REVIEW OF LITERATURE

Oil is a nonpolar chemical substance, viscous liquid at ambient temperatures, hydrophobic and lipophilic. It has high hydrogen and carbon atoms, usually surface active and flammable. Oil originates from animals, vegetables or petrochemical feed stocks. In the mid-1950s, the critical source of energy was petroleum and served as the lifeblood for the industrialized nations of the world. It mainly supplies energy to power industry and homes, to provide fuel for aeroplanes and vehicles. Besides, it also plays a vital role in the production of everyday essentials such as detergents, fertilizers, paints, plastics and medicines. Organic oils also contain proteins, waxes and alkaloids other than lipids. Lipids have a high carbon and hydrogen contents and lack oxygen compounds. (Alberts *et al*., 2002).

The diversity of plants, animals and other microorganisms during their natural metabolic processes produce organic oils. Lipids are fatty acids, steroids and chemicals present in oils produced by the living things. Lipids can be classified based on their chemical structure and solubility in water. Various edible vegetable and animal oils are used for food preparation. Oils also used to modify the texture of foods, add flavor to them, moisturizing agent and to light lamps.

Crucial resources in the modern economy are petroleum or crude oil and its refined components collectively known as petrochemicals from ancient fossilized organic materials namely algae and zooplankton which was converted to petroleum by geochemical processes (Kvenvolden and Keith, 2006). A wide variety of hydrocarbon components are refined from crude oil. Petrochemicals are used to make various chemical products such as medicines, plastics, detergents, paints, synthetic rubber and fibers. The oil industry employs thousands and lakhs of people and makes a significant contribution to the world economy. In oil, colour pigments are easily suspended and made suitable as a supporting medium for paints. Oils are mainly composed of glycerides. Fats and oils store the energy in most plants and animals as triacylglycerols. Fats remain solid or semisolid at room temperature whereas oils are liquid at that temperature. The different melting temperature of various fatty acids is due to the side chains of triacylglycerols. The fatty acids of oils contain many double bonds than the fats. These molecules make better energy storing units, during their oxidation, releases high energy than the amino acid or carbohydrates.

In membrane lipids, essential fatty acids play as precursors to serve intercellular signals in animals (Uauy *et al*., 2000).

Oils are useful as lubricants for many engineering purposes due to their nonpolar nature; they do not adhere to other substances. Some oils are aerosol burnt to generate heat and light used directly or converted into electrical or mechanical energy. Crude oil converted into diesel fuel, methane, fuel oils (commercial fuel used in ships), gasoline, benzene, jet fuel, kerosene and LPG (Kraus and Richard, 2011). Fatty acid is a carboxylic acid which is saturated or unsaturated with a long aliphatic chain. Fatty acids that occur naturally posses unbranched chain of an even number of carbon atoms from 4 to 28. Three main classes of fatty acids are triglycerides, phospholipids and cholesterol esters. Michel Eugene Chevreul introduced the concept of fatty acid though he used some variant terms as acid fat and fatty acid (Moss *et al*., 1997; Leray, 2017).

Fatty acids are categorized based on their length of chain as short or long. Unsaturated fatty acids have one or more C=C bonds and gives either *cis* or *trans* isomers. However, in saturated fatty acids, C=C double bonds are not found. They have the same molecular formula $CH_3(CH_2)nCOOH$ with variations in"n". Stearic acid (n= 16) is an essential saturated fatty acid. Saturated and unsaturated fatty acids play an essential role in the biological processes and the construction of cell membranes. The plasma fatty acids are not found as ester and termed as non-esterified fatty acids (NEFAs) or free fatty acids (FFAs). FFAs bound to transport protein especially in albumin (Nomenclature of lipids, 1977). Carbon oxidation found in fatty acids to CO_2 involves a change in oxidation number from -2 to +4. Whereas, the carbon oxidation of carbohydrates involves conversion from 0 to +4. The more significant change in the oxidation number results that of the oxidation of fat that releases high energy. Amino acids and carbohydrates oxidize anaerobically, whereas fats oxidize aerobically. The fat prevents O_2 requirement to molds and bacteria, thus acts as a food preservative.

Usually, fatty acids are produced industrially by the hydrolysis of triglycerides with the removal of glycerol. Hydro carboxylation of alkenes is the other method for the production of fatty acids. In animals, the formation of fatty acids from carbohydrates occurs in the adipose tissue, liver and mammary glands during

lactation. During partial hydrogenation, the isomerization occurs in unsaturated fatty acids from *cis* and *trans* configuration (Klaus and Kurt, 2005). The triglycerides were coated with protein and cholesterol into a compound termed as chylomicron.

Fatty acids are essential for good health and are obtained from the food but not found in sufficient quantity in other substrates (Breuer *et al*., 1987). Two essential fatty acids are α- linolenic acid (α LA) and linolenic acid (LA). These FAs widely distributed in plant-derived oils. The human body has a limited ability to transfer α LA into the longer – chain omega – 3 fatty acids – eicosapentaenoic acid (EPA) and decosahexaenoic acid (DHA). Omega -3 and omega -6 fatty acids are biosynthetic precursors for neurogenic, anxiolytic and antinociceptive properties (Bolsover *et al*., 2004). In mammalian skin, the fatty acids are exuded together with pyruvic and lactic acid that enable animals with a strong sense of detection to differentiate individuals (Ramsden *et al*., 2015). The analysis of the physical properties of oils and fats helps us to know the characteristics of these elements with their differences.

The refractive index of a substance is the ratio between the speed of light in air and oil or fat that is to be analyzed. The solubility of fats in the organic solvents decreases with increasing length of the chains and the saturation degree. The plasticity of fat is caused by the three-dimensional network of crystals presents inside the liquid fat which is immobilized. They supply energy for the living organisms in the insulation of body organs and the transport of fat soluble vitamins through the blood (Robert and Bradley, 2010; Regina and Bailey, 2018).

The increased percentage of short-chain fatty acids lowers the melting point of fat. The hydrolysis of fats and oils used to make soap in the presence of a base. Double bonds in the unsaturated triglycerides can be hydrogenated and converted into margarine. In fats and oils, the characteristic colours, flavours and odours are imparted by the lipid soluble foreign substances. For example, the presence of carotene pigment gives a yellow colour to the butter; the taste of butter is from the two different compounds namely diacetyl and 3-hydroxy-2-butanone produced from the bacteria. Density of fats and oils are lighter than water having 0.8g / cm^3 density. They are poor conductors of electricity and heat, and it is used as excellent insulators for the body that reduces the loss of heat through the skin (Ball *et al*., 2018).

Fat soluble vitamins are A, D, E and K and are digested, absorbed and transported in conjugation with fats. Fats play a significant role in maintaining healthy hair and skin, promoting healthy function of cells, maintaining body temperature and insulating body organs against shock. It also plays as a useful buffer against a host of diseases. Fat tissues protect vital organs by metabolizing or removing offending substances from the body through accidental or intentional bloodletting, sebum excretion, hair growth, excretion and urination. In animals, fatty tissue (adipose tissue) stores metabolic energy over extended period. From the diet and liver metabolism fat cells (adipocytes) are formed; during stress, these cells degrade and supply fatty acids and glycerol. Several hormones namely epinephrine, glucagon and insulin regulate metabolic processes. The fatty tissues secrete the hormone leptin (Yu *et al*., 2015).

Firestone (2013) stated the significant properties and low-level constituents of nearly 500 fats and oils based on the following parameters such as refractive index, tocopherol, tocotrienol, sterol, specific gravity, iodine, saponification value, titer value and fatty acid value. Fats and Oils have a greasy feel, colourless, odourless and tasteless in pure state. They are soluble in organic solvents such as benzene, chloroform, ether and insoluble in water. They have lesser density than the water and float on the surface consequently when mixed with water.

Agricultural wastes such as the shells of dry fruits, hemp fibre, rice husks and wheat husks can be used to produce fibre, reinforced polymer composite for commercial purposes. Coconut fibres considered as organic waste are extensively used to make traditional ecological products such as brushes, carpets, mats, ropes, automotive components and gardening products. Phenolic compounds from the coconut exhibits antimicrobial activities, high antioxidant potential and act as good food stabilizers (Bhatnagar *et al*., 2010).

Cocos nucifera L. (family Arecaceae) commonly known as coconut is an important fruit crop in the tropical countries and 92 countries produce worldwide in 10 million hectares of land. Coconut trees grow without much care, the mean daily temperature for their growth is above 12-13^{o}C (53.6 – 55.4^{o}F), the mean yearly rainfall should be above 1000 mm (39.37) and a very little or no overhead canopy. The primary limiting component for the growth of Coconut tree is the sandy soil and

salt spray. Coconut is a tropical fruit consumed in many countries for its medicinal and nutritional properties. Coconut is known for its essential oil that provides biological activities (Reynolds, 1973). Coconut products were used in various parts of the world; especially in coastal regions 60% of the domestic waste consists of coconut shell (Rodrigues and Pinto, 2007).

From the coconut, various products were obtained such as tender coconut water, copra, coconut cake, coconut oil, coconut toddy, coconut shell, wood-based products, coconut leaves, coir pith, etc. Thus, the coconut tree termed as Kalpavriksha, the all giving tree in Indian classics and thus it describes the facts and phenomena related to its use in health and disease prevention. Tender coconut water and coconut kernel have various medicinal properties such as antidermatophytic, antioxidant, antiparasitic, antimicrobial, antiviral, hepatoprotective, hypoglycemic and immunostimulant (Debmandal and Mandal, 2011)

After Indonesia and the Philippines, India is the third largest country in coconut production. Coconut trees cultivated to an area of approximately 1.78 million hectares. Annual production of coconut is about 7562 million with an average of 5295 nuts per hectare (Shashikumar and Chandrashekar 2014). In India around 90% of coconut produced in the four south Indian states namely Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. The usage of coconut for food and its applications in Ayurvedha were documented 4000 years ago in Sanskrit. In Ayurvedha medicine the coconut oil and coconut milk used for burns and heart problems.

The coconut trees are grown for several beneficial products such as fibre, timber, functional food and oil. It is mainly cultivated as an oil crop that is rich in lauric acid with a wide variety of other uses in addition to commercial oil production (Harries *et al*.,1998). Over the years, Coconut palm leaves were used for thatching roofs and wood to build houses, bark as fillers in the cement industry, coir for making ropes and its fruit to quench thirst and hunger. Coconut shell located on the inner side of the fiber and lies surrounding the coconut fruit to protect the fruit core, ranges between 3 to 6mm in thickness. It contains cellulose, hemicellulose, lignin and approximately 6 – 9% of water content (Tilman, 1981). The coconut shell crude extract is used to treat microbial infections and some of the human diseases (Siddeshwar *et al*., 2013). In India, menstrual cycle disorders are cured by the intake

of infusions of coconut inflorescence (Bhandary *et al*., 1995). Coconut water and kernel are used to cure various diseases namely asthma, bronchitis, flu, constipation, earache, abscesses, diarrhoea, burns, hemostat and pediculicide (Singla *et al*., 2011). The white flesh of the coconut is used to cure fever and malaria (AlAdhroey *et al*., 2007) also relieves skin rashes caused by HIV infection (Nagata *et al*., 2011).

The coconut meat and water has antimicrobial, antiviral, antipyretic, anti-inflammatory (Zakaria *et al*., 2006) and antioxidant activity (Rajeev *et al*., 2011). Coconut water contains sugars, enzymes namely catalase, diastase, peroxidase, RNA polymerases and acid phosphatase, phytohormones namely cytokinin and auxin, 1, 3- diphenyl urea and growth promoting factors. The dried kernel named as copra, mainly used for extraction of oil contains 65% to 75% oil. The unopened spathe contains toddy, which is used to make jaggery, vinegar and sugar. The moist meat is called kernel used to prepare chutney, curries, toffee and other cooking purposes. Coconut shell oil was shown to have antimicrobial property (Verma *et al*., 2014).

In 2010, approximately 60 million tons of coconut was generated worldwide: 85% in Asia, 8.5% in America, 3.2% in Oceania and 2.9% in Africa. Brazil produces approximately 2.5 million metric tons of coconut husks in a year. However, only 15% of the coconut fibre were used out of the total quantity of coconuts harvested around the world (Wei and Gu, 2009 a). More than 90 tropical countries cultivate coconut trees as an important source of income (Santana *et al*., 2011). From the coconut fruit copra, oil, coconut milk, coconut water, fibre, flour and lauric acid were obtained and used for several applications such as animal feed, beverages, composites, cosmetics, detergents and soaps (Silva *et al*., 2000).

In India, the coconut oil producing industries account for over a quarter of the world's total coconut oil output. It also accounts for the nation's pollution issue as a solid waste in the form of shells approximately 3.18 million tons (Gunasekaran *et al*., 2012). More than 60% of the native wastes are coconut shells. It represents serious disposal problems for the local environment. In developing countries, the discharge of agricultural and industrial wastes in large quantities pose a problem; these wastes are recycled as possible material in the construction industry. Coconut fibre is used as a protective material in the packaging system (Osborn 1967). Green coconut husk is an agricultural residue that corresponds to about 85% garbage and has

become a severe environmental problem due to its poor degradation (John and Thomas, 2008). Coconut shell is composed of cellulose, hemicellulose, lignin, pectin and minerals that are used in the preparation of composites such as bio plastics. These bio plastics are natural adsorbent and used in the removal of pollutants like dyes, metal ions, organic and inorganic substances in the wastewater (Sousa, 2010).

Coconut oil is used as an excellent skin moisturizer and softener; it also prevents hair damage (Aarti and Mohile 2003). Coconut oil was shown to possess analgesic, anti-inflammatory and fever-reducing properties. Coconut oil is found to be effective against skin diseases, the milk is useful as the conventional drug sucralfate and associated antiulcer drug (Intahphuak *et al*., 2010). In Northeastern Brazil, decoction of *Cocos nucifera* husk fiber used as traditional medicine to treat diarrhoea and arthritis. Water extract from coconut husk fibre on separation in adsorption chromatography fractions proved to have antimicrobial activity against *Staphylococcus* bacteria.

The crude extract of *C. nucifera* and its fractions were abundant in catechin and have inhibitory activity against Herpes simplex virus Type 1 (HSV-1) (Esquenazi *et al*., 2012). Viju *et al*., (2013) evaluated the antibiofilm activity of Coconut Husk Extract (CHE) which also exhibits antimicrobial activity against *Pseudomonas sp*., *and Gallionella sp*. CHE affected the production of Extracellular Polymeric Substance (EPS). In the culture medium, the growth of the biofilm was affected by the CHE. It also changed the hydrophobicity of the bacterial cells and was used to isolate antifouling compounds. In traditional medicine, different parts of the coconut are used to treat various diseases and preventive alleviation of symptoms related to menopause (Dua *et al*., 2013; Morii *et al*., 2015). Coconut milk and water are used in the treatment of ulcer and as food supplement due to its rich nutritional content (Nneli and Woyike, 2008).

United States Department of Agriculture (2008) stated that tender coconut, the endospermic liquid, as a delicious natural soft drink with 174 / 100g calorific value. It provides Vitamin B which include, biotin (0.02µg/mL), folic acid (0.003µg/mL), nicotinic acid B_3 (0.64µg/mL), riboflavin B_2 (0.01µg/mL), pantothenic acid B_5 (0.52 µg/mL) and trace quantity of thiamine B_1 and pyridoxine B_6. According to Effiong *et al*., (2010) tender coconut water has various medicinal properties; it is

a better drink for cholera patients due to their abundant availability of saline and albumin content. Coconut water is rich in lauric acid, which provides 50% of coconut fat content. It effectively destroys capsulated bacteria by lipid membrane disintegration. It is active against some bacteria which cause dental cavities, food poisoning, stomach ulcers and urinary tract infections.

Coconut has glycolipid and sucrose monolaurate components that are responsible for anti-caries effect (Alviano, 2008). In many regions of the world, coconut oil is used as a traditional medicine for antiseptic effects. It is used as an effective skin moisturizer (Agero and Verallo, 2004). Coconut contains monolaurin that shows broad spectrum of activity against Gram-negative and Gram-positive bacteria isolated from skin infections (Verallo-Rowell *et al*., 2008). The coconut kernel contains protein which shows anti-diabetic activity by reversing the glycogen levels, inhibiting the carbohydrate inducing enzymes and reduces damage to pancreatic cells to the normal levels. The regeneration of pancreatic cells takes place by arginine (Salil, 2010).

Bhagya *et al*., (2010) stated that tender coconut water helps to prevent and reinstate high blood pressure induced by a fructose-rich diet. They mentioned that drinking coconut water reduces heart diseases. The researchers concluded that coconut water contains calcium, magnesium and potassium that help patients with heart problem.

Syafriani (2014) evaluated the effect of coconut water on hypertension-induced rats and monitored their heart rate frequency changes. Coconut water showed significant effect on heart beat frequency compared to isotonic drink. Filho (2004) evaluated the leishmanicidal effects (*Leishmania amazonensis)* of coconut water in the infected macrophage. *C. nucifera* extract at 10µg/mL was active as a leishmanicidal substance that inhibits the development of promastigote and amastigote. *C. nucifera* husk fiber rich in polyphenolic constituents possess antimicrobial, antiviral activities and inhibit the proliferation of lymphocytes. Alviano (2004), demonstrated the analgesic and DPPH free radical scavenging activity of *C. nucifera* husk fiber. The aqueous extracts of *C. nucifera* when orally administered to the mice, inhibit the acetic acid induced writhing response and their attenuation to the heat stimulus response. *C. nucifera* extract on the topical treatment

of rabbits does not produce any irritation on dermic or ocular applications. This extract also shows free radical scavenging activities.

Akinyele (2011) assessed the husk of *Cocos nucifera* crude aqueous and n-hexane extracts against *Vibrio sp.* and some bacterial pathogens that usually cause food spoilage and wound infections. The husk fiber n-hexane extract showed antibacterial activity against 38 of the *Vibrio sp.* isolates and 21 of the tested bacterial species. Akinpelu (2015) demonstrated the antimicrobial activities of the *C. nucifera* husk extracts on selected pathogenic bacteria. The MIC of the extracts ranged from 0.16 to 5.00 mg/ml. Minimum of 27.8% killed at initial dilution after 15 min. time with the fractions and a maximum of 95% killed after 120 min with different percentage of proteins, nucleotides and potassium ions leaked from the selected bacterial species.

According to Rinaldi (2009), *C. nucifera* crude extracts was active against analgesia and inflammation and shows antinociceptive and anti-inflammatory properties. From the results, they evaluated that significant development in the peripheral and central antinociceptive regions but lesser activity was seen in the supraspinal brain region. Antinociceptive effect of *C. nucifera* crude extract and the fractions inhibit the opioid antagonist, naloxone. Inhibition of rat paw edema by coconut extract and F1 by histamine and serotonin confirms the use of this extract for several inflammatory activities. Zuraida *et al*., (2011) investigated the antibacterial activity of Coconut shell liquid smoke (CS-LS) and its importance for the preservation of fish balls. The MIC of CS-LS evaluated using broth dilution method and able to inhibit *Staphylococcus aureus* and *Pseudomonas aeruginosa*.

Coconut haustorium, a spongy tissue developed during the germination of coconut contains ash, soluble sugars, starch, phenols, protein, fat, soluble and insoluble dietary fibres. Amino acids like isoleucine (68%), methionine + cysteine (57.6%), leucine (45.7%) and phenylalanine + tyrosine (32.6%) found in low quantities (Manivannan *et al*., 2018). According to Oyi (2010) and his co-researchers, coconut oil based creams applied to different spots on skin infected with *Aspergillus niger, Bacillus subtilis, Candida albicans, Escherichia coli, Pseudomonas aeruginosa, P. vulgaris* and *S. aureus* revealed good antimicrobial properties and

confirmed the compatible formulation of the ingredients. The coconut cream also showed to be more stable to withstand shock and maintain their physical parameters.

Albanese and Corpuz, (2017) reported that coconut methyl ester (CME) or coco- biodiesel obtained from coconut oil was more desirable than standard diesel fuel. The World Fuel Charter permits blending up of biofuel to 5 % but adding 1% mixture of coco biodiesel reduces the emission of smoke. Coconut shell used to produce activated carbon and considered as superior to other sources mainly due to their small macropores which render it more useful for the gas and vapour adsorption. It yields liquid fuel through pyrolysis method (Joardder *et al*., 2011; Clívia *et al*., (2012). Coconut fibres are used in packaging systems as cushioning material. The coconut fibres without agglutinating agents showed high performance by giving the most significant tendency to minimize impact acceleration. The fibres are similar to the cellulosic cushioning materials that effectively protect fragile products.

The cetane number of diesel is 56 which was lower than the cetane number of Coconut methyl ester which was 70 that implicit that it burns thoroughly, resulting in extra mileage and lesser emissions. At the same time CME is easy to store than diesel and safer. CME need high temperature to explode fire (Robeerto, 2001). Tan *et al*., (2004) stated the reduction of CO_2 emission is estimated around 77- 104 g/mL of diesel displaced by the biodiesel produced from the coconut shell. Coconut shell is mainly used to make charcoal by traditional pit method and has high calorific value and produces bio-oil, biochar, steam and energy-rich gases etc. The high amount of cellulose and lignin found in coconut husk has a high calorific value of about 18.62 MJ/kg. Coconut husk was changed into a value-added fuel by replacing wood and other traditional fuel sources.

Cashew tree, *Anacardium occidentale* L., belongs to the order Sapindales and family Anacardiaceae consists of 75 genera and 700 species that include trees and shrubs primarily with resinous bark, resin canals and milky exudates. Under numerical taxonomy, only nine species identified in the genus *Anacardium*. It is an evergreen nut bearing multipurpose tropical tree. It has great economic importance to third world countries including Brazil, Guinea Bissau, Ghana, India, Nigeria, Philippines, Srilanka, Tanzania and Vietnam. From the nuts of Cashew worlds highly

delighted roasted kernel snacks, kernel oil and Cashew nut shell liquid is derived and from the cashew apple, jam, juice and alcohol are obtained. Cashew wood is used to make furniture and fishing boats. Cashew cultivation and processing activities provide employment and income for women and smallholder farmers (Akinwale, 2000). Cashew nut consumption lowers the risk of cardiovascular disease and diabetes (Akash *et al*., 2009). Cashew nut shell is about 4-6 mm in thickness and produces oil which is dark reddish brown contained in a soft honeycomb matrix. It is the pericarp fluid of the cashew nut present in between the outer and inner shell.

The *A. occidentale* is native to Eastern Brazil. In the tropical regions of India, Indonesia, South East Asia and Africa the Portuguese introduced this tree in the 16^{th} and 17^{th} centuries. Around the world, the total production of cashew is about 1.2 million tonnes and the total cultivation area is approximately 2 million hectares. During 16^{th} centuries, Portuguese missionaries introduced Cashew in Goa and Malabar coastal regions later it was dispersed to other parts in India (De costa *et al*., 1978). The largest producer of cashew is Vietnam (8,27,000 tonnes) the second largest producer is India (4,60,000 tonnes) and Brazil is the third largest producer (2,51,000 tones). The factories use the cashew seed to yield 45% of oil content and the oil is used for two main purposes, i.e., used in brake lining and floor coating material. India provides around 55% supply of cashew kernels to the world. The primary states of India that cultivate cashew are Kerala, Goa, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Maharashtra and West Bengal.

Cashew nut contains a high content of amino acids, phytosterols, unsaturated fatty acids, vitamins, minerals and a generous content of fibre. In Brazil, jams and soft alcoholic drinks were prepared from the cashew apple (De Lima *et al*., 2008). From the Cashewnut shell oil (CNSO) a variety of products were made and is used as antioxidants, emulsifiers and stabilizers for the petroleum industry (Menon *et al*., 1985). CNSO also produced for its biological activity as antioxidant (Oliveria *et al*., 2010) and antitumour activities (Wu *et al*., 2011). Anacardic acid from the CNSO is inhibitory to *S. aureus* (Parasal *et al*., 2011). From the cashew nut shells, lower quantities of hydroxyl alkylphenols were obtained (Gomez *et al*., 2010).

Traditionally, crude plant extracts of Cashew were used in the form of decoction, infusion, tincture and herbal extract to cure many diseases including

infectious diseases. They have phytochemicals namely flavonoids, lignin, phenolic acids and other small compounds. These phytochemicals are responsible for many health-related effects such as antimicrobial, anticarcinogenic, antithrombotic, antimutagenic and vasodilatory activities (Bidlack *et al*., 2000). A wide range of phytochemicals are present in the plant that inhibits microbial pathogens (Romero *et al*., 2005). Cashew apple is rich in vitamin C. Cashew extract exhibited antioxidant property that increases the activity of SOD and CAT antioxidant enzyme, decrease peroxidation of lipids and reduce cell membrane damages. Kubo *et al*., (2006) stated that anacardic acid and cardanol isolated from the cashew oil inhibit peroxidation of lipids because they do not donate a hydrogen atom to the peroxy radical obtained from the free fatty acid. Consumption of nuts with healthy diet reduce the risk of cardiovascular disease and mortality (Ros *et al*., 2010), diabetes (Kendall *et al*., 2011), stroke (Estruch *et al*., 2013), depression (Sanhueza *et al*., 2013) improves mental health (Carey *et al*.,2012), and metabolic syndrome (Fernandez *et al*., 2013). Trox *et al* (2010) reported the conventional shelling methods of cashew nut including novel flore hand crack method, drying, oil bath roasting, steam roasting and open pan roasting. They reported a significant reduction in β-carotenoids, thiamin and saturated fatty acids by hand crack method when compared to other unprocessed samples.

The nutritional composition of cashew includes phenolic lipids (Shobha *et al*., 1992), phytosterols (Ryan *et al*., 2006), tocopherols, fatty acids and bioactive compounds such as α- tocopherol, β- carotene, γ- tocopherol, thiamine, stearic acid, oleic and linoleic acid. Leaves, stem and bark extracts of *A. occidentale* were extensively used to treat diarrhoea, dysentery and colonic pain and possess antimicrobial, anti-inflammatory, antidiabetic and analgesic activities (Arekemase *et al*., 2011; Olatunji *et al*., 2005). The ethanolic extract of *A. occidentale* leaves show antimicrobial activity which is attributed to 2- hydroxyl pentadecylbenzoic acid, tatrols and tannins. Phytochemical analysis of *A. occidentale* results in a rich variety of secondary metabolites (Rajesh *et al*., 2009) from the ethanolic extract of *A. occidentale* flowers ethyl gallate (William and Douglas, 2006), quercetin and from the tender leaves β- sitosterol was isolated (Subramanian *et al*., 1969). From the ethanolic extract of *A. occidentale* nuts cardanol, 2-hydroxy-6-pentadecylbenzoic acid and salicylic acid were isolated (Terdong *et al*., 2010). The nut is rich in protein, antioxidants, low cholesterol and low fat which is beneficial to the heart. It helps to

prevent skin diseases, hemorrhoids and dysentery. It strengthens hair and nails. Cashews traditionally used in oral hygiene care (Anand *et al*., 2015).

Lowor and Agyanti, (2009) stated that the mature cashew seed contains 542 calories of carbohydrates, fibre, ash, protein, calcium, phosphorus, iron, thiamine, riboflavin, niacin and ascorbic acid. The cashew apple contains 87.9% water, carbohydrate, fat, protein, ash, calcium, potassium, vitamin C and carotene. The testa contains leucocyanadine, proanthoocyanadine, leucopelargodonidine, α-catechin, β-sitosterol and γ- epicatechin. The nut is dark in colour due to the presence of the iron-polyphenol complex. The cashew seed comprises of a double-walled shell which is the source of Cashew nut shell liquid (CNSL) and is brown coloured liquid when crude and after processing becomes pale yellow colour. In folklore medicine, CNSL is used to treat tooth abscesses, fungal infections and cracked heels for centuries. CNSL contain unsaturated hydrocarbon phenol which plays as monomer during the production of polymers. Cashew nut shell oil has approximately 90% anacardic acid ($C_{22}H_{32}O_3$) and 10% cardol ($C_{32}H_{27}O_4$) (Santos and Magalhaes, 1999; Ikeda *et al*., 2002).

Murthy and Yadava (1972) examined 24 different cashews and reported that the shell oil yield ranged from 16.6 to 32.9%. The cashew gum contained galactose, xylose, arabinose, rhamnose and used in acid-resistant paints, black lacquers for decorating vases, foundry resins, insecticides, fungicides. It has been used in traditional medicine to treat elephantiasis, leprosy, psoriasis, ringworm and warts. Phytochemical tests of *A. occidentale* showed a rich variety of secondary metabolites. The nuts of *A. occidentale* ethanolic extract contain phenols, triterpenoids and volatile oils. Ethyl acetate extract showed phytochemicals with different combinations: carbohydrates, phenols, volatile oils and xanthoproteins. Acetone extract contains carbohydrates, flavonoids, triterpenoids, phenols, volatile oils and xanthoproteins. From the cashew apple, 2-hydroxy-6-pentadecylbenzoic acid and 2,6- dihydroxybenzoic acid were isolated. (Paramashivappa *et al*., 2001; Assuncao and Mercadante, 2003). It is rich in vitamin C and has five times more vitamin C than an orange. It is also rich in tannins, sugars, minerals mainly phosphorous, calcium and iron. The fruit is used to cure scurvy, diarrhoea, neurological pain, rheumatism and help to prevent cholera. Rico *et al*., (2015) determined the presence of amino

acids, vitamins, minerals and sterols in different raw cashew kernels collected from Brazil, India, Ivory Coast, Kenya, Mozambique and Vietnam.

The most occurring sterol is β- Sitosterol, the highest amount of amino acid is Glutamic acid whereas the lowest aminoacid is tryptophan. The most abundant vitamin is vitamin E. In cashew apples, the highest amount of mineral content is potassium. Alvarenga *et al*., (2016) reported that the ethanolic extract of cashew contains 7 compounds namely anacardic acid diene, anacardic acid triene, cardol monoene, cardol oldiene, cardol triene, 2-methylcardol diene and 2- methylcardol triene. These seven compounds were active against *Schistosoma mansoni* male adult worms. The concentrate of cashew apple juice contains cashew nut legumin, vicilin and proteins with IgE-reactive epitopes (Comstock *et al*., 2008). Carvalho *et al*., (2015) studied the protective property of cashew gum (CG), a complex heteropolysaccharide extract from *A. occidentale* on naproxen (NAP) induced damage in gastrointestinal lesion in rats that reduces the inflammation by increasing the adherent mucus amount in the mucosa.

Anacardic acids are the chemical constituents present in the cashew nut shells that forms the phenolic lipids. An acid form of anacardic acid known as urushiol on direct contact with skin leads to skin rash called as urushiol-induced contact dermatitis (Rosen and Fordice, 1994). The significant component of liquid extracted from the shells of cashew nut was anacardic acid that contains aliphatic side- chain of 15 carbon atoms with two double bonds. Paul and Yeddanapalli, (1954) reported the separation of the mixture of various compounds and the identification of their olefinic structure. Chemically, anacardic acid is a combination of various relevant organic compounds with saturated and unsaturated molecules. While heating, decarboxylation takes place in most commercial oil processing which results in the change of anacardic acid to alcohol as cardanol (Patel and Patel, 1936).

According to Gerold *et al*., (2012), metabolic profiling tools were used to identify commercial cashew nuts for the semi quantitative analysis of various anacardic acids. He detected twenty anacardic acids in the mass range from m/z 163 and m/z 657. The solubility percentage for natural Cashew nut shell liquid in SC-CO_2 under a parameter of operating states of pressure (100, 200 and 300 bar), the CO_2 flow rate is about 5, 10 and 15 g min-1 at temperature 40 and 50^{o}C. They isolated

better quality of anacardic acid from natural crude CNSL (82% of total anacardic acid) within 150 min through conventional methods (Joseph *et al*., 2008). Verma *et al*., (2014) proposed advanced methodology to extract cashew kernel from the cashewnut. Patel *et al*., (2006) explained the CNSL extraction using supercritical carbon dioxide (SC-CO_2). They investigated the effects of the process that included extraction pressure, the flow rate of SC-CO_2, temperature and evaluated the yield of CNSL that increased with increasing the process parameters. The CNSL obtained through SC- CO_2 shows better quality than the CNSL obtained through thermal method (Setianto *et al*., 2001).

Jennifer *et al*., (2010) reported the effects of different conventional shelling processes such as oil- bath roasting, drying, open pan roasting, direct steam roasting as well as the ancient method, flores hand cracking of cashew nut kernels and their bioactive compounds. The cashew nut kernels were observed to have certain bioactive compounds such as β- carotene, α- tocopherol, γ- tocopherol, oleic acid, lutein, linoleic acid, zeaxanthin, thiamine and stearic acid. Cashew nut shell oil contains sixteen phenolic substances and has been isolated. They tested CNSO against four typical microorganisms such as *Bacillus subtilis* (Gram-positive bacteria), *Escherichia coli* (Gram-negative bacteria), *Penicillium chrysogenum* (mold) and *Saccharomyces cerevisiae* (yeast). Anacardic acid showed more potent antibacterial activity except for molds (Himejima and Kubo, 2015).

In the cosmetic industries, oil with rich fatty acids was shown to be beneficial to the skin (Nemarundwe *et al*., 2008; Lautenschlager, 2003). Oleic acid showed high permeation effect among unsaturated fatty acids and palmitic acid exhibited more potent on skin permeation activity among saturated fatty acids (Kim *et al*., 2008). In the plastic and resin industries, CNSO is used widely for its phenolic content (Murthy and Sivasamban, 1985). The CNSO is used in the production of brake linings and applied as anticorrosive agents in metals (Patela *et al*., 2005). CNSO has anacardic acid 60-65%, cardol 15-20%, cardanol 10% and traces of methyl cardol (Gandhi *et al*., 2012).

CNSL on separation by using liquid chromatography analysis showed anacardic acids (50%), cardols (21%) including mono, di, and triene compounds. Cheriyan and Abraham, (2010) evaluated the use of enzymes, proteases and

oxidoreductases for the bioremediation of Cashewnut shell liquid that possesses phenolic compounds, primarily cardanol. They concluded that the colour of the CNSL was reduced by peroxidase removal through polymerization, precipitation and the phenolic compounds were degraded by laccase, papain, bacterial and fungal proteases. The Cashew nut shell oil properties are equivalent to those of petroleum with a high calorific value of 40 MJkg, low ash content (0.01%) and limited water content (3 – 3.5 wt. %).

Mohod *et al*., (2011) described Cashew nutshell as a potential substitute for fuel wood in factories. They investigated that the combustion of cashew nut shell directly was annoying because it emitted high smoke and low efficiency and recommended as an alternative thermal transformation of Cashew nutshell. It can be used as feedstock for a gasifier. Andrade *et al*., (2011) stated that cashew extracts play a vital role as an electron donor, acting as a significant antioxidant that performs the electron passage by quick stabilization of molecules. The cashew peduncle extract reduces lipid peroxidation level in the liver, plasma and brain tissues.

According to Morais *et al*., (2010) cashew extracts have the potential to increase the CAT antioxidant enzymes and SOD activity and decrease the lipid peroxidation and thereby reduce the cell membrane damage. The leaves of cashew nut exhibited antioxidant activity through FRAP analysis. The antimicrobial activity of the leaves of cashew showed better results against Gram-negative bacteria and was not effective on fungi (Ajileye *et al*., 2015). Barcelos *et al*., (2007 a and b) described that the methanolic extract of cashew stem bark showed antigenotoxic and antimutagenic activities on Chinese hamster lung fibroblasts V79. It was also used to cure gastrointestinal disorders, throat problems and mouth ulcers (Akinpelu 2001).

Tchikaya *et al*., (2011) studied the effects of *Anacardium occidentale* stem bark extract on cardiovascular parameters in animal models. The aqueous extract showed cardio inhibitory effects. It induces strong hypertensive and cardio inhibitory effects in animal models. *A. occidentale* leaves were used in folk medicines for its therapeutic properties due to the presence of phenolic compounds. They studied the hydroethanolic leaf extract (AoHE) to analyze the cytotoxicity on lymphoblastic leukaemia cells (Janaina *et al*., 2018). The cashew nut tree contains major phytochemical constituents as flavonoids and phenolic acids. These chemical

compounds reported to have different health benefits with a variety of biological activities such as antimicrobial, antioxidant, antiallergic, anti-inflammatory, anti-hypertensive, anti-proliferative and vasodilatory effect (Pietta *et al*., 2003 and Yao *et al*., 2004).

Nugroho *et al*., (2013) described the use of *A. occidentale* leaves to treat hypertension. From the young leaves of *A. occidentale* flavonoids of quercetin, quercetin- 3- O-rhamnoside, amentoflavone, myricetin were isolated and known to possess ulcerogenic effect (Arya *et al*., 1989; Konan and Bacchi 2007). Kogel and Zech (1985) reported that the leaves of *A. occidentale* contain phenolic compounds such as cinnamic, coumaric, ferulic, gallic and protocatechuic p-hydroxybenzoic acids. Shukri and Alan (2010) isolated fifteen glycosides from the leaf shoots of two varieties of Cashew nut. The primary compounds were kaempferol 3-O- arabinofuranoside, kaempferol 3-O- glucoside, quercetin 3- O- galactoside and quercetin 3- O-glucoside. In cashew leaves, quercetin was dominant among flavonoids and chlorogenic acid was dominant among phenols (Andarwulan *et al*., (2012), cyanin, anthocyanin and peonidin are the other phenolic compounds reported by Kongkachuichai *et al*., (2015).

Maia *et al*., (2000) reported phytoconstituents of essential oils obtained from the leaves, fruit and flowers of the cashew plant. The leaf oil reported to posses α- copaene, β- ocimene and δ-cadinene. The fruit oil possesses oleic acid and palmitic acid. The flower oil contains benzyl benzoate, methyl salicylate and β- caryophyllene. According to Razali *et al*., (2008) the ethanol extract of *A. occidentale* shoot showed higher phenolic content, DPPH activity and Ferric oxide reducing assay than the hexane and ethyl acetate extracts. The ethanolic extract of *A. occidentale* leaves exhibited significant DPPH free radical scavenging activity and Nitric oxide scavenging assays than the aqueous and petroleum ether extracts (Jaiswal *et al*., 2010). β – sitosterol is a well-known antioxidant which is responsible for reducing DNA damage and the level of oxygen free radicals increase the level of antioxidant enzymes. During the last century, natural seed oils were replaced by synthetic substitutes. However, due to toxic properties, the natural oils are reverted in use by the cosmetic and pharmaceutical industries.

Rotaviruses are the primary causative agent for diarrhoea that affects infants and young children. In Brazil, among the 15 medicinal plants tested against Simian (SA 11) and human (HCR 3) rotavirus, the *A. occidentale* aqueous leaf extract inhibit the SA-11 virus growth by 85% at a non-cytotoxic concentration of about 4.0 µg/mL (Goncalves *et al*., 2005). Shetty *et al*., (2014) evaluated the anticandidal activity of cashew leaves. The denture swabs collected before and after application of cashew leaf extract as cleansing agents and total candid counts were done. Results proved that the leaves of cashew show significant antifungal activity and used as a natural cleansing medium; although their antifungal property was not as potent as denature cleansing tablets such as Triphala. Sokeng *et al*., (2001) experimented the leaves of *A. occidentale* for hypoglycemic activities; the blood glucose level in rats was in normal range. It showed a protective effect against Streptozotocin induced diabetic rats.

A. occidentale ethanol leaf extracts showed high proliferative activity on Jurkat cells with agathis flavone, an isolated biflavonoid tested against human gingival fibroblast and Chinese hamster lung fibroblast (V79) cell lines. Cashew leaves was reported to possess stronger anti-inflammatory effect in the ethanol extract than the aqueous extract. *A. occidentale* leaf extract reported to possess significant effect of lowering the blood glucose levels in normal glycaemic and hyperglycaemic rabbits (Esimone *et al*., 2001).

In Dutch, the import and export of oils, fat and oilseeds grew rapidly in 2017. More than 8 billion euros earned through the export of oils and fats for the Dutch export of agricultural goods (De Nederlandse landbouw export report, 2018). Also, the export of coconut oil, palm oil, and combinations of fats and oils for nonfood applications increased. Netherland is the second largest agricultural exporter in the world and also a significant global player in agribusiness for many years (MVO, 2013). Throughout the world, fats and oils were used for food applications and industrial uses. They were consumed in the form of butter, cooking oil, margarine, and salad oils, as well as animal feeds, biodiesel, fatty acids, soaps, paints, personal care products, lubricants and greases. Fats and oil sources for consumption are edible vegetable oil, palm oil, animal fats and marine oils.

In Europe, the industrial consumption of rapeseed oil increased for biodiesel production. In Central and South America soybean oil also used for biodiesel production. World consumption of fats and oils is more in Asia, which use about 48% of the world total production. India and China combined 30% of the world total production. Chinese mainly use soybean oil, followed by canola and palm oils. India is a significant consumer of the canola oil and also uses palm oil and butter (Jeremy *et al*., 2004). About 10% of world fats and oils consumed by the US mainly added in the food like salad and cooking oils, for biodiesel and fatty acid production. Germany has grown with the use of biodiesel, but France continues to consume fats and oils for food. Africa and the Middle East primarily use palm oil as low consuming regions. Asia leads the global production of fats and oils. Indonesia is the world's largest producer of about 18% of global production and 56% of palm oil. China ranks second to produce fats and oils to 14% of total global production. India also produces canola and butter in large volumes. Asia accounts for approximately 54% of the world's production of fats and oils (Gunstone, 2000).

Seed oils were used by rural communities as food, medicine, cosmetic application and as fuel for centuries. The production of lubricants, soaps and medicines for hair dandruff, varicose veins, muscle spasms and wounds has increased oil usage (Zimba *et al*., 2005). Demand for seed oils for food, cosmetics and biofuel has increased in recent years to seek natural alternatives (Mitei *et al*., 2008).

The *trans* esterification process is the most viable method to lower the catalyst viscosity. The reaction of the fat or oil in the presence of a catalyst with alcohol form glycerol and esters. Glycerol is the byproduct which has high commercial value. The physical characteristic features of fatty acid ethyl or methyl ester are very close to the petro diesel fuel. Wei *et al*. (2009 b) stated that the waste catalyst could use up to 13 times without high loss in their activity. Calcined eggshell act as a reusable solid catalyst during *trans* esterification of vegetable oil and methanol to produce biodiesel. The eco-friendly and economically it is useful to reduce the processing cost of biodiesel to make it competitive with petroleum diesel. In large-scale industrial production of biodiesel, the low-cost catalyst is used to make the process cheap and ecologically safe.

Sanjay (2013) reported that the readily available, biodegradable and environmentally acceptable are the three criteria for the catalyst in large scale usage and does not cause disposal problem. These catalysts usually considered as a green catalyst obtained from the renewable biomass. Nakatani *et al*., (2009) stated that the highest biodiesel yield was obtained from soybean oil and oyster shells as a catalyst. Viriya *et al*., (2012) reported maximum biodiesel obtained from the palmolein oil using *trans* esterification process with methanol and oil in the ratio 15:1 with catalyst.

The calorific value is the energy released during combustion of unit mass of fuel. It is basic for the determination of energy system. In the determination of thermo chemical processes it is important to separate the gross calorific value (GCV) or higher heating value (HHV) from the net calorific value (NCV) or lower heating value (LHV) (Gravalos *et al*., 2010). GCV is a significant indicator of biomass quality that depends on ash content, elemental composition and moisture content (Montes, 2011).

The Cetane number (CN) is a measure of the ignition characteristics of diesel fuel oil in compression ignition engines. It is determined at constant speed in a precombustion chamber type compression ignition test engine. This method is used by the petroleum refiners and marketers, engine manufacturers and in commerce as a primary specification measurement related to matching of fuels and engines. The CN scale covers the range from zero to 100, but typical testing ranges between 30 to 65 CN (ASTM, 2018).

An immense amount of agricultural waste is produced all over the world should be treated as a resource for its prevalence and renewability. While developed countries are concerned with utilization and environmental issues, focus on the economic factors of social housing, especially in rural areas is needed. Fortunately, environmental awareness has been raised up using agricultural wastes into partial replacement for coarse aggregates, powder aggregates, reinforcing materials, cement and binders.

Coconut shell is an agricultural waste and available in plentiful quantities throughout tropical countries worldwide. In many countries, coconut shell is used to open burning which contributes methane and CO_2 emissions. The smoke evolved

during burning cause health hazard. Coconut and cashewnut shells are more suitable for pyrolysis process as it contain high volatile matter, less moisture content and available at cheap cost.

This study is an attempt to create awareness on the coconut and cashewnut shells as a source of essential bioactive compounds, at the sametime used for the production of biofuels to replace fossil fuels. The motivation of this research is reusing high efficient and low cost agrowastes such as coconut and cashewnut shells to produce biofuel.

During pyrolysis process the coconut (CSO) and cashewnut shells (CNSO) yield oil. The obtained oils were analyzed for the phytochemical constituents by using standard procedures. The activity of the CSO and CNSO would be evaluated for their antimicrobial activities. *In vitro* antioxidant properties of the ethanol, acetone and petroleum ether extracts of CSO and CNSO would be studied by using DPPH and Nitric oxide assays. The CSO and CNSO would be tested for anti-cancer activity. The CSO and CNSO extracts would be evaluated for its antibacterial activity against *Staphylococcus aureus* and Minimum Inhibitory Concentration would be calculated through agar dilution method. The HPTLC fingerprinting of ethanolic extract of CSO and CNSO would be studied. An attempt would be taken to separate the bioactive compounds and their structures would be elucidated, by GC-MS analysis.

The small molecules thus obtained would be docked with the cancer causing receptors by both Autodock and Autodock Vina tools. The cytotoxicity assay would be performed by MTT assay.

Biooils could be prepared from the CSO and CNSO and would be tested for biofuel efficacy. The biofuel parameters such as kinematic viscosity, flash point, density, gross calorific value and cetane number would be measured.