols and flavonoids and also exhibit potential antioxidant activity when analysed with assays like DPPH radical assay and ABTS radical assay. Pea peel extracts were reported effective against bacterial strains like *E. coli, K. pneumonia, B. subtilis, P. vulgaris, L. lactis, P. aerugionosa, S. aureus, S. enteric* and fungal strains like *C. albicans* and *A. niger* (Saha et al., 2014; Hadrich et al., 2014).

### 2.7 *Eugenia jambolana* Lam (Black plum)

*Eugenia jambolana* Lam. is commonly known as black plum in English and jamun in Hindi belongs to family Myrtaceae. Most of the plant parts of it are used in traditional system of medicine in India. Its fruit contain 25% waste i.e. seeds. Literature indicates that proximate composition of *Eugenia jambolana* seeds is 3.24 to 25% total ash, 0.77 to 3.2% water soluble ash, 0.41 to 2.5% acid insoluble ash, 1.97 to 8.5% crude protein, 0.78 to 1.18% crude fat, 12.38 to 16.9% crude fiber, 0.41% calcium, 0.17% phosphorus, 41% starch, 0.98 to 13% moisture content, 0.40 to 1.39% vitamin C, 3.06 to 3.64 % Total Sugar, 1.22 to 1.41% reducing sugar, 1.84 to 2.12% non-reducing sugar, 96.28 to 97.07% total solids (Shahnawaz et al., 2009; Modi et al., 2010; Ranjan...
et al., 2011; Chitnis et al., 2012; Nair et al., 2013; Raza et al., 2015). Eugenia jambolana seed’s extractive value ranged from 1.16 to 40% for water, 14 to 45% for alcohol, 0.07 to 45% for Methanol, 1 to 36% for Chloroform, 0.6 to 28% for Petroleum-ether and 1.2% for ethyl acetate (Modi et al., 2010; Agrawal and Argal, 2014).

Preliminary phytochemical analysis indicated the presence of alkaloids (jambosine), flavonoids, tannins, phenolic compounds (jambidol and ellagic acid), glycosides (jambolin or antimellin), steroids, triterpenoids, saponins, carbohydrates, proteins & amino acids, fatty acids, gallic acid, starch a trace of pale yellow essential oil, fat, resin and albumin (Ranjan et al., 2011; Chitnis et al., 2012; Hajoori et al., 2013; Agrawal and Argal, 2014). Reported fatty oils from Syzygium cumini seeds are lauric, myristic, palmitic, stearic, oleic, linoleic, malvalic, sterculic and vernolic acid. Other constituents are phytosterols such as β-sitosterol and tannins, predominantly corilagin, ellagitannins, ellagic acid, galloyl-galactoside and gallic acid (Lock et al., 2009).

*Eugenia jambolana* seeds are reported for effective hypoglycaemic properties, antibacterial activity, antioxidant activity, central nervous system activity, chemopreventive action, α amylase inhibitor activity, anti-inflammatory effects, antiviral properties and antidiarrheal effects (Yoganarasimhan, 2000; Khare, 2004; Kumar et al., 2007; Shihabudeen et al., 2010; Ugbabe et al., 2010; Sreevani et al., 2011; Alam and Rahman, 2012; Jayachandra et al., 2012).

The seeds are claimed to be rich in flavonoids and total phenolics, well-known antioxidants, which accounts for significant antioxidant activity. Seed extracts were found to be efficient antioxidant when analysed with different methods like DPPH radical scavenging activity, Total antioxidant capacity, FRAP assay, reducing power assay, hydroxyl radical scavenging activity, ABTS assay, nitric oxide scavenging activity assay, total reducing antioxidant potential (Ravi et al., 2004; Bajpai et al., 2005; Shahnawaz et al., 2010; Margaret et al., 2015).

Extracts of Eugenia jambolana seeds with different solvent showed inhibitory action against microbial strains like *B. subtilis, B. megaterium, B. cereus, S. paratyphi, S.*
typhi, P. vulgaris, S. aureus, E. coli, K. pneumonia, P. aeruginosa, C. albicans (Baga et al., 2012; Chitnis et al., 2012; Hajoori et al., 2013).

2.8 Annona squamosa L. (Custard apple)

*Annona squamosa* L. belongs to family Annonaceae and commonly known as custard apple is a native of the West Indies. The plant is a deciduous small tree and grows well in regions of medium humidity. It is widely grown in India and also popularly cultivated in the north eastern parts of Thailand for its delicious fruits. Seed and peel are the major waste from the fruit. Its seeds comprise 30% of fruit’s weight and is well known for killing head lice but there has been no report on the active component (Pinto et al., 2005; Intaranongpai et al., 2006).

Studies for the proximate composition of custard apple seeds revealed that seeds contain 0.58±0.36 to 4.602% total ash content, 1.22% to 6.82+1.11% moisture content, 4.4 ± 0.72% to 17.5± 0.2% protein, 16.8 ± 0.2a % to 36.33 ± 1.17 Fiber, 30.0 ± 0.3a% to 12.45 ± 2.76 Carbohydrate, 26.8± 0.4a% Fat, 44 ± 3.06% Crude lipid and 463.55 ± 4.50 Kcal/100g energy value (Hassan et al., 2008; Mariod et al., 2010; Kulkarni et al., 2013; Sharma et al., 2013; Kadarani et al., 2015).

Several researches have been undertaken to analyse the phytochemical status of *A. squamosa* L. seeds. Qualitative analysis of extracts prepared by using different solvents indicated the presence of alkaloids, quinone, tannins, flavonoids, proteins, carbohydrates, beta cycnins, cardioglycosides, terpenoids, phenolics, coumarins, steroids, acetogenins and saponin (Das et al., 2007; Kavitha et al., 2013; Biba et al., 2013; Kadarani et al., 2015). About 30 acetogenins from the seeds of *A. squamosa* Linn were isolated such as Squamocins B to N, Coumarinoligans. Annotemoyin-1, Annotemoyin-2, squamocin and cholesteryl, glucopyranoside. These compounds shows remarkable antimicrobial and cytotoxic activities (Ranjan and Sahai, 2009). Among all reported acetogenin, squamocin was reported as the major one (Araya et al., 2002).

According to literature, the extracts of ripe and unripe seeds made in different solvents contain phenolics within the range of 11.9 mg/gm to 534.0 mg/gm (GE equivalent) while flavonoids are present in 5.72±0.38 mg/gm to 42.44±1.13 mg/gm.
(QE equivalent). It also contain good concentration of alkaloids, saponins and flavanol in compare to pulp (Bhardwaj et al., 2014; Gowdhami et al., 2014). Seed possesses 14 to 49% of oil which contains 9.8% hydroxyl acid, the oil contains 38.6% saturated fatty acids and 61.4% unsaturated fatty acids (29.0% oleic and 32.0% linoleic), with a saponification value of 191.8% (Ansari et al., 1985; Lala et al., 2014). Studies have revealed that the oil of A. squamosa is somewhat viscid in appearance, pale yellow in colour and with a persistent smell. The oil is freely soluble in petroleum ether (Rafeeq et al., 2002).

Annona squamosa seed extract showed significant antioxidant activity, when tested for total antioxidant activity and DPPH radical scavenging activity (Pandey and Barve, 2002; Biba et al., 2013; Kavitha et al., 2013). Free radicals act as a trigger to a number of degenerative diseases, therefore samples having free radical scavenging activity can be of potent medicinal importance. This has been proven as a study concluded that custard apple seeds were 300 times more effective than Taxol, an anticancer drug (Chenyong et al., 2012). A. squamosa seeds possessed significant antitumor activity in vivo against AK-5 tumor (Khar, 2004). It also proven a cell growth inhibitor for nasophageal carcinoma cells, MCF-7, breast carcinoma and K-562, erythro leukemia and COLO-205 colon carcinoma cells (Pardhasaradhi et al., 2004; Biba et al., 2013). Two Acetogenins, squamocin and squamostatin, isolated from A. squamosa seeds have shown cytotoxic activity (Fujimoto et al., 1994). Recently, two more acetogenins, squamocin-O 1 and squamocin-O 2 were reported from the methanolic extracts of the seeds of A. squamosal (Araya et al., 2002). The seed extract of A. squamosa Linn. also hold antiimplantational and abortifacient activities (Mishar et al., 1979).

Annona squamosa seeds are traditionally used against insects and hair lice. They also represent an alternative natural source for anthelmintic compounds (Marta et al., 2008). Numerous studies proven its strong antimicrobial activity. The various extracts of A. Squamosa seeds showed inhibitory activity against a range of microbial strains like E. Coli, K. pneumonia, V. cholerae, S. typhi, S. paratyphi, P. mirabilis, B. subtilis, B. cereus, B. megaterium, S. aureus, S. b-haemolytica, S. lutea, S. dysenteriae, S. shiga, S. flexneriae, S.sonnei, P. aeruginosa, Klebsiella spp., A. flavus, T. rubrum, A. niger, C. albicans, S. marcurss, E. faecalis, P. aerugenaosa, S.aeurus, E.
faecalis, *P. aeruginosa* and *K. pneumoniae* (Vidyasagar et al., 2012; Baranwal et al., 2013; Gowdhami et al., 2014; Bhardwaj et al., 2014). The seeds of *A. squamosa* were reported to have insecticidal and abortifacient properties. The crude oils from seeds of it significantly reduced the leaf damage caused by larvae (Babu et al. 1998). It is also effective against insects like *H. armigera*, *S. litura*, *T. castaneum* (Malek and Wilkins 1995; Sonkamble et al., 2000).

2.9 *Citrus sinensis* L. (Orange)

Citrus fruits are occupying the top position in fruit production with significant economic value. Citrus fruits are mainly used for juice, oil and pectin production and are underutilized sources for dietary fiber and antioxidants. Among all citrus fruits, an orange, specifically the sweet orange i.e. *Citrus sinensis* L. is the most abundantly grown fruit tree in the world. It is widely cultivated in tropical and subtropical climates for the sweet fruit, which is peeled or cut (to avoid the bitter rind) and eaten whole, or processed to extract orange juice and also for the fragrant peel. It is processed mainly to obtain juice, but also in the canning industry to produce marmalade, segments of mandarin and by the chemical industry to extract flavonoids and essential oils. The peels obtained from fruits constitute between 50 and 65% of the total weight of the fruits. Sweet orange peel also has a lot of health importance, and it is very rich in antioxidants (vitamins A & C, flavonoids) that helps to fight illness, and helps in reducing cholesterol, promotes healthy skin, aids digestion, good source of vitamin-packed flavouring. But, when this peel is not processed further, it becomes a very troublesome waste capable of causing serious environmental pollution (Izquierdo and Sendra, 2003; Mandalari et al., 2006; Pandharipande and Makode, 2009; Kamal et al., 2011; Hegazy and Ibrahim, 2012).

Proximate analysis of orange peel confirms the presence of total sugars ranged within 9.21 to 23.8 %, Carbohydrates 40.47 to 42.90 %, Protein 0.5% to 8.72%, total ash 1.50 to 14.35 %, Cellulose 2 to 13.61 %, Moisture 2.20 to 11.86 %, Fat 1.57 to 10.00 % and Total dietary fiber 12.47 to 74.87%. Starch, pectin, lignin, lipid and hemicelluloses were also reported in fewer concentration (Nassar et al., 2008; Ververis et al., 2007; Sharoba et al., 2013; Sadiq et al., 2014). Apart from this, nine elements (Fe, Mn, Zn, Ni, Cu, Cr, Pb, and Cd) were also detected from the peel (Narjis et al., 2009; Peter et al., 2013).
The preliminary phytochemical investigation of Citrus sinensis L. peels revealed the presence of various metabolites like reducing sugars, deoxysugars, alkaloids, tannins, steroids, resins, saponins, terpenoids, tannins and flavonoids, while Antraquinones, anthracene glycosides, cardiac glycosides and coumarins were found to be absent. (Arora and Kaur, 2013; Oikeh et al., 2013). Several components like ascorbic acid, d-limonene, hesperidin, naringin, and auraptene were reported in greater concentration than the juice and pulp. D-Limonene, which comprises > 90% of citrus peel oil, has demonstrated chemopreventive activity against a variety of chemically induced rodent cancers (Hakim and Harris, 2001). Peel oil is a by-product of the juice industry produced by pressing the peel. It is used as a flavoring of food and drink and for its fragrance in perfume and aromatherapy. Citrus fruits have peculiar fragrance partly due to flavonoids and limonoids present in the peel and these fruits are good sources of vitamin C and flavonoids (Sawalha et al., 2009).

Quantitative studies of secondary metabolites from the orange peel shows the presence of alkaloid within the range of 0.60 to 0.99 mg/100g, Phenol 1.39 to 780mg/100g, Tannin 0.59 to 7.40+0.06 mg/100g, Flavonoid 0.16 to 0.48 mg/100g and Saponin 0.33 to 1.70mg/100g (Hegazy and Ibrahium, 2012; Park et al., 2014; Singh and Immanuel, 2014; Bernard et al., 2014). The main flavonoid groups found within the fractions examined were polymethoxylated flavones, O-glycosylated flavones, C-glycosylated flavones, O-glycosylated flavonols, O-glycosylated flavanones and phenolic acids along with their ester derivatives. In addition, the quantitative HPLC analysis confirmed that hesperidin is the major flavonoid glycoside found in the orange peel (Kanaze et al., 2009).

The presence of phenolic compounds and flavonoids gives an indication of having antioxidant properties. Several studies revealed that orange peel also exhibit strong antioxidant activity The antioxidant/radical scavenging capacity and reducing power ability of different extracts of orange peel were investigated and it was noticed that ethnolic extract showed very strong antioxidant activity than rest of the extracts which was almost equal to synthetic antioxidants (BHA) (Qian and Nihorimbere, 2004; Velázquez-Nuñez et al., 2013; Park et al., 2014). Researchers have determined orange peel extract inhibits the way cancer cells divide and grow. In laboratory studies,
orange peel extract prevented breast, skin, liver, lung, pancreatic, colon and stomach cancers (Vigushin et al., 1998; Giri et al., 1999; Yano et al., 1999).

Various orange peel extracts were found to be effective against a series of microbial strains like *A. hydrophila*, *C. albicans*, *E. coli*, *S. aureus*, *A. hydrophila*, *E. feacalis*, *S. aureus*, *Listeria spp.*, *P. fluorescens*, *P. aerugenosa*, *K. pneumonia*, *Proteus spp.*, *C. albicans*, *S. aureus*, *E. faecalis*, *P. aeruginosa* and *Shigella sp.* (Osarumwense et al., 2011; Dhiman et al., 2012; Dwivedi et al., 2013; Srividhya et al., 2013).

### 2.10 *Citrus limetta* Risso. (Sweet lime)

*Citrus limetta* is a member of citrus group which belongs to the family rutaceae. The fruit holds immense nutritional and medicinal properties. Sweet lime fruits are mainly used by juice processing industries and the main by-products of its processing are the peel, pulp and seeds. These by-products account for 40-50% of the whole fruit. Since this amount is almost half of the fruit, very large amount of waste is generated every year after processing (Licandro and Odio, 2002). Mostly citrus by-products are used for animal feed (Ting and Rouseff, 1986). As these wastes are rich in nutrients and contain many phytochemicals which can be used in pharmaceutical drugs or as food supplements (Middleton et al., 2000). Sweet lime peels are a good source of pectin which is known to possess blood sugar-lowering and cholesterol-lowering properties (Baker, 1994). Its peel can be incorporated in jam as a source of pectin and many useful byproducts can be obtained from its waste, such as pectin, marmalades, beverage bases, molasses, peel seasoning, purees, dried pulp, citrus alcohol, bland syrup, citric acid, and flavonoids (Braddock, 1995; Braddock and Cadwallader, 1992; Licandro and Odio, 2002).

Proximate analysis of sweet lime peel powder revealed the presence of 10.70% moisture, 5.39% protein, 1.58% fat, 3.39% ash and 17.58% crude fiber (Younis et al., 2015). Methanolic extract of sweet lime showed the presence of alkaloids, flavonoids, saponins and tannins (KunduSen et al., 2010). GCMS analysis of *C. limetta* shown the presence of compounds like α-pinene, Cyclohexene, 1-methyl 5 (1-methyl ethenyl) (R), Linalyl anthranilate, Terpinen4-ol, α-Terpineol, Phenol, 2methoxy3 (2 Propenyl) and 3allyl 6 methoxyphenol (Gupta et al., 2014). Total phenolic content from sweet lime peel was recorded within the range of 0.7% to 12.5% and flavonoid
content was 0.05% (KunduSen et al., 2010; Muthiah et al., 2012). The phenolic compound concentration is directly proportionate to the antioxidant activity. Phenolic compounds behave as hydrogen donor due to the availability of hydroxyl groups. So, high radical scavenging activity can be expected with the extract having high phenolic components (Bala et al., 2009).

Several studies have exhibited the potential antioxidant activity of sweet lime peel. The extracts were found to be effective in assays for measuring antioxidant potential like Superoxide anion scavenging activity, Hydroxyl radical scavenging ability, Reducing power ability, nitric oxide radical activity and DPPH radical scavenging activity (Kakoti et al., 2007; Gupta et al., 2014; Younis et al., 2015). Peel extract also showed inhibitory activity against cancer cell line MCF-7 and HEP2 (Rather et al., 2010).

Extracts of sweet lime peel showed antimicrobial activity against Pseudomonas sp., E.coli., E. aerogenes, S. typhi, Acinetobacter sp., M. catarrhalis, Ps. Aeruginosa, Klebsiella sp., A. fumigates, P. chrysogenum, P. aeruginosa, S.aureus, E. faecalis, S. pneumoniae, S. pyogenes (Mishra et al., 2012; Nada Khazal and Zainab Adil, 2013; Dwivedi et al., 2013).

The fruit peels of C. limetta is also reported for having potent antihyperglycemic activity against STZ-induced diabetes as well as having hypoglycemic activity in normoglycemic rats and in glucose overloaded rats. Peel is rich in flavonoids and limonoids, which are known for their antitumor and anti-inflammatory activities. (KunduSen et al., 2011). C. limetta peel possesses essential oils, mainly used in aromatherapy and perfumes.

The active phytochemicals from the peel may have been investigated in recent time but the importance of sweet lime peel is known traditionally. The peel is chewed to sweeten the breath in the Mediterranean regions. It is also used to treat partial paralysis and the juice extracted from the peel is effective against snake bite. The ash of the peel is good against leprosy and skin diseases (Efrayim and Zohar, 2008). Essential oil extracted from peel has been known not only for its aromatic functions
but also for its physiological properties, such as chemoprevention against cancer and aromatherapy effects (Sawamura, 2010).

2.11 *Citrullus lanatus* (Thunb.) Matsum. & Nakai (Watermelon)

Watermelon, *Citrullus lanatus* belongs to gourd family (Cucurbitacea) and is cultivated for its edible fruit. It is one of the most economically important fruit in gourd family (Koocheki *et al.*, 2007). Watermelon is a warm-season crop from the cucurbit family. Water melons have been part of human diet for ages due to its nutritional values. It is consumed fresh, canned or processed and consumption generates vast amount of agricultural waste and that could bring about environmental pollution if not properly handled (Ahmed, 1996; Chidan Kumar *et al.*, 2012). It has been reported that approximately 33% of Watermelon fruit is rind out of which about 4.36% is the outer green portion and 29% is the inner white portion (Kumar, 1985; USDA, 2004). Watermelon rind is generally dark green or sometimes pale green stripes that turn yellowish green on ripening (Perkins-Veazie and Collins, 2004). The rind is usually discarded; they are edible, and sometimes used as a vegetable (Liu *et al.*, 2006).

Conventionally watermelon peel is being used in several alternative ways. It is being used to make products like pickles, jam, tutti fruity, fruit cheese, vadiyams (Bhatnagar, 1991; Madhuri and Devi, 2003). The thick rind of the fruit can be cooked or candied or made into chutney. It is also used in preserves and jellies (Godawa and Jalali, 1995; Gupta, 2002). In China, rind of the fruit is powdered after drying and after incineration is used for aphthous mouth sores (Parmar and Kar, 2009). Watermelon peel powder is rich source of crude fiber and minerals. Therefore, it can be utilized in food fortification (Apsara and Pushpalatha, 2002). Watermelon peel is also been explored for its phytochemical potentials.

Proximate composition of watermelon peel indicates the presence of moisture within the range of 5.08±0.02% to 91.22±0.65%, Total ash content from 0.41±0.02% to 12.93± 0.32%, protein content from 1.52±0.05 to 7.11±0.00%, Crude fiber from 0.97±0.04% to 16.8± 0.20%, Carbohydrates from 4.68±0.10% to 81.62± 0.05%, lipid content from 0.21±0.01% to 2.21± 0.16%, energy value from 129.99±2.59 K/cals to 365.81±0.18 K/cals (Erukainure *et al.*, 2010; Hanan *et al.*, 2013; Fila *et al.*, 2013; El-
Badry et al., 2014; Cemaluk and Egbuonu, 2015). TLC profile of peel indicated the presence of sugars; Rhamnose, sucrose, mannose and glucose (Chidan Kumar et al., 2012).

Peel also contains minerals like Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Phosphorus (P), Iron (Fe) and Zinc (Zn) (El-Badry et al., 2014). Preliminary phytochemical screening indicates the presence of saponins, Alkaloid, carotenoids, phenolics, flavonoids, tannins. Watermelon peel is also rich in secondary metabolites like phenolic compounds, flavonoids, tannins, saponins, carotenoids (Erukainure et al., 2010; Johnson et al., 2012; Nessma Ahmed, 2015). This bioactive compounds in fruits are originally found in the peels with higher concentration towards the flesh (Goulas and Manganaris, 2012). It consists of higher concentration of vitamin A, C, B6 and citrulline, a non-protenious amino acid. Citrulline converts to arginine, an amino acid vital to the heart, circulatory system and immune system. It has been hypothesized that watermelon rind might relax blood vessels as cancer and cardiovascular diseases. It also has antioxidant effects and known for stimulator of nitric oxide (Rimando and Perkins-Veazie, 2005; Yadla et al., 2013).

Watermelon peel showed the potential antioxidant activity when analyzed with DPPH free radical scavenging assay (Leong and Shui, 2002; Lewinsohn et al., 2005; Hanan et al., 2013; Nessma Ahmed, 2015). Fruit rind is also effective in the treatment of alcoholic poisoning and diabetes. Watermelon peel extract was explored to certain microbial strains to analyze antimicrobial activity. Extract was found to be effective against strains like S. pyrogen, S. aureus, S. typhi, E. coli, C. albicans (Rahman, 2010), B. subtilis, S. pruinosum (Saha et al., 2013), F. oxysporum and P. aerginosa (Nessma Ahmed, 2015).

2.12 *Arachis hypogaea* L. (Peanut)

*Arachis hypogaea* L., commonly known as groundnut or peanut is an annual herbaceous plant belongs to family fabaceae. It is normally grown in tropical and warm-temperate regions worldwide for its seeds and their oil. It is the second most largely produced legume in the world after soybean (Redden et al., 2005). Peanut comprises of skin, hull and kernel (seed). Peanut skin and hull are by-products of peanut processing industry. These are often considered as agro waste but some time
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used for animal feedstuffs and fertilizers (Yu et al., 2005). As global production of peanut has been increased in recent years, it led to concern on agricultural waste management (Dongmeza et al., 2009; USDA, 2012).

Previous studies directed the proximate composition of peanut shell i.e. 6.41±0.40% to 8.5±0.040% moisture content, 49.2% to 73.2% total dietary fibre, 3.90± 0.12% to 8.2% protein, 3.10± 0.22% to 21.7± 0.0% total ash, and 0.1± 0.02% to 1.30% oil. It is also rich in lignin, cellulose and carbohydrates (Hegazy et al., 1991; Kerr et al., 2006; Sim et al., 2012; Fakhriya et al., 2012). Other components reported from peanut shell in considerable amounts are phenolic compounds, saponins, phytic acid and alkaloid (Yen and Duh, 1995; Yu et al., 2005).

8 flavonoids and two novel indole alkaloids were isolated from peanut skin extract. These new flavonoids have been identified as isorhamnetin 3-O-[2-O-beta-glucopyranosyl-6-O-alpha-rhamnopyranosyl]-beta-glucopyranoside and 3’, 5, 7-trihydroxyisoflavone-4’-methoxy-3’-O-beta-glucopyranoside. They also possess strong antioxidant activity (Lou et al., 2001). Peanut shells were also reportedly having potential antioxidant activity and antimutagenic effect (Duh et al., 1992). Peanut shell extract was found to be very effective when tested for antioxidant activity by DPPH and FRAP assay (Lee et al., 2006; Fidrianny et al., 2014). Peanut plant also contain resveratrol, a kind of natural product with antioxidant and anti-cancer properties (Chung et al., 2003; Marwin et al., 2011). Duh et al. (1992) extracted antioxidant compounds from peanut hulls. The peanut hull extracts inhibited peroxidation (95%), similar to BHA (ca. 95%) and greater than α-tocopherol (ca. 77%). Later fractionation of the hull extract indicated high antioxidant activity in a fraction that was later attributed to luteolin, which is a known antioxidant and flavanoid present in plants.

Peanut shells also known as peanut hulls are classified as low value agricultural wastes or agricultural by-products. However, new technology and innovation has converted peanut hulls to a wide range of applications. Yue et al. (2009) stated that peanut shells is a unique renewable energy resource has a high potential to be an alternative for fossil fuels. Other applications of peanut shell include adsorbent for heavy metals, development of fertilizer carriers, plastic composite materials,
insulation block, bedding purpose, floor-sweeping compounds, manufacture of linoleum and dynamite, preparation of magnesium tiles and plaster (Clay, 1941). In early 1940, literature sources have reported the utilization of peanut shell as animal feedstuffs, such as dogs, cattle and horses (National Research Council, 1989) as peanut shells or peanut hulls was found to be contained moderate level of protein (8%) as well as high level of crude fiber and lignin (Clay, 1941; Utley and McCormick, 1972).

Peanut shell extract was found to inhibit the growth of two pathogenic fungi *R. solani* and *S. rolfsii*. A flavonoid decomposition compound, DHC (5, 7-dihydroxychromone) is found in peanut shell is responsible for inhibition of these fungi (Vaughn, 1995).

### 2.13 *Punica granatum* L. (Pomegranate)

*Punica granatum* L. (pomegranate) is a member of family punicaceace. It has been described as nature’s power fruit and it is a plant used in folkloric medicine for the treatment of various diseases (Ajaikumar et al., 2005; Abdel et al., 2011) widely cultivated in the Mediterranean region. It is an important commercial fruit crop for the countries in the near east, India, (south eastern) Spain, Israel and the US (California). Pomegranates are popularly consumed as fresh fruit and juice, beverages, food products (jams and jellies) (Cerda et al. 2003). Peels and seeds are the major by-product of pomegranate processing industries. Pomegranate is an important source of bioactive compounds and has been used in folk medicine for many centuries. Most pomegranate fruit parts are known to possess enormous antioxidant activity. Pomegranate juice has been demonstrated to be high in antioxidant activity and is effective in prevention of atherosclerosis, low-density lipoprotein oxidation, prostate cancer, platelet aggregation and various cardiovascular diseases (Adhami and Mukhtar, 2006). Pomegranate by-product, its peel has been studied extensively for its phytochemical richness and medicinal importance.

Proximate analysis of pomegranate peel revealed the concentration of various compounds like moisture is ranged within 4% to 18%, Ash from 3.11% to 5%, Fat from 1.73 % to 9.4 %, Crude Fiber11.22% to 21 ± 0.6%, Reducing Sugar from 16.94% to 30.40 %, Protein from 3.10 % to 8.719%. Peel was also found to be rich in total sugars and carbohydrates (Naseem et al., 2012; Sangeetha and Vijayalakshmi,
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Preliminary phytochemical analysis confirmed the presence of various metabolites in the pomegranate peel. These metabolites are carbohydrates, tannins, saponins, quinones, terpenoids, steroids, flavonoids, flavonols, phenols, anthraquinone, proanthocyanidins, glycosides, reducing sugars, alkaloids, cardiac glycosides, anthocyanins, coumarins, cyanidins, beta cyanin and vitamin C (Li et al., 2006; Bhandary et al., 2012; Hajoori et al., 2014; Janarthanam and Sumathi, 2015). Apart from these metabolites, Rajan et al. (2011) also reported the presence of Lignin, Fat and Oil, Inulin and Proteins.

Pomegranate peel extracts prepared with various solvents like hot water extract, ethanol extract, methanol and acetone extract contains total phenolics ranged within 64.2 mg/g to 298 ± 4.86 mg/gm DW, total flavonoids from 23.05 ± 1.54 mg/g to 135.33±8.08 mg/g and Tannins from 81.66±3.51 mg/g to 139.63 ± 4.25 mg/g (Negi and Jayaprakasha, 2003; Fischer et al., 2011; Yehia et al., 2011; Elfalleh et al., 2012; Rowayshed et al., 2013; Al-Rawahi et al., 2014; Janarthanam and Sumathi, 2015). Peel also contains flavonol and anthocyanins in a good quantity. Flavonoids such as kaempferol, luteolin, and quercetin were also identified from the peel (Van Elswijk et al., 2004). Hydroxybenzoic acids such as gallagic and glycosides were reported by Amakura et al. (2000). Hydrolyzable tannins were also identified as punicalin, pedunculagin, and punicalagin (Seeram et al., 2005). Anthocyanidins such as cyaniding, pelargonidin and delphinidin and esters of hexahydroxydiphenic acid and glucose or quinic acid were also identified from the peel extracts (Clifford et al., 2000; Noda et al., 2002).

Prior mentioned studies revealed that pomegranate peel contains abundant flavonoids, phenols and tannins (Sudheesh et al., 1997; Abdel et al., 2011). It is well known that plant phenolics and flavonoids are highly effective free radical scavengers and antioxidants (Al-Rawahi et al., 2014). The ellagi-tannins present in the pomegranate peel accounts for approximately 92% of the total antioxidant activity (Gil et al., 2000).

Several studies have been carried out to analyse the antioxidant activity of pomegranate peel and it has been reported to have pronounced antioxidant activity (Reddy et al., 2007 and Al-Zoreky, 2009). High level of free radical scavenging
activity was reported when the peel extracts (acetone, ethanol, petroleum ether, chloroform and aqueous) were analysed with hydrogen peroxide scavenging activity, ferric-reducing antioxidant power (FRAP), ABTS assay and free radical scavenging activity (DPPH) (Yehia et al., 2011; Elfalleh et al., 2012; Al-Rawahi et al., 2014; Janarthanam and Sumathi, 2015). Pomegranate peel discovered for its strong antioxidant, antimutagenic and anti-inflammatory properties, recent studies have also confirmed its anti-cancer activity against several human cancer cell-lines (Adhami and Mukhtar, 2007; Naveena et al., 2008).

Pomegranate peel is being recognised for its nutritional value since ancient times. It was used as anti-tracheobronchitis, for healing wounds, ulcers, bruises, stomatitis, diarrhea, vaginitis, and against excessive bleeding (Ross, 2003). Recent studies have added more benefits of peel such as abortifacient, analgesic, anti-ameobic, antibacterial, anticonvulsant, antifungal, antimalarial, anti-mutagenic, antiviral, antispasmodic, diuretic, hypoglycemic, hypothermic, and antioxidant activities (Seeram et al., 2005).

Aqueous peel extract of punica granatum showed the antibacterial activity against B. subtilis, B. cereus, P. aeruginosa, S. aureus and E. coli (Khan and Hanee, 2011; Janarthanam and Sumathi, 2015), B. megaterium, S. typhi, S. paratyphi A, S. paratyphi B, P. vulgaris (Hajoori et al., 2014), L. acidophilus, S. mutans (Nikfallah et al., 2014), S. typhimurium (Nuamsetti et al., 2012), B. coagulans and K. pneumonia. Methanolic extract of pomegranate rind shows inhibitory activity against fungal strains like A. niger, M. indicus, P. citrinum, R. oryzae and T. reesei (Dahham et al., 2010). P. stutzeri, an opportunistic bacteria isolated from poultry meat also showed sensitivity to aqueous extract of pomegranate peel (Devatkal et al., 2013).

2.14 Vigna radiata (L) wilczek (Green gram)
Mung bean (Vigna radiata (L) wilczek, Syn. Phaseolus aureus proxb, P. mungo, P. radiatus L) also known as green bean, mung, golden grain and green soy. Its origin is South East Asia (India) and it is abundantly grown in Asian countries. Now, it has been spread to Africa, South America, Australia and the United States also (Kim et al., 2007). Indo Burma region produces its 90% share of world production. The crop
requires warm temperature and loamy soil for its best cultivation (Opoku et al., 2003). Mungbean consist of seed coat, embryo and cotyledons.

The seed coat (hull) is often indigestible and may have a bitter taste. Dehulling is one of the most important operations in post-harvest handling of legumes. Dehulling has been reported to improve the palatability and taste (Singh and Singh, 1992). Dehulling also reduces the cooking time of pulses by removing its impermeable seed coat which hinders water uptake during cooking. The seed coat or hull, which acts as a protective barrier for the cotyledon, represent only a small part (10–11%) of the total weight of the seed in grain legumes. But it contains the highest concentration of phenolic compounds which contribute more to the antioxidant capacity of the seed (Duenas et al., 2003; Kanatt et al., 2011). Seed coat is the major by-product of dehulling process and treated as waste.

Proximate analysis of green gram shown that it is composed of moisture content ranged from 4.00 to 12.07%, ash content 2.91 to 4.29%, Protein content 13.20 to 31.32%, crude fat 1.15 to 2.26%, crude fiber 0.30 to 7.1%, Carbohydrates 54.9 to 60.35%, caloric value 340 - 347 kcal/100g, 247.67 to 277.3 mg/100 g calcium and 5.03 to 12.63mg/100g iron (Habibullah et al., 2007; Anwar et al., 2007; Pasha et al., 2011; Shabnum et al., 2012; Phule and Annapure, 2013; Riaz et al., 2014). The difference between proximate composition of unihulled mungbean and dehulled mungbean has been analysed by Blessing and Gregory (2010) and Oburuoga et al. (2012). Remarkable difference was noticed in parameters like protein content, fiber and ash content. Other parameter showed minor difference.

Preliminary phytochemical screening of green gram methanolic extract indicated the presence of carbohydrates, proteins, amino acids, steroids, triterpenoids, glycosides, flavonoids, polyphenols, tannins and alkaloids (Jaya Prakash et al., 2012; Khandelwal, 2006). It is also rich in lysine (Harper et al., 1996). Various mung bean cultivars were found to be rich in total phenolics and flavonoids (Ramesh et al., 2011; Kanatt et al., 2011; Anwar et al., 2007 and 2013). No reports were found for the seed coat proximate analysis and phytochemical analysis.
Vigna radiata seeds and sprouts were explored for their antioxidant activity and results showed their strong free radical scavenging capacity when analysed with assays like DPPH free radical assay and reducing power assay. The methanolic extracts of sprouts and seeds of Vigna radiata and Macrotyloma uniflorum were showed potent total antioxidant capacity (Anwar et al., 2007 and 2013; Riaz et al., 2014). Few studies were carried out to evaluate the antioxidant activity of green gram hull and it showed effective antioxidant activity when analysed by reducing power assay, DPPH scavenging activity and Superoxide radical scavenging activity (Kanatt et al., 2005).

A study was conducted to investigate the impact of mung bean sprout extracts and mung bean seed coat extracts on type 2 diabetic mice (male KK-Ay mice and C57BL/6 mice). After oral administration of extracts for 5 weeks, results indicated lowered blood glucose, plasma C-peptide, glucagon, total cholesterol, triglycerides, and blood urea nitrogen (BUN) levels in mice. At the same time, both treatments markedly improved glucose tolerance and increased insulin immunoreactive levels (Yao et al., 2008).

V. radiata seed and sprout extract showed antimicrobial activity against microbial strains like S. sureus, B. subtilis, E. coli, P. aeruginosa, K. pneumoniae, S. enterica, S. typhimurium, S. typhi, P. vulgaris and S. faecalis (Hafidh et al., 2011; Jaya Prakash et al., 2012; Camalxaman et al., 2013).

2.15 Capsicum annuum L. (Chilli)
Chilli (Capsicum spp.) is an important commercial spice and vegetable crop for small and marginal farmers in Asia, Africa and South America. Among the 5 cultivated species of the genus Capsicum, C. annuum is the most widely cultivated in India for its pungent (chilli syn. hot pepper) and non-pungent (sweet pepper syn. capsicum, bell pepper) fruits. The cultivation of C. frutescens, C. chinense and C. baccatum is limited and usually restricted to homestead gardening in different regions (Reddy et al., 2014).

Numerous studies have been conducted with different parts and varieties of green and dry Capsicum annuum L. for its proximate and phytochemical analysis. Proximate
composition recorded from the studies were moisture from 8.8% to 85.7%, dry matter from 9.92% to 95.60%, proteins from 2.6% to 25.19%, ash from 0.58% to 17.99%, cellulose from 15.05% to 26.37%, total sugar from 6.88% to 11.19%, reducing sugar from 2.95% to 20.42%, fat from 1.05% to 14.10%, total fiber from 2.37% to 35.05% and carbohydrates from 3.00% to 68.28% (Gupta and Tambe, 2003; Ogunlade et al., 2012; Zaki et al., 2013; Simonovska et al., 2014; Emmanuel et al., 2014; Raimi et al., 2014).

Preliminary phytochemical analysis showed the presence of steam-volatile oil, fatty oils, carotenoids, vitamins, protein, fibre, saponins, tannins, alkaloids, glycosides, steroids (Vinayaka and Nandini, 2010), phenolic compounds, flavonoids and carotenoids (Alvarez-Parrilla et al., 2011). It is also rich in vitamins it contains vit C, vit A, vit E, Niacin, vit B6, folic acid and vit K. It also contains mineral elements like Ca, Na, K, Mg, P, Fe, Cu, Zn, Co and NI (Esayas et al., 2011; Ogunlade et al., 2012; Emmanuel et al., 2014). HPLC analysis of different parts of chilli (C. annum) revealed the presence of a number of phenolic acids, namely, tannic, gallic, caffeic, vanillic, ferulic, chlorogenic and cinnamic acids (Singh et al., 2007). The flavonoids found in most peppers are glycosides and aglycones of myricetin, quercetin, luteolin, apigenin and kaempferol (Bae et al., 2012).

Quantitative analysis for metabolites indicated that the varieties of C. annum are rich in metabolites like tannins, flavonoid, alkaloids, anthraquinones, phenolics, saponins, glycosides, terpenoids, limonoids, carotenoids, ascorbic acid (Kevers et al., 2007 Esayas et al., 2011; Khabade et al., 2012; Shaha et al., 2013; Emmanuel et al., 2014), capsaicin and dihydrocapsaicin (Bae et al., 2012).

Gallic acid was found to be the major phenolic acid in all parts of green chilli. A number of phenolic acids, namely, tannic, caffeic, ferulic, chlorogenic, vanillic and cinnamic acids were detected in different parts of green chilli (Singh et al., 2007). Studies have proven that the characteristic pungency of c. annum is due to capsicinoids, a group of alkaloids (Todd et al., 1977; Britton and Hornero-Mendez, 1997). They are produced in the placenta of the fruit (Minamiyama et al., 2005) and are important in the pharmaceutical industry for their neurological effectiveness.
In peppers, there are phytochemical property that have many biochemical and pharmacological properties which includes antioxidants, anti-inflammatory, antiallergenic and anti-carcinogenic activities (Kim et al., 2011). Capsaicin was found as the main antimicrobial component (Soetarno and Sukrasno, 1997).

Various extracts of *C. annuum* reported for their efficient antioxidant activity. Their antioxidative activities were determined by measuring their ABTS and DPPH radical scavenging activities (Medina-Juárez et al., 2012; Ogunlade et al., 2012; Shaha et al., 2013), reducing power activity, free radical scavenging activity, lipoxygenase inhibition activity (Khabade et al., 2012).

*C. annuum* extract also hold strong antimicrobial and insecticidal potency. Okonkwo and Ohaeri (2013) have studied its insecticidal activity against German cockroach (*Rhaffella germanium*). It was also found to be effective against *Staphylococcus* sp., *E. coli*, *B. aureus*, *B. subtilis*, *Enterobacter* sp., *S. marcescens*, *Shigella* sp., *Salmonella* sp., (Siehta et al., 1984; Singh et al., 2016), *S. typhimurium* (Shayan and Saeidi, 2013), *L. monocytogenes*, *S. enterica Enteritidis* (human) and *S. enterica*, *B. thuringiensis*, *Y. enterocolitica* (Hleba et al., 2015), *K. pneumonia*, *P. aeruginosa* (Vinayaka and Nandini, 2010) *V. cholera*, *S. aureus* and *S. typhimurium* (Koffi-Nevry et al., 2012). Capsicum showed high antimicrobial activity against *Micrococcus* sp, *Bacillus*, *E. coli*, *Pseudomonas* sp. and *Citrobacter* sp. (Careaga et al., 2003; De Lucca et al., 2006; Hemalatha and Dhasarathan, 2013).

Abundant scientific literature is available for *C. annuum* fruit after removing its pedicel. But the pedicel is still untouched with such studies. It can also be proved a rich source of secondary metabolites and natural antioxidants.

2.16 *Artocarpus heterophyllus* Lam. (Jackfruit)

*Artocarpus heterophyllus* Lam. commonly known as jackfruit (english) and Kathal (hindi), belongs to family moraceae. They grow abundantly in India, Bangladesh, and in many parts of Southeast Asia (Rahman et al., 1999). It is an important part of Indian diet since long. Jackfruit pulp is eaten afresh and used in fruit salads and possesses high nutritional value. Jackfruit processing generates a large amount of
waste in the form of seeds and peel. The peel waste of jackfruit has been reported for anaerobic biohydrogen production (Vijayaraghavan et al. 2006; Koh et al., 2014).

Adequate studies have been conducted on jackfruit young, ripe pulp and its seeds. Fruit rind is not much explored yet, only few reports are available about it. Proximate composition of various parts of jackfruit in various ripening stages contains moisture from 6.09% to 83%, protein 1.2 g/100g to 15.88%, fat 0.1 g/100g to 10.26 %, carbohydrate from 9.4 g/100g to 79.34 %, fibre from 1.0 g/100g to 11.32g/100g, total sugars 20.6 g/100g (Gunasena et al., 1996; Badrie and Broomes, 2010; Gupta et al., 2011; Okafor et al., 2015), ash from 0.15±0.01 g/100g to 5.91± 0.22 g/100g, caloric value from 42.74±0.93 Kcal/100g to 382.79 kcal/100g. K, Na, Ca, Cu, Mn and Fe minerals are also recorded from the fruit (Ocloo et al., 2010; Feili et al., 2013; Eke- Ejiofor, 2013).

Artocarpus heterophyllus extract showed the positive results for saponins, tannins, terpenoids and flavonoids (Delphin et al., 2014). Quantitative estimation for various metabolites indicated that the extracts were rich in phenols, flavonoids, sapoinins and alkaloids (Gupta et al., 2011; Yamini and Anand, 2009). Higher concentration of phenols and flavonoids can lead towards effective antioxidant activity, several studies have been done to evaluate its antioxidant activity.

Jackfruit extract showed higher radical scavenging activity when examined by DPPH free radicle scavenging assay, ABTS scavenging assay, ferric ion reducing activity (FRAP assay), reducing power assay (Gupta et al., 2011). It also exhibited hepatoprotective activity (Yamini and Anand, 2009). Few studies have been conducted to reveal the antimicrobial activity of jackfruit peel. Results showed that the peel extract was found to be effective against microbial strains like K. pneumoniae, E. faecalis, P. vulgaris, E. faecalis, E. coli, S. aureus, B. subtilis, L. lactis, A. niger, C. albicans, S. pruinorum (Saha et al., 2013), P. aeruginosa, S. typhii and S. pyrogenes (Roy and Lingampeta, 2014). Activated carbon was prepared from jackfruit peel, an agricultural waste and its effectiveness as an adsorbent was analysed. Results showed that the activated carbon can be used for removal of phenol, 2-chlorophenol, 4-chlorophenol, 2, 4-dichlorophenol from aqueous solutions. Results are very promising one in the field of water purification (Jaina and Jayarama, 2007).
2.17 *Cucumis sativus* L. (Cucumber)

*Cucumis sativus* L., commonly known as Cucumber (English) and Khira (Hindi) is belongs to family cucurbitaceae. It is of Indian origin and found wildly in the Himalayan regions. It is commercially cultivated worldwide as a seasonal crop (Mukherjee, 2013; Mallik *et al.*, 2013). It is one of the oldest cultivated vegetable crops. It is known in the history for over 3,000 years. It is widely consumed fresh in salads or fermented (pickles) or as a cooked vegetable (Sotiroudis, 2010). Traditionally, this plant is used for headaches; the seeds are cooling and diuretic, the fruit juice of this plant is used as a nutritive and as a demulcent in anti-acne lotions. (Joshi, 2003; Nadkarni and Nadkarni, 2005). Abundant literature is available for the fruit seed and pulp, but only a few reports are availbale on the study of cucumber peel.

Different parts (peel, pulp and seeds) of cucumber were analysed for its proximate compositions. Results indicated the presence of ash in the range of 02.20% to 9.67%, protein from 1.0% to 17.25%, fat from 02.6% to 0.6%, moisture from 35.35% to 97.80%, fiber from 0.7% to 49.07% and carbohydrates from 1.2% to 63.06%. Volatile matter also shared a good share in composition (Abulude *et al.*, 2007; Okoye, 2013; Roe *et al.*, 2013; Ghosia *et al.*, 2014). Quantity of sugars like Glucose, Fructose, Sucrose, Maltose and Lactose is below 1mg/100g for each. While total sugar and starch shares 1.2% and 0.1% of fruit’s composition respectively (Roe *et al.*, 2013).

Unpeeled cucumber fruit contains more than 96% water in it. According to literatures, other constituents of cucumber fruit like vitamins, minerals, amino acids, phytosterols, phenolic acids, fatty acids, and cucurbitacin, traces of essential oil, pectins, curcurbitacin (Patri and Silano, 2002), glycosides, steroids, flavonoids and tannins were identified from the cucumber fruit (Kumar *et al.*, 2010; Waziri and Saleh, 2015). Few studies also indicated the presence of saponins, alkaloids (Mallik and Akhter, 2012; Saidu *et al.*, 2014) and triterpenoids (Gopalakrishnan and Kalaiarasi, 2014).

Quantitative analysis of some secondary metabolites showed that the of total phenolic content, total flavonoid content, alkaloids, tannins, saponins and glycosides were available in average concentration (Agarwal *et al.*, 2012; Sahar *et al.*, 2013; Budhiraja
et al., 2014; Gopalakrishnan and Kalaiarasi, 2014). Based on its traditional use and phytoconstituents, the fruit of was selected and screened for its antioxidant potentials (Joshi, 2003; Nadkarni and Nadkarni, 2005).

From the results of antioxidant assays, it can be said that cucumber fruit represents an average antioxidant. Total antioxidant activity, DPPH radical scavenging, Anti-radical power, ABTS radical scavenging activity and capacity of reducing ferric ions into ferrous ions (FRAP assay) were tested for various extracts of different parts of fruits (Kumar et al., 2010; Agarwal et al., 2012; Budhiraja et al., 2014; Lutfullaha et al., 2015).

The extracts of cucumber fruit pulp, seed and peel inhibited the growth of B. cereus, E. coli, S. aureus, K. pneumoniae, A. niger, A. alternate, P. digitatum (Ghosia et al., 2014), S. epidermidis (Budhiraja et al., 2014), B. dermatitides, C. albicans, P. ovale, Trichophyton spp., Microsporum spp. (Mallik and Akhter, 2012), B. subtilis, Straptococcus sp., (Sahar et al., 2013), S. faecalis, K. aerogenos, P. aeruginosa, P. vulgaris and A. flavans (Gopalakrishnan and Kalaiarasi, 2014).

A study revealed that the methanolic fruit pulp extract of C. sativus contains active substances with hypoglycemic activity and could be used in the treatment and management of diabetes mellitus (Saidu et al., 2014). The extract has shown strong analgesic action in mice, by inhibiting the acetic acid-induced writhing and by increasing the latency period in the hot-plate test (Kumar et al., 2010).

2.18 Outcome of Review

Literature indicates the immense nutritive value of fruits and vegetable by-products. They are also rich in secondary metabolites. These metabolites are responsible for various pharmacological activities of plants. So, the extracts of selected plant waste materials can give positive results for qualitative analysis for primary as well as secondary metabolites. They can also possess a worthy quantity of these metabolites with a number of forms of their which can be separated by chromatography technique. Due to these metabolites, these waste materials can possess substantial antioxidant as well as antimicrobial activities and also they can be transformed into products.