CHAPTER 4 REVIEW OF LITERATURE

Seeds of *B.lanzan* family Anacardiaceae and extracts of seeds of *Simmondisia chinesis are* a miracle herb widely used by Indian tribes for treating various diseases. Literature review reference for the pharmacological properties, pharmacognostic studies and phytochemical investigation of these two seeds extracts.

Mitra et al., (2015) Priyal is commonly known as 'Chironji' or 'Charoli' and is ascribed to the plant species Buchanania lanzan Spreng., family Anacardiaceae. In the present investigation, pharmacognostical characters of the fruit and seed of the *Buchanania lanzan* Spreng. and the commercial samples of 'Chironji' have been described which will enable to evaluate the potentiality of the drug.[40]

Abhijit B et al., (2015) Buchanania lanzan Spreng, a dry deciduous forest tree of family Anacardiaceae is widely used by Indian tribes for treating various diseases. Three major chemical constituents of potent medicinal value, namely celidoniol, vomicine, epinitol have been characterized from an organic extract of leaves. Such extracts mainly exhibit antidiabetic, antihyperlipidemic, antioxidant, anti-inflammatory, wound healing, antidiarrheal, antivenom activity including a host of other curative properties. Very recently, unique biomaterials and biofilms are being extracted from seeds, which promise to become a major contributor in pharmaceutical industry. This review attempts to present thorough updated account of ongoing and emerging areas of research of this plant, especially in the field of phytomedicnes and pharmaceuticals.[41]

Mehta SK et al., (2010) The leaves of Buchanania Lanzan (Anacardiaceae) are reported to have great medicinal value. Phytochemical screening including qualitative chemical examinations and quantitative analysis was carried out using HPTLC techniques. Identification, separation and quantification of chemical constituents was carried out on the leaves of buchanaia lanzan, an evergreen member of the family anacardiaceae, using, chemical testing, TLC and HPTLC techniques. Two major class of secondary metabolites were detected Glycosides, Phenolic compounds. These findings are useful in establishing a relationship between chemical composition of the leaf extract and previously reported activities of B. lanzan and also may assign a new potential role of B. lanzan extract in human health care[42]

Bhatnagar S et al., (2022) *Buchanania lanzan* is a medicinally useful evergreen tree with edible seeds and fruits. Flowers are yellowish-white, bisexual, pentamerous, complete, and grouped in

panicles at the top and bottom of the plant. The annual growth phase of the observed plant lasted about 11 months. The drupe-like fruits were round, indehiscent, and took 80–87 days to mature. The average number of flowers is 580 per inflorescence; however, only 5–25 fruits were produced per inflorescence. The reduced flower to fruit and fruit to seed ratio is one of the major causes of reproductive failure. The anatomical study shows the endocarp of *B. lanzan* is multilayered, with crystalline exterior cells and sclereids interwoven with a mass of cells in the inner five or six-cell layers. Morphological studies showed exalbuminous and polymorphic seeds with variation in weight. The kernel is pale yellow, with two large plano-convex cotyledons in the embryo. The structural anatomy of *B. lanzan* fruit and seed has never been studied. The goal of this research is to learn more about fruit and seed biology, as well as the factors responsible for its extinction in the wild. The availability of a hard seed coat, low germination capacity, and a short seed viability time are the factors that have contributed to the extinction of this medicinally important tree species from India's Western Ghats. The findings are a valuable addition to our understanding of this species and will aid conservationists.[43]

Rajput BS et al., (2018) Chironji, Charoli or Char, (*Buchanania lanzan* Spreng.), a member of the family Anacardiaceae, originated in the Indian sub-continent, is an excellent multipurpose tree species. Traditional indigenous knowledge reveals the immense value of almost all parts of the plant i.e. roots, leaves, fruits, seeds and gum for various medicinal uses. At present, it is growing under forest condition as an under exploited fruit and gives monitory reward to tribal community of the country. The tree is natural wild growth in the tropical deciduous forests of Northern, Western and Central India, mostly in the States of Chhattisgarh, Jharkhand, Madhya Pradesh and in Varanasi and Mirzapur districts and Bundelkhand region of Uttar Pradesh. Besides India, the plant is also found in other tropical Asian countries, Australia and Pacific islands. *B. lanzan* also a vulnerable medicinal plant, is included in the Red Data Book published by International Union for Conservation of Nature and Natural Resources. In this background, there is compelling need for developing a suitable technology facilitating easy multiplication, regeneration and conservation of the species, simultaneously imparting and disseminating proper knowledge and education to the tribal population.[44]

Sengupta A et al., (1977) The fatty acid composition of *Buchanania lanzan* seed oil, determined by urea complex formation and gas liquid chromatography (g.l.c), was found to be: myristic, 0.6; palmitic, 33.4; stearic, 6.3; oleic, 53.7; and linoleic, 6.0%. Triglyceride compositions of the

native seed oil and its randomised product were calculated from the fatty acid compositions of the triglycerides and of the corresponding 2-monoglycerides produced by pancreatic lipase hydrolysis. The oil is composed of 3.2, 35.8, 45.5 and 15.5% trisaturated, monounsaturated disaturated, diunsaturated monosaturated and triunsaturated glycerides respectively. The special characteristic of the *B. lanzan* seed oil is its content of 22.7, 31.0 and 11.3% dipalmitoolein, dioleopalmitin and triolein respectively. The percent GS_3 content in the oil increased from 3.2 to 7.5 by the process of randomisation. On directed interesterification the oil yielded a product with a slip point of 41.5°C which may be suitable as a coating material for delayed action tablets. The oil also appears to be a promising one as a commercial source of palmitic and oleic acids.[45]

Shende S et al., (2005) *Buchanania lanzan* (Spreng) is an endemic but vulnerable plant from the tropical region of India. A tissue culture technique for the rapid clonal multiplication of *B. lanzan* was developed. The decoated seeds were cultured on MS medium enriched with various concentrations of auxins and cytokinins alone or in combination. Combinations of Benzyl amino purine (BAP) and napthalene acetic acid (NAA) were found to be superior to BAP and Indole butyric acid (IBA). Murashige-Skoog (MS) medium supplemented with 22.2 µM of BAP and 5.37 µM of NAA promoted formation of the maximum number of shoots. Furthermore, MS medium containing 23.3 µM kinetin induced profuse rooting of the initiated shoots. We propose here that multiple shoot formation is one of the effective techniques for rapid clonal multiplication.[46]

Bothara SB et al., (2012) *Diospyros melonoxylon Roxb*. belonging to family Ebenaceae, commonly known as Tendu in Hindi is a small tree with rather slender stem and smooth grey bark. *Buchanania lanzan* spreng. commonly known as Char in Hindi is a tree of 12-15 mt high, with straight trunk, belonging to family Anacardiaceae. *Manilkara zapota* (Linn.) P. Royen syn., belonging to family sapotaceae commonly known as Chiku in Hindi is a large, evergreen, forest tree more than 30 mt in height. These three plants are easily available in the forests of Chhattisgarh used in various diseases traditionaly. The pharmacognostical studies of these plants were done by evaluating its microscopical studies, phytochemical screening, flourescence analysis of extracts of the seeds with different reagents and presence of Elemental analysis such as CHNS and heavy metals. The microscopical studies revealed the specific characters in all three seeds, it has obsereved and identified. Phytochemical screening revealed the presence of carbohydrates, proteins, fat and oils, present in extracts of all three seeds. Flourescence analysis

of Extarcts of seeds shows diffrent colours with different reagents. The above pharmacognostical and preliminary phytochemical studies will be beneficial for proper identification and authentification of seeds of *D. melonoxylon Roxb*., *B. lanzan* spreng, *M. zapota* (Linn.) P. Royen syn.[47]

Singh S et al., (2020) This study was aimed to develop an oral bio-based mucoadhesive polymer from seeds mucilage of *Buchanania lanzan* spreng, belongs to family anacardiaceae. Isolated mucilage was evaluated for mucoadhesive strength and compared with existing polymer. The mucilage showed shear stress results (0.099 ± 0.0001N), with comparable adhesiveness to methocel E5 (0.098 ± 0.0008N). Force of adhesion required to detach the seed mucilage and methocel E5 tablets from the mucin of intestinal tissue were 0.0276 ± 0.0019 (N) and 0.0049 ± 0.0006 (N), respectively. Seed mucilage revealed significant ($P<0.01$) higher detachment time, erosion time, *in-vitro* wash-off time and *ex-vivo* residence compared to methocel E5 and lactose tablets. *In vivo* test indicated that seed mucilage tablets possessed good mucoadhesive strength compared to methocel E5 and resisted disintegration for ≤ 8 h. The swelling index and wetting time showed comparable results between the mucilage and synthetic polymer tablets. Mucilage demonstrated high moisture absorption, percentage hydration, and matrix erosion of 18.57 ± 0.036, 50.00 ± 0.051, and 8.30 ± 0.155 compared to methocel E5 10.0 ± 0.079, 36.00 ± 0.089, and 1.26 ± 0.085, respectively. Mucoadhesive properties of seeds mucilage were comparable to guar gum and methocel E5, thus seed mucilage of *B. lanzan* can be potentially exploited for usage as a bioadhesive pharmaceutical excipient.[48]

Von TI et al., (1988) The anatropous, unitegmic and pachychalazal mango ovule develops into the campylotropous, pachychalazal seed. The undifferentiated seed coat is of dual origin, developing from the integument as well as from the pachychalaza. The term ‘peritesta’ is suggested for the peripheral, band-like integumentary part of the seed coat. The major saddle-shaped chalazal part is associated with a tanniniferous hypostase. The discussion includes the anatomy and histochemistry of the seed. The pachychalazal seed with undifferentiated seed coat probably characterizes the tribe Mangifereae. After consideration *inter alia* of seed characters, it is concluded that, according to generally accepted criteria, the Anacardiaceae is phylogenetically one of the more advanced forest families.[49]

Malik SK et al., (2012) *Buchanania lanzan* Spreng. (Chironji) is a socio-economically important underutilized fruit and life support species of tribal populations of north, west and

central India. A survey and germplasm collection programme undertaken in the Indian states of Rajasthan, Gujarat and Madhya Pradesh observed that *B. lanzan* is found as natural wild in the forest, marginal lands and occasionally in farmer's fields. A total of 72 diverse accessions of this important tree species were collected from the diversity–rich areas of India having wide range of variation in agro-morphological traits among the accessions. This species has high socio-economic value providing livelihood to tribal population of these areas and has high potential as commercial horticulture species. Fresh ripen fruits and extracted seed kernels have several nutritional and medicinal properties. Seed kernel and extracted kernel oil is used for the preparation of several Indian dishes. Traditional indigenous knowledge revealed immense importance of almost all parts of plant like roots, leaves, fruits, seeds and gum for various medicinal applications like cure for blood disorder, fever, ulcers, burning sensation of body, diarrhoea, dysentery, asthma, snakebite, etc. Due to direct harvesting of economically important parts of tree from natural habitat, genetic resources of *B. lanzan* are facing severe threat of extinction and need immediate conservation efforts. [50]

Siddiqui MZ et al., (2016) Gum of *Buchanania lanzan* Spreng. (Anacardiaceae) is being traditionally used for various medicinal purposes. This study evaluates the phytochemicals as also the physico-chemical properties and antioxidant activity in gum exudates of *B. lanzan* Spreng. Seven samples of gum exudates of *B. lanzan* Spreng. were collected from Bilaspur (Chhattisgarh), Simdega and IINRG farm (Jharkhand), Dindori and Umaria (Madhya Pradesh) and Mirzapur (Uttar Pradesh) for studying variations in their major phytochemicals, physico-chemical properties and antioxidant activity adopting standard procedures. Twenty percent and ten percent concentrations of gum exudates were used for determining their viscosity (cP) at ambient temperature. The antioxidant potential of the gum exudates was evaluated by free radical scavenging activity using 1,1-diphenyl-2-picryl hydrazyl assay. Flavonoids, saponin, amino acid/protein and carbohydrates were found in all the gum exudates. All of them showed intra-specific variation in the physico-chemical properties viz. moisture level, color parameters (L, a, b), ash content, elemental (CHN) level, specific rotation [α] and heavy metals. Tannin was present only in the black gum exudates collected from Madhya Pradesh and Chhattisgarh. *B. lanzan* gum exudates, at twenty percent and ten percent concentrations, exhibited shear thinning/pseudoplastic flow pattern in their viscosity. Antioxidant activity was found only in samples with tannin and the magnitude was related to the tannin level in the gum. The findings

show the significant qualitative and quantitative intra-specific variations in *B. lanzan* gum exudates, collected from different places, for their phytochemicals, physico-chemical properties and antioxidant activity.[51]

Vijay MK et al., (2022) Buchanania lanzan Spreng (Chironji), is a member of the family Anacardiaceae. It exhibits an extensive therapeutic profile which has proven to be a socio-economic boon to the tribal community. Plant parts such as leaves, seeds, bark, and kernels have been shown to retain a variety of metabolites with great potential. Presently, B. lanzan is grouped as non-nationalized minor forest produce and widely distributed in the forest regions. Indiscriminate and improper harvesting, climate change, large-scale urbanization and developmental activities, lead to a very severe threat of its existence. It has been classified as a redlisted medicinal plant species of Indian origin, necessitating a comprehensive conservation strategy, as reported by many organisations. The major problem in the reforestation or domestication of this species is the low percentage of seed germination due to hard seed coats, recalcitrant in nature, and fungal contamination associated with the storage of seeds. Vegetative propagation has also not proved successful in this species so far. Thus to augment its sustainable production and conservation, proper research support is an urgent requirement for addressing the problems and further multiplication in the forest area. Also, need to promote awareness among various stakeholders regarding the conservation of this valuable species.[52]

Ajith S et al., (2018) Buchanania lanzan Spreng. (Anacardiaceae) is an endangered medicinal tree of the Western Ghats of India, is at the verge of extinction due to the destruction of habitat, prolonged dormancy, uprooting of trees and over exploitation of seedsfor its great medicinal value to cure diarrheal, diabetic and various skin diseases. An efficient method to standardize for breaking the dormancy of one year old stored seeds. Seeds are surface sterilized with 4% HgCl2 for 10 min and seed coat is removed by gentle hammering. Scarification of seeds with different degree of hot and cold water and chemical treatment with various concentrations of H2SO4 and GA3 was followed. Hundred Seeds each are sown in seed flats in greenhouse and germination was observed daily for a 30-day period. Treatment with 200ppm GA3 and 4% H2SO4 are the efficient methods to break the dormancy of the seeds and resulted in 90% and 61% of germination respectively. In cold water treatment only 56% of seeds germinated, in control only 25% seeds germination in the untreated seeds and germination was not observed in the intact seeds with the impermeable seed coat. Results indicative of positive responses to treatments,

while impermeable seed coats may be responsible for prolonged dormancy in intact control seeds.[53]

Kannan P et al., (2022) Embryo rescue refers to an *in vitro* technology have been used for propagating plants under *in vitro* from poorly developed embryos by avoiding embryo abortion. The aim of the present study was to *in vitro* regeneration of a medicinally wild tree species *Buchanania lanzan* through embryo rescue method. Isolated immature poorly developed embryo dissected out from de-coded seeds collected from 15 years old trees were cultured an Woody Plant Medium (WPM) was used to test *in vitro* germination. 100% embryo germination were recorded when the embryos inoculated on the medium supplemented with 1.5 mg/L^{-1} 6-benzylaminopurine (BAP) and 50 mg/L^{-1} adenine sulphate (AS). Further, a week-old seedling derived explants viz embryo axis and cotyledonary node were selected to study *in vitro* clonal propagation. On medium augmented with 1.5 mg/L^{-1} 6-benzylaminopurine (BAP) showed maximum mean shoots numbers (4.2±1.80) with 4.0±0.98 cm shoot height were achieved in cotyledonary node. Compare to Kinetin (Kn) BAP was to be better in shooting response and multiple shoot induction. Healthy regenerated shoots was separated from multiple shoots cluster and transferred to a rooting medium containing half strength WP medium fortified with Indole-3-butyric acid (IBA). IBA at 0.5 mg/L^{-1} showed 90% rooting response and maximum mean roots (4.9±0.98) per shootlet was obtained. The rooted *in vitro* plantlets were transferred to polythene bags containing autoclaved humus, red soil and farmyard manure (1:1:1 ratio) for acclimation at 25 ± 2 ^{o}C. Later, these plantlets were gradually transferred to field condition. About 70% survival rate was recorded after three months period. The protocol developed in the present study was to restore the viable embryos from poorly developed immature embryos and rapid multiplication can help to *ex situ* conservation of this threatened tree *B. lanzan.* [54]

Michelson AO et al., (2022) Experiments were conducted to study the foraging behaviour of blowfly species, Chrysomya putoria (Diptera: Calliphoridae) on Ricinus communis (Euphorbiaceae) in Sudano-Sahelian area of Cameroon in 2017 and 2018. To do so, castor bean plants were flagged and fly foraging parameters were recorded. The effects of blowfly activity on pollination and fruiting rate of R. communis were estimated by comparing unrestricted and restricted racemes. Chrysomya putoria accounted for 82.33% of the total number of flower visits among the 15 anthophilous insects recorded. Pollen and nectar foraging occurred throughout the day, with a major peak at 8-9 am. The density of foragers was about 300 individuals per plant.

The mean duration of a flower visit for male and female flowers was significantly different and resulted in a foraging speed of 3-5 flowers/minute which increases cross-pollination of R. communis. The floral activity of C. putoria improved the fruiting rate of castor bean by about 11% and conversely, this plant appeared as an important food source for the conservation of its main flowervisitor. Castor bean and the blowfly species seem to have a mutualistic relationship[55]

Gentry HS et al., (1958) *Simmondsia chinensis is* unique in many ways. Endemic to the Sonoran Desert of Mexico and the United States, its broad, persistent, heavy leaves are unlike any of its associates. Its large edible seeds contain about 50% oil, which is directly used as a cooking oil and as a hair oil. The oil has excellent qualities for many industrial and medicinal uses. Chemically it is a liquid wax and by hydrogenation is easily converted to a hard white wax. Jojoba's singular characteristics as a desert shrub, however, present many problems facing its development as a cultivated plant.[56]

Sturtevant D et al., (2020) Seeds of the desert shrub, jojoba (Simmondsia chinensis), are an abundant, renewable source of liquid wax esters, which are valued additives in cosmetic products and industrial lubricants. Jojoba is relegated to its own taxonomic family, and there is little genetic information available to elucidate its phylogeny. Here, we report the high-quality, 887-Mb genome of jojoba assembled into 26 chromosomes with 23,490 protein-coding genes. The jojoba genome has only the whole-genome triplication (γ) shared among eudicots and no recent duplications. These genomic resources coupled with extensive transcriptome, proteome, and lipidome data helped to define heterogeneous pathways and machinery for lipid synthesis and storage, provided missing evolutionary history information for this taxonomically segregated dioecious plant species, and will support efforts to improve the agronomic properties of jojoba.[57]

Abbassy MA et al., (2007) Insecticidal, antifeedant and antifungal activities of two glucosides isolated from the seeds of jojoba plant, *Simmondsia chinensis* (Link) Schneider, were tested. Bioassay-driven fractionations of the chloroform extract of the plant seeds over silica gel columns followed by recrystallization afforded two glucosides, simmondsin and simmondsin 2′-ferulate. The structure of these glucosides was confirmed by physico-chemical properties and spectroscopic analyses. In topical application assay, simmondsin and simmondsin 2′-ferulate showed a strong insecticidal activity against the third instar larvae of *Spodoptera littoralis* Boisduval (Lepidoptera: Noctuidae) with LD_{50} values of 1.49 and 2.58 μg/larva, respectively. Both compounds showed antifeedant activity against *S. littoralis* in a concentration-

dependent manner. In addition, the isolated compounds showed moderate to high antifungal activity against four plant pathogenic fungi. This is the first study on the insecticidal, antifeedant and antifungal activities of these glucosides.[58]

Tietel Z et al., (2021) Jojoba, *Simmondsia chinensis* (Link) C.K. Schneider is an evergreen shrub widely grown in Israel, the Middle East, South America, Africa, India and Australia used as an agricultural crop for commercial purposes and as a source of its non-edible natural wax. It is widely used in pharmaceutics and cosmetic formulation due to its unique structural characteristics and beneficial health effects. In addition, extensive work has been published on the plant's health-promoting activities, ranging from antioxidant activities to the treatment of cancer. Being a rich source of natural liquid wax, the majority of research regarding jojoba focuses on its applications, as well as on the ability to exploit the residual plant materials obtained in its production. To date, several potent phytochemicals have been attributed to its medicinal properties, e.g., simmondsin and phenolic compounds. The current review emphasizes the evidence-based medicinal qualities of the wax and plant extracts and highlights the gaps of knowledge in these research areas and the importance of acquiring additional understanding of jojoba distinctive traits.[59]

Arya D et al., (2016) Simmondsia chinensis, a multipurpose, drought resistant, perennial plant belonging to Simmondsiaceae family has started to gain a lot of importance because of unusual oil which is actually a liquid wax i.e., an ester of long chain fatty acids and alcohols. Jojoba was introduced to India near the year 1965 and since then it has been a major source of income for both local farmers (having cultivations in locations like Sriganganagar, Sikar, Jhunjhunu, Churu and Jodhpur) and those who are working in jojoba oil trade. Jojoba oil has many usages depending on the site where the modification is being done. Virtually no traces of glycerine make it a very unique plant-based oil along with the fact that it can be modified via hydrogenation, sulfurization, halogenation, sulfurhalogenation, phosphosulfurization, ozonization, hydrolysis, amidation and many other techniques. With uses in industries like cosmetic, pharmaceutical, lubricant and petrochemicals, the importance of jojoba oil in the market is high. Before exploiting any plant for industrial application, it is imperative to have complete information about its biology, chemistry and all other applications so that potential of plant could be utilized maximally. Overall, this paper introduces the shrub in its botanical totality, informs about its growth requirements and its local distribution in India. The purpose of

this paper is to review the available propagation techniques, inform about its oil and seed meal processing and give detailed physico-chemical description of jojoba oil and cake. Moreover, it also informs about the importance of jojoba oil and its applications.[60]

Reddy MP et al., (2009) Wax esters have important applications in medicine, and in the cosmetics and food industries, besides their more traditional usage as lubricants. The value of the wax from sperm whales was one of the factors responsible for this animal being hunted to near extinction, which prompted the eventual ban on harvesting and the search for alternative sources. Recognition of jojoba oil as an alternative to sperm whale oil has led to a surge of interest in jojoba across the globe. The hardiness of this plant, which is amenable to cultivation even on water-deficient wastelands, has led to it being cultivated as a crop in several semi-arid and arid regions of the world. In addition, oil from the seed de-oiled cake is rich in protein and can be used as livestock feed and as a source of commercial enzymes. The plant is dioecious, and exhibits tremendous variability in male:female ratio in a given population, with male plants generally outnumbering female plants, leading to low yields as expected due to heterogeneity in the population. High yielding genotypes have been selected from experimental plantations, and vegetative propagation methods have been developed to provide genetically uniform, known sex plants to boost yields. Due to limited production, jojoba waxes are not available for a number of applications in spite of high demand. The advent of genetic engineering has provided novel opportunities to tailor the composition of plant lipids and also engineer agronomically suitable oilseed crops to produce high levels of wax esters in the seed oil. This chapter discusses efforts made towards the domestication, genetic improvements for yield and oil content, detoxification of cake for use as a livestock feed, and aspects of micropropagation of this species.[61]

Prat L et al., (2008) The effect of foliar application of cytokinin (benzyl-adenine, 150 mg L^{-1}) and gibberellin ($GA_4 + GA_7$, 150 mg L^{-1}) on growth and flower development of 5-year-old plants of two jojoba clones was studied. The plant growth regulators were applied on October 5, 1999 (spring) and the plants were evaluated 120, 240 and 360 days after application. Shoot length, total number of nodes and number of nodes with branching were statistically different between clones but not between the growth regulator treatments. The total number of flowers on both clones was significantly increased by treatment with benzyl-adenine (BA) and significantly reduced by treatment with gibberellin. The seed yields, evaluated 180 days after application, were not statistically different from the control due to an increase in flower abortion. One clone

treated with gibberellin showed a significant decrease in number and weight of seeds, the other did not.[62]

Subramanian K et al., (2023) The primary goal of this research is to produce energy from discarded Simmondsia chinensis seeds. In a CRDI diesel engine, methyl acetate (MA), a novel and renewable component, is blended with Simmondsia chinensis biodiesel (SCB), and various fuel injection techniques and exhaust gas recirculation (EGR) are employed. After that, the fuel was compared to diesel fuel to improve ignition patterns and reduce exhaust emissions. Non-edible biodiesel has a higher viscosity than diesel, resulting in higher emissions. So, the novel oxygenated additive MA was used as an ignition enhancer. Initially, the test used diesel at 10% EGR and DBMA20 (50% Diesel, 30% SCB + 20% MA by vol.) at 10% EGR. Results found that the brake thermal efficiency (BTE) decreased, and emissions increased. Further, work carried out modified operating parameters pilot injection timing (PIT), pilot fuel injection quantity (PFIQ), and EGR at maximum load conditions. The experiments were done with an optimal blend ratio of DBMA20 at 10% EGR with PIT (35°bTDC, 40°bTDC, and 45°bTDC) and PFIQ (10, 15, and 20% by vol.). The results revealed that at peak load, PIT 45° at PFIQ 20%, the BTE increased by 1.71%, BSFC decreased by 21.87%, SO reduced by 26.61%, HC reduced by 47.69%, CO reduced by 56.41%, and NO_x reduced by 11.34 % when contrasted with the DBMA20 outcomes with 10% EGR at standard injection settings. So, the PIT 45° at PFIQ 20% with 10% EGR was better than the other operating conditions. As a result, using biodiesel along with a pilot fuel injection technique was viable in operating conditions to improve efficiency and reduce emissions in CRDI diesel engine applications.[63]

Hani AQ et al., (2014) Plant parts were subjected for hot extraction by solvents of different polarity (hexane, methanol and ethanol) in addition to cold pressing extraction for seed. Furthermore, the active compounds were isolated by preparative thin layer chromatography, followed by identification for simmondsin and three of its derivatives namely Simmondsin-3'-ferulate, 4, 5-Didemethylsimmondsin and 4-Demethylsimmondsin-2'- ferulate, in addition to phenolic compounds, phytosterols, toccopherols and fatty acids. This was accomplished using chemical reagents along with various methods of chromatography and spectral analysis. The evaluation of antioxidant activity of extracts was done by 2, 2-Diphenyl-1-pircryl hydrazyl (DPPH) free radical scavenging method comparing to ascorbic acid activity. Antibacterial and antifungal activities were done using two methods; the agar well diffusion and disc diffusion

methods, against (Staphylococcus aureus, Bacillis subtilis, Escherichia coli, Klebsiella pneumonia and Candida albicans).[64]

Feki F et al., (2021) A closed-vessel microwave-assisted extraction (MAE) of simmondsins and polyphenols from defatted Jojoba cake using Box-Benkhen design with four independent variables (solvent/cake ratio, ethanol concentration, extraction time and microwave power) was investigated. ANOVA results showed that the obtained models were significant at 95% confidence level. Optimal extraction conditions were found for highest values of microwave power (500 W) and extraction time (15 min) and for moderate values of solvent to cake ratio (41 – 45 mL/g). Optimum simmondsins yield (23.35%) was obtained with pure water as solvent. However, optimum polyphenols yield (2.33%) and ORAC antioxidant activity (656 µmol TE/g) were obtained with 46.79% and 42.04% ethanol in water, respectively. ORAC antioxidant activity was found to be well correlated to polyphenol and simmondsin contents. These results indicate that MAE is an effective technique for recovery of bioactive compounds for food and pharmaceutical industries from Jojoba by-products.[65]

Wardlaw IF et al., (1984) Growth of the capsule and seed of jojoba were followed from pollination to maturity at eight temperature regimens ranging from 15/10 to 36/31¦C (8/16 h; photoperiod 16 h). There was an initial lag before the onset of rapid (linear) seed development, during which the capsule expanded, and this lag varied from 106 days at 15/10¦C to 7 days at 36/31¦C. The wax concentration in the seed was low during the initial stages of development, but reached a maximum when the seeds were 70-75% of their final dry weight. The maximum rate of dry matter accumulation in the seed increased with temperature up to 33/28¦C but, because of the longer growth period at low temperature, seed size at maturity was greatest at 18/13¦C. The current work suggests that prolonged periods with temperatures above 36/31¦C, or below 15/10¦C would be harmful to the development of jojoba seed. The high optimum temperature for growth rate of the seed (33/28¦C) and sensitivity to a temperature of 15/10¦C, puts jojoba into the same group as many subtropical species. However, the lower optimum temperature for seed weight at maturity (18/13¦C) is close to that observed for the temperate cereals.[66]

Feki F et al., (2022) This study aimed to investigate the hepatoprotective activity of jojoba seed cake extracts against an acute paracetamol (PC) intoxication. Two aqueous extracts from jojoba (*Simmondsia chinensis*) seed cake, a simmondsin-rich extract (WE), and a simmondsin-hydrolyzed extract (NE) using Viscozyme L enzyme have been prepared and characterized.

After enzyme treatment, simmondsin content decreased from 33.0 % to 3.0 % and glucose content increased from 16.2 % to 27.3 % reflecting simmondsin hydrolysis. Both extracts were administered to different rat groups via gavage (0.6 g/kg b.w.) before PC treatment (2 g/kg b.w.) three times a week for 3 weeks. The PC intoxication altered the serum biomarkers, the oxidative status, and the Tumor necrosis factor alpha (TNF-α), Bax and Bcl-2 protein expressions of tested animals. In addition, the histological analysis of liver tissues proved significant injury and hepatocellular necrosis. WE and NE extract showed a relatively high in vitro radical scavenging (ORAC) and averting activities (HORAC) with a polyphenol content of 3.6 % and 2.9 %, respectively. Both extracts showed a powerful in vivo hepatoprotective activity against PC-induced toxicity by improving the hepatocellular antioxidant status and blocking proteins expression (TNF-α, Bax and Bcl-2), involved in inflammation and liver damage. However, the enzymatic treatment improved the hepatoprotective activity of NE despite its lower simmondsin content and lower in vitro antioxidant capacity. This enhancement could be linked to the synergetic effect between the antioxidant components and the new hydrolytic products as glucose, uronic acids, arabinose and simmondsin-aglycons. These results suggest that jojoba waste could be potentially valorized in developing hepatoprotective drugs.[67]

Tong et al., (2011) have developed electro-responsive hydrogels containing PVA, which was crosslinked along diethyl acetamidomalonate, hydrogels formulated using polyaniline as responsive element and formulated into cylindrical devices containing the drug indomethacin. The physicochemical as well as physico-mechanical profiles of gels are been evaluated. Conductive property and responsiveness of gels were analysed by cyclic voltammetry. 65-70% was the efficiency range of drug entrapment. The pulsatile release ("ON-OFF") of drug from the developed hydrogels was evaluated at 0.3–5.0 V at interval of every minute for hour and release of drug was 4.7–25.2% after end of 4h. The release of indomethacin was relying on amountof crosslinking agent from various formulations. 1.2V was used to peform Box- Behnken experiment for baseline difference. Therefore, it showed proper swelling and drug diffusing property, it was increased on applying high conduction. AMBER- force field experiment was performend on devices to examine the release of NSAID from it. It was also evaluated by various factors for the reaction between polyaniline and applied energies externally. The above technique can release the drug on applying external energies in delicate working condition.[68]

Saluja et al., (2013) have developed donepezil incorporated wearable electronic delivery

(WEDD®) patches for the treatment of alzheimer's disease at supplied current levels of 0, 0.13, 0.26 and 0.39 mA. The Donepezil extracted from plasma was analyzed by HPLC and non-compartmental analysis. The quantity of drug delivered across the hairless rat skin and areas under the curve (AUC) were found to rise in proportion to the supplied current levels. Peak plasma levels of 0.094, 0.237 and 0.336 g/ml were achieved at 0.13, 0.26 and 0.39 mA respectively. Time to peak plasma concentrations was once termination of current and same for all current levels. Transdermal elimination half-life was considerably raised from actuality value of 3.2 h because of depot formation, prolonging complete absorption of the drug. Iontophoretically Donepezil was successfully delivered at adequate amount to produce pharmacodymanic results. At current levels flip flop kinetics following iontophoretic administration demonstrated linear kinetics.[69]

Rajesh Kumar., (2016) have synthesized and characterized carboxymethylcellulose- graft-copolymer in which *N*-vinyl caprolactam was grafted onto carboxymethylcellulose has been carried out in inert atmosphere using free radical initiator. Potassium bromate was used as an oxidizing agent and thiourea as reducing agent. They reacted in acidic media and produced radicals. The radicals attack on CMC and NVCL produces CMC-graft-copolymer. The grafting was further confirmed on the basis of data of FTIR spectra and thermogravimetric analysis of graft copolymer.[70]

Indermun et al., (2014) have characterized hydrogels used for controlled delivery of drug, and its uses in drug release on applying electric stimuli. Electro-conductive hydrogels (ECHs) were synthesized from semi-interpenetrating networks (semi- IPNs) containing poly(ethyleneimine) (PEI) and 1-vinylimidazole (VI) compound mix because the novel electro-active species displayed electro-responsive drug release from it. The semi-IPNs systems comprised of polyacrylic acid (PAA) and poly(vinyl alcohol) (PVA). The various attributes are considered investigated for the electro-responsive ECHs, through institution of a statistical experimental design. The systematic optimization of the ECH composition was done by construction of a Box– Behnken style model. The design model comprised of three variables, viz. poly(ethyleneimine) volume; 1-vinylimidazole volume; and applied voltage, critical to the success of the formulation. Electro-responsive drug release was resolute on Formulations exposed to varying environments to establish the optimal environment for the specified release. A water content and swelling study by gravimetric analysis was also conducted. Matrix

resilience profiles were obtained as associate insight to the power of the ECH to revert to its original structure following applied stress. The outcomes of the study incontestable the success of electro responsive drug unleashes.The findings of the study will be used for the development of electro responsive delivery systems of alternative medication for the safer and effective drug delivery. Volumes of poly (ethyleneimine) (>2.6 mL) and 1-vinylimidazole (>0.7 mL), resulted in ideal therapeutic electro-responsive drug release (0.8 mg) for indomethacin.[71]

Zuo et al, (2014) have studied the relation between the several drug properties and iontophoresis effect on transdermal. Various NSAIDs were used for this study. The drugs used were measured for oil-water partition coefficients. The hydrogels were prepared by carbomer base. In-vitro delivery of drug across skin of rat was enhanced considerably on applying electric stimulus. Strong lipophilicity could lead on to high permeation of medicine. However, the dissociation extent (indicated as pKa) of medicine was the key issue to see the transcutaneous improvement impact of electromotive drug administration. A lot of dissociation the medicine was the upper the transcutaneous improvement impact of iontotherapy. The drug-loaded hydrogels combined with iontotherapy improved the treatment of rat raw's inflammatory syndrome. The 5-carboxylfluoresce in hydrogels with the application of iontophoresis was made more permeable into the hypodermis, dermis and epidermis, more deeply than the application of drugs alone according to the experimental result. Iontophoresis crystal rectifier to the unordered arrangement of skin intercellular lipids, the considerably raised flowability and loose stratum structure with high safety and efficiency to improve transdermal drug delivery Iontophoresis is a promising approach.[72]

Kalaria et al., (2014) have investigated the delivery of pramipexole (PRAM) under iontophoretic condtion. PRAM is dopamine loving used in treating Parkinson's disease, in this study it is determined that required amount of PRAM can be delivered through skinor not. Iontophoresis method is used to measure the in vitro drug delivery across the skin using ear of porcine and abdominal skin of human. In vivo permeation rate of drug was confirmed by pharmacokinetic study by using male wistar. The relase rate of PRAM on application of current (0.5 mA/cm2 for 6 h) was 60.2 ± 5.3% and on addition of Na metabisulfite (0.5%) rate increased upto 97.2 ± 3.1%. In Vitro delivery of PRAM under iontophoretic condition was enhanced. 2.5 to4 fold enhancements in permeation of drug is observed with increase in the density ofelectric stimuli from 0.15 to 0.3 and 0.5 mA/cm2. Co-iontophoresis of acetaminophen demonstrated that

electro-relocation was the prevailing electro- transport system and here was absence of electro-osmotic stream with any thickness. In addition, combined iontophoretic saturation through human and procaine skin was shown to be factually proportionate.For PRAMm high transport and delivery effeciences have been achieved. Using steady and time-variation models, the plasma fixation profiles acquired concentrates in iontophoresis. The in vivo drug input rate indicated that PRAM electro-transport concentrations would be appropriate for therapeutic delivery and Parkinsonism treatment.[73]

Malinovskaja et al., (2014) have studied effect of steady and pulsed electric flow on the vehicle of nonapeptide leuprorelin acetate on epidermis of porcine. Likewise, evaluation of drug delivery system was carried for the delivery of identical peptide. This study demonstrated the benefit of pulsed current (Tn = 2.59 x 10-4) over constant current (Tn = 1.7x10-4) for transdermal delivery of peptides. Due to reduced passive transport and electro-osmotic transport on application of pulsed current increased electro-osmotic marker was observed. They also showed a promising approach using ion-exchange fibers for controlling the release and iontophoretic transdermal delivery of peptides. Positively charged leuprorelin acetate was guaranteed to the ion-exchange teams of cation-exchange fibers till it had been step by step discharged by mobile counter ions within the external solution. Transdermal flux from acrylic acid grafted Smopex-102 fibers remained higher (Jss = 0.71 lg/h cm2) than from sulfonic acid grafted Smopex-101 fibers (Jss = 0.31 lg/h cm2) due to better drug release.[74]

Kalaria et al., (2014) have investigated the delivery of pramipexole (PRAM) under iontophoretic condtion. PRAM is is a dopamine loving used in treating Parkinson's disease, in this study it is determined that required amount of PRAM can be delivered through skin or not. Iontophoresis method is used to measure the in vitro drug delivery across the skin using ear of porcine and abdominal skin of human. In vivo permeation rate of drug was confirmed by pharmacokinetic study by using male wistar.Studies disclosed that on applying current,enhancement in permeation was seen upto 60.2 ± 5.3% of its initial value. Were as upon adding Na metabisulfite (0.5%), associate inhibitor, enhances to 97.2 ± 3.1%. Procain skin was used to study the pram transport under iontophoretic condition. Cumulative permeation was increased by 2 to 4 folds by increasing the current density. 2-fold increase in PRAM concentrationwas observed by increasing current Between PRAM flux and both the applied current density and drug concentration in the formulation, good linearity was observed. Constant

and time-varient input models were used to model the plasma concentration profiles obtained in the iontophoretic studies in vivo, a superior quality fit was provided by the latter. The in vivo input rate of medication recommended that PRAM electrotransport rates be sufficient for helpful transmission and treatment of parkinsonism.[75]

Zuo et al., (2014) have reported affinity within the physicochemical properties of drugs and the transdermal enhancement effect of iontophoresis. Non-steroidal anti- inflammatory drugs (NSAIDs) like aspirin, ibuprofen and indomethacin were used as model drugs. The carbomer-based hydrogels of containing NSAIDs were prepared. Iontophoresis significantly enhanced in vitro transdermal delivery across the rat skin. Strong lipophilicity could lead on to high permeation of drugs. The drug-loaded hydrogels combined with iontotherapy improved the treatment of rat raw's inflammatory syndrome. Application of iontophoresis has led to the unordered arrangement of skin intercellular lipids, the significantly increased flowability and loose stratum corneum structure. Hence, the iontophoresis is a promising approach to improve transdermal drug delivery with safety and high efficiency.[76]

Bhatia et al., (2014) have investigated the delivery of lidocaine hydrochloride through porcine skin using iontophoresis technique. It was evaluated with and without direct current. Direct and pulsed current was applied for one hour and 2 hours (0-1 h and 4-5th h) employing a 1 %w/v solution of lidocaine hydrochloride. He delivery system was evaluated for amount of drug permeated into the layers of skin and extracted skin was further evaluated for amount of drug present in amount of skin layers. At predefined period samples were collected from receptor compartment any analyzed. After 2h of DC current 1069.87 ± 120.03 mcg/sq·cm of lidocaine was delivered through porcine skin and 744.81 ± 125.41 mcg/sq·cm of lidocaine was delivered after altering the DC current. Due to Iontophoretic effect delivery of lidocain was seen twelve folds more than the delivery by passive mode 91.27±18.71mcg/sq·cm of lidocaine. Modulated iontophoresis enhanced the delivery of lidocaine hydrochloride across porcine skin as compared to the passive delivery. Balanced substituting current for 2 h period, 1 kHz recurrence was seen as practicallyidentical through constant DC electric current for 1 h.[77]

Zorec et al., (2013) have reported comparing different combinations of square wave short high voltage (HV) and longer low voltage (LV) electroporation pulses. The in vitro experimental results show that longer LV pulses significantly increase subsequent passive transport of calcein through dermatomed pig skin, while short HV pulses alone result in negligible calcein passive

transdermal transport. When the long lv pulses were preceded by short period HV pulses, the overall calcein transported was reduced considerably. This result was explained using a theoretical physics based model of individual local transport region (LTR) evolution during the applied LV pulse. The theoretical model showed that HV pulses alter the structure of the stratum corneum in such a way that when the LV pulses were applied, insufficient thermal energy was generated to initiate LTR expansion. Together, the experimental results and theoretical predictions showed that the total pulse energy alone cannot account for total solute transport: that the order of the types of pulses administered must also be considered.[78]

Pescina et al., (2013) have reported delivery of methylprednisolone hemisuccinate with iontophoresis. Further performed the study with concentrated drug solutions andapplying electric stimuli for short period to mimic the iontophoretic conditions of in- vivo studies. The concentration of drug to be delivered from donor compartment through porcine skin was 45 mg/ml under passive condition and after applying electric stimuli for 2-15 min. In the other part of study the drug delivery was carried at 0.9–7.2 mA intensity for 5min. On withdrawal of drug donating compartment, unleash of drug up to 24hwas seen. In cathodal iontotherapy, there was increase in accumulation of drug between the charge 0.3 and 1.44 Coulomb. When the charge was enhanced to 2.16 Coulomb along with enhanced time or intensity there was no improvement. This conduct can be credited to significant medication adsorption on the scleral tissue, as exhibited through spilling expected investigations, with the ensuing increment of the electroosmotic stream that restricts tranquilize transport. The study suggested that could help in carrying the in vivo studies using animal models and help in decreasing number of in vivo experiments.[79]

Blagus et al., (2013) have developed and evaluated delivery ofradioactive particles through transdermal route. Multi-array electrodes are used for Electroporation (EP) of mouse skin, which can deliver the electric current within electrodes of 70 to 570

V. The developed films were applied on the skin prior and after to the electrportaion which are treated with fluorescein-isothiocyanate dextran (FD), antibiotic drug or painkiller. The delivery of FD from developed systems through the region of treated skin was determined using fluorescence microscopy. It resulted that the transdermal delivery of FD enhanced upon application of electric stimulus, and thus strated to decline with higher amplitudes. Topical delivery steady increased byenhancing amplitude of the delivered electrical pulses, being even

above when tape baring used as a positive control The non-invasive observation of the delivery of DOX, a fluorescent chemotherapeutic drug, qualitatively and quantitatively confirmed the effects of EP at 360 and 570 V pulse amplitudes on topical and transdermal drug delivery. Delivery of FEN at 360 and 570 V pulse amplitudes verified the ascertained effects as obtained with FD and DOX, by the measured physiological responses of the mice as well as FEN plasma concentration.[80]

Djabri et al., (2012) have investigated transdermal iontophoretic delivery of ranitidine hydrochloride in children. Constant, DC, anodic iontotherapy of ranitidine was performed in vitro across dermatomed pig skin. The impact of donor vehicle, current intensity, and drug concentration were first examined using aqueous solutions. It was found that drug delivery was higher at pH 7 (donor: 5 mm Tris) than ph 5.6 (donor: water). In the presence of low levels of competing background electrolyte, ranitidine delivery increased linearly with applied current but was independent of the donor drug con-centration. The second part of the study evaluated 2 Pluronic® F-127 gels as potential vehicles for ranitidine delivery. The formulations were characterised in terms of apparent viscosity, conductivity and passive permeation measurements. Iontophoretic delivery of alkalizer was solely slightly affected once delivered from the gels relative to liquid solutions. Overall the results demonstrated that therapeutic paediatric doses of ranitidine (neonates: 0.09–0.17_mol/kg h; 1 month to 12 years: 0.36–0.71 _mol/kg h) could be easily achieved by gel patch (0.2–1.5 cm^2/kg) having surface area with applying iontophoresis transdermaly.[81]

Gratieri et al., (2013) have investigated the iontophoretic conveyance energy of ketorolac (KT). The early study documented that effect of in vitro experimental conditions on porcine and human skin exploitation by KT iontotherapy. The results indicated that KT electrotransport was linearly dependent from 0.1875 to 0.5 mA/cm^2on current density and from 5 to 20 mg/ml on drug concentration. Iontophoretic KT permeation of a 2% hydroxymethyl cellulose gel was similar to that of an aqueous solution with an analogous drug loading solution. Cumulative permeation and steady state flux were statistically comparable across procain and human skin, confirming the models validity across porcine and human skin. The biodistribution of drug was assessed in skin. Iontophoretic administration for 30 min was superior to passive topical delivery for 1 h and resulted in statistically important will increase in KT levels within the skin. In addition to increasing bioavailability, iontophoretic administration of KT showed clear property for native

delivery to the striated muscle femur at the treatment site. These results demonstrated that the iontophoresis of ketorolac enables local enhanced topical delivery to subjacent muscle; this may have clinical application in the treatment for localized inflammationand pain.[82]