Plant Archives Vol. 20, Supplement 1, 2020 pp. 3794-3805 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

REVIEW ARTICLE
MORINGA GUM: A COMPREHENSIVE REVIEW ON ITS PHYSICOCHEMICAL AND FUNCTIONAL PROPERTIES

Sonika, Sonia Dhiman, Thakur Gurjeet Singh*, Govind Arora and Sandeep Arora
Chitkara College of Pharmacy, Chitkara University, Punjab, India
*Author for correspondence: Thakur Gurjeet Singh
Chitkara College of Pharmacy, Chitkara University, Rajpura, Punjab, India
E-mail: gurjeet.singh@chitkara.edu.in; gurjeetthakur@gmail.com

Abstract

Naturally occurring polymers are presently of major importance among that polysaccharides occupy larger position due to their easy use, eco- friendly and non-toxic nature. Gums are naturally occurring constituents in plants, which are basically cheap and abundant. The development of delivery systems using natural polymers such as, gums offers different advantages, such as, biocompatibility, biodegradability and cost efficiency. The modifiers of drug release in pharmaceutical dosage forms require diverse uses as thickeners, emulsifiers, viscosities and sweeteners etc. It should be compatible, non-toxic, stable, commercial, when it affects the drug release. The gum deed as virtuous mucoadhesive polymer, disintegrating agent and binder. For manufacturing applications the gum illustrate great potential mainly in nutrients, knits and therapeutic trades. To modify the physicochemical properties the need of the gum is amended. Few resins in their putative forms are well functioned as drug release modernizers in dosage forms owed toward their excessive swelling index /solubility at acidic pH. This appraisal is expected to provide the indication about the amendment of gums through derivatization of functional groups, grafting with polymers and cross-linking with ions. Hence, gums need to be modified to change their physicochemical properties.

Keywords: *Moringa gum*; Physicochemical properties; Functional properties; Mucoadhesive polymer; Disintegrating agent.

Introduction

In the development of new preparations the natural occurring and modified gums are mostly used. The additives which are used in the advancement of pharmaceutical dosage forms are gum acacia, tragacanth, agar, starch, etc (Patil *et al.*, 2011). The selection of the origin of natural excipient is based upon the synthetic and semi-synthetic ones. This is mainly due to the lack of toxicity, low price, calming action, accessibility and non-irritant nature of the excipients (Deogade *et al.*, 2012). These polysaccharides are obtained from natural origin which is capable to increase in a solution's viscosity. It has various other advantages and applications like as thickening agents, gelling agents, emulsifiers, stabilizers (Choudhary *et al.*, 2014), etc. Moreover, certain industrial applications which include its use as adhesives, binding agents, crystal inhibitors, encapsulating agents, clarifying agents and as foam stabilizers. The gums procured from herbal resources are now used in many newly developed drug delivery systems which in turn results in better stability and processing. Examples of such delivery systems are like microspheres, Nano spheres, nanoparticles, liposomes, hydrogels, Aquasomes, etc. Also, by altering the chemical entity by use of reagents or by enzymes help in promoting the better characteristics of the delivery system. However, uses of naturally procured gums are much more advantageous than chemically modified/ synthesized gums. Natural gums are easy to obtain and are non-toxic in nature, less expensive than synthetically modified gums. Oral delivery systems are more supporting while formulating delivery systems via use of natural gums. In food industry, these natural gums are usually implemented as food additives and as drug molecule carrier in case of delivery systems. Many types of higher plants under stressed conditions like drought, cell wall lysis, formation of gummosis, leads to release of a gum which in turn is the metabolic output of their pathological changes (Bhosale *et al.*, 2014). Herbal gums are emerged as major multi-disciplinary and extensive research application with a broad variety of bioactive molecules which includes insecticides, pesticides, etc. Newly developed natural gums are used as biodegradable and biocompatible, and if it is not converted into biodegradable then they are incorporated with biodegradable component. The major advantages of gum based drug delivery systems includes as: The enhanced drug utilization has the superior selectivity in targeting of drug with a pharmacological activity. It improves the patient compliance and prevents the overloading of drugs which is due to the decrease in toxicity.

Some recently investigated natural gums are as follows:

1. Abelmoschus Gum:

The okra gum (also known as Abelmoschus gum) which is found from the fresh fruits of the plant *Abelmoschus esculentus* (family Malvaceae). In this polymer the tablets are prepared by using the gum mucilage and HPMC E15 and also used for the expansion of a gastric dosage form. It was seen that the formulation also containing gum mucilage which has a poor floating capacity but it also showed a sustained release action. However, the formulation containing polymer (HPMC) had better floating properties but has a poor sustained release effect of the drug (Chodavarapu *et al.*, 2011). The aim of this study was to determine the extracted gum of *Abelmoschus esculentus* by using ultrasonic method. The okra fruit gum has wide application in medicine and health care (Nagpal *et al.*, 2017) and which is acquired after the lyophilization and it is further determined by Tapped density, Bulk density, Car's index, Angle of repose, Hausner's ratio.

2. Albizia Gum

Albizia gum is found from the incised trunk of the tree *Albizia zygia* (Family- Leguminosae). It comprises of β -1-3-

linked D Galactose units with certain β 1-6-linked D-Galactose units. The promising substitute for the gum Arabic which is used as natural emulsifier in pharmaceutical (Ashton *et al.*, 1975; US National Academy of Sciences., 1979) and manufacturing industry. Moreover, it is used as coating material, binding agent in tablet formulation and also in food industry (Odeku *et al.*, 2005). The current studies of gums are used in the tablet formulation by using binding agent which have quicker onset of action and improved the properties which is associated with gelatin BP. This gum used in the tablet manufacturing which improve the dissolution times and have a high mechanical strength in rate release of drug delivery system (Oluwatoyin *et al.*, 2005).

3. Carob gum

Locust bean gum (LBG) (also known as carob gum) is found from the developed endosperm of seeds from the carob tree *Ceratonia siliqua* (family: Leguminosae). The gum contains D-galactose, D-mannoglycan pentane, proteins and cellulose. In this research, Locust Bean Gum (LBG) is used for the controlled drug delivery system and by using various extraction techniques LBG were removed from seeds. The physicochemical properties were evaluated for gums. The ash content was found to be 1.94% and protein content around 6.65% when determined by water extraction gum. Also the value of acid-insoluble ash was around 3.58% and 44.17 and of foreign substances by HCL extraction gum method. Thus it was concluded that the H_2SO_4 extraction technique was much more considerable and effective than water and HCl extraction method. The quality of gum obtained by H_2SO_4 was good and functional (Küçüköner *et al.*, 2015).

4. Honey Locust Gum

The gum is found from the seeds of the plant *Gleditsia triacanthos* (family: Leguminosae). The constituents of this gum involve the seed which consist of the fibers, vitamins, proteins, carbohydrates and fats. By the wet granulation method the honey locust gum formed by the matrix tablets at different concentrations as (5% and 10%) (Unerand *et al.*, 2004).

5. Tara Gum

The biological source of this Tara gum is *Caesalpinia spinose* which is obtained from the endosperm of seed (family: Leguminosae or Fabaceae).The gum mainly contains galactomannans. The major application of the gum is that it acts as carrier in the formulation of emulsions, gastro retentive system for the controlled release of the tablets which mainly occur due to the swelling of the gum (Zeng *et al.*, 2007).

6. Almond Gum

Almond gum is procured from the tree *Prunus amygdalus* (family: Rosaceae). The main chemical constituents of this gum consist of D-mannose, aldobionic acid, L-arabinose and L-galactose and further contains the dissimilar components which have the pharmaceutical agents such as the coagulating agent, glazing agent, blending agent, stabilizers, gelling agent, thickening agent, suspending agent, epoxy resin, etc. Moreover,

The objective of this following research site is oral drug delivery system in which the almond gum is much more beneficial for the tablet formulation. The current study revealed that the gums are used for the preparation of uncoating dosage form (Sarojini *et al.*, 2010) and particularly the drug used cefopodoxime proxetil which enhances the bioavailability. Different parameters were evaluated for the formulated globules which comprise of particle size, surface topology, buoyancy properties, micrometric properties, percentage drug efficiency, and invitro drug release studies. This study concluded that the invitro drug release (68.12%) enhanced the gum formulation and its bioavailability with specific time of 12 hours (Sarojini *et al.*, 2016).

7. Cashew Gum

Cashew gum is the exudate from the stem bark of *Anacardium occidentale* (family: Anacardiaceous). The chemical constituents of the gum includes glucose, rhamnose, galactose, glycolic acid, arabinose with additional residues such as sugar, which comprises of glucuronic acid, D-galactose, L- arabinose , L-rhamnose etc. The research is intended at generating gum from cashew tree latex, which can act as auxiliary for gum Arabic. The technique used contain drying and size decrease of the exudates gum, sieving of the gum to eliminate impurities, dissolution of the gum in distilled water, filtration to eliminate polysaccharide surplus and finally concentration and stability of the gum. The pH and Viscosity on adding of various percentage concentration of stabilizing agent were determined. The gum can be recycled as an alternative for synthetic adhesive used presently for stamps and packets (Lima *et al.*, 2002).

8. Moi Gum

Moi gum is obtained from the leaves, stems, fruits, and bark of the stem *Lannea coromandelica* (family: Anacardiaceae). The morphological characteristic of gum occurs as fresh in yellowish white color and dark color is obtained when it dries. The gum has various forms which exist as stem, leaves, seeds, flower and fruits (Venkaiah *et al.*, 1984). Moreover, Moi gum is formulated as microsphers by the solvent evaporation method which in further have standard morphology and size and help as carrier in the drug delivery as sustained release.

9. Kondagogu Gum

The natural polysaccharide Kondagogu gum is derived from the exudates of *Cochlospermum religiosum* with family (Bixaceae) and commonly called by name Hupu gum. The main constituents of the Hupu gum comprises of the galactose, fructose, rhamnose, glucronic acid, α and β-D-glucose, arabinose, mannose, glactose uronic acid which impacted the polymer metoprolol succinate tablet dosage form as the rate controlling to assest with a sustained drug realse dosage form. However, such tablets have an enteric coating of shellac which is further used in the manufacturing.

10. Gum Copal

Gum Copal is biologically obtained as natural tacky substance from plant *Bursera bipinnata* Family: Burseraceae. The main constituents of Copal resin includes Agathalic acid, Sandaracopimaric acid, Transcommunic acid, Ciscommunic acid, Mono-Methyl Ester Agatholic acid, Polycommunic acid and Acetoxy Agatholic acid (Cortina *et al.*, 2005). For sustaining drug delivery system the gum is assessed as the matrix forming agent.

11. Hakea Gum

Hakea gum is a dried exudate which is naturally obtained from the plant *Hakea gibbosa*, Family: Proteaceae.

Main constituents of the gum consist in the ratio of 12:43:32:5:8 as Glucuronic acid, Galactose, Arabinose, Mannose and Xylose and it is patially soluble in water of the oozed gum (Okafor *et al.*, 2001). Similarly its appilication is in the formulated buccal tablets as Mucoadhesive and Sustained release of drug delivery.

12. Grewia Gum

Grewia gum is a polysaccharide derivative which is obtained from the inner bark of the ripe plant *Grewia mollis* (family: Tiliaceae). The gum as core monosaccharide comprises of Galactose, Glucose, Rhamnose and Galactouronic acid (Martins *et al.*, 2008). The pharmaceutical application of Mollis gum in tablet preparation is evaluated as diluent, binder as PCM, stabilizing agent and also investigated in enhancement of the fluidity of granules when compared with PVP. Similarly, the binder formulation of the *Grewia mollis* which contains PVP has dignified onset. Grewia gum has been evaluated as a binder in paracetamol which has benefits in tablet preparations (Gowthamarajan *et al.*, 2012).

Some of the modifications of the fums with respect to their doage form are lusted in table1:

Table 1: Some modification of gums with their dosage forms.

S.No	Gums	Modification	Dosage form	Year	References
1.	Cashew gum	Grafting	Buccal tablets	2012	Aminabhavi *et al.*, 2004
2.	Guar gum	Grafting	Matrix tablet	2013	Castro *et al.*,2014
3.	Guar gum	Carboxymethylation	Microspheres	2014	Lazzari *et al.*,2018
4.	Moringa gum	Carboxymethylation	Matrix tablet	2016	Huanbutta *et al.*, 2017
5.	Guar gum	Grafted	Matrix tablet	2016	Ghosh *et al.*, 2015
6.	Xanthum gum	Grafted Carboxymethylation	Matrix tablet	2016	Morkhade *et al.*, 2017
7.	Tamarindus indica and cassia fistula gum	Carboxymethylation	Thai cordial tablet	2016	Rana *et al.*, 2015
8.	Locust bean gum	Crosslinking	Microspheres	2016	Rani *et al.*, 2012
9.	Gellan gum	Crosslinking	Microspheres	2017	Bhattacharya *et al.*, 2008
10.	Mastic gum	Microencapsulation and matrix forming material.	Matrix tablets	2017	Silva *et al.*, 2007

Natural or herbal gums obligate the epoxy resin, aperients and used in diverse pharmaceutical application and dental measures. On the other side gum has firm complications which are associated with the solubility, pH reliant, unrestrained proportions of hydration, drop fall in viscosity, improper storage and the risk of microbial contamination.

For drug delivery, various natural gums were modified to formulate best product and that can be compete with synthetic and semi-synthetic polymers which are easily available in the market. There are different types of modification but the chemically modified gums permit the particular use for drug delivery system (Pandey *et al.*, 2015). Although these gum are soluble in water due to the occurrence of an extreme amount of hydroxyl group (-OH) moieties which forms the hydrogen bonds (H) (Sutirman *et al.*, 2016). Generally, gums are pathological products and have wide applications in food and pharmaceutical industries which considered as enhanced and non-toxic for human consumption.

Grafting

Certain types of copolymers have different geometrical arrangement and crystalline arrangements in their molecular level, like some single polymers consists of a very large arrangement of the molecules in it geometry having multiple branches as well. Such singularly arranged graft polymers can be synthesized to provide free radical spaces or sites providing the ability to be aided as external agents. Also, such free spaces help to give many free radical sites for further chain formation and branching.

However, while formation of free radical sites there may be chances of rupture or tear down of the structural basement. So it is important to monitor the effectiveness of such agent to prevent any teardown or disruption. The reason for grafting is to bring changes or to modify the characteristics of gum like swelling capability, ability to form film and also to enhance or promote the release of the drug from the formulation when put in the fluid or body matrix (Sorour *et al.*, 2013). Also the natural polysaccharides can be modified to retain the polymerizing properties in form of hybrid features applicable for certain kinds of uses and application. This it becomes clear that chemical modification in gum by grafting creates a link bridge between naturally occurring and synthetic polymers having hybrid properties of both natural and synthetic. Hybrid gum possesses polymer chains attached to it which act as a backbone to the polymer. Grafting is achieved by linking of the polymer chains with certain functional groups like ester groups and Methyl alcohol, etc. In return the grafted gum obtained helps in formation of compound having drug release profile as desired. Also grafted polymer due to hybrid nature does not have any influence on the backbone polymers due to side chain linking mainly (Zhang *et al.*, 2000).

For the synthesis of graft copolymerization several techniques are used in general which compromises of the free radical which act on the performed polymer for the utilizations of the chemical free radicals which further consist of the conventional method (Pandey *et al.*, 2011; Zheng *et al.*, 2005; Singh *et al.*, 2009; Barsbay *et al.*, 2009; Geresh *et al.*, 2004; Huang *et al.*, 2003; Helin *et al.*, 2008; Deng *et al.*, 2009; Shanmugharaj *et al.*, 2006; Pandey *et al.*, 2016), radiations of high energy such as electron beam ray and gamma rays (Pandey *et al.*, 2016; Pandey *et al.*, 2012), UV-radiations which in the presence of photo sensitization (Singh *et al.*, 2010; Singh *et al.*, 2007; Singh *et al.*, 2006) and not more the least is microwave methods (Singh *et al.*, 2006; Salaheldeen *et al.*, 2014; Kalia *et al.*, 2013; Singh *et al.*, 2006; Salaheldeen *et al.*, 2014; Al-husnan *et al.*, 2016). The copolymerization grafting method has the specific two techniques which are not as much effective and efficient which consist of UV-radiation and high energy radiation

process Moreover, radiation of high energy happens because of more chances of the vandalism of polysaccharide radiolysis which is not suitable for owing to the synthesis of copolymer due to enhancement of penetrating power. In addition to this the UV-radiation power makes the surface grafting restricted only for the UV-rays of low penetrating power. Most of the effective methods used for the synthesis of graft copolymerization, now these days are the Microwave irradiation and the conventional method and has powerful impact on the initiation of developing a homogenous mixture. Microwave irradiation has many advantages over the grafting copolymerization as follows:

a) Depletion of lethal solvents.

b) Enhancement in the product yield.

c) Lessons the reaction time (Singh *et al.*, 2006).

In comparison of Conventional Method over the Microwave Irradiation technique conveys that the microwave radiation method doesn't required the inert atmospheric condition which further implicated its qualities as highly reproducible, cheap, ease of accessibility, reliable process, easy to operate, highly developed with equiffied advancement, fast, most superior in the grafted copolymer synthesis.

Moringa olifera gum

Moringa olifera is a natural polymer which is characterized to mono-generic family (Moringaceae) and includes 13 sorts which is mainly distributed and originated from India, Africa several other tropical and arid countries (Al_husnan *et al.*, 2016; Arora *et al.*, 2013; Mehta *et al.*, 2011). Generally Moringa gum is a quick emergent tree of small genus which is well-known by Horseradish tree, Ben oil and Drumstick (Panda *et al.*, 2008). It is originated from Western and the Sub Himalayan tracts, Africa, India, Asia, and Pakistan (Patel *et al.*, 2011) and further dispersed in Central America, Cambodia, Caribbean Islands, Philippines, and North and South America (Dekker *et al.*, 2002). In the preparation of glucuronic acid as 10:7:2 this further includes polyuronide which consist of an arabinose with 26.9%, rhamnose 5.6%, galactose 41.5% and xylose with 25.9% (Alam *et al.*, 1971).

Moringa gums are also used as food vegetables and also as an Indian Tradition medicine for treatment of illness and infections. Its scientific name is *Moringa olifera* which is locally known as Zogallagandi (Hausa), OkweOyibo (Igbo) and Yoruba. Its vegetable features are most common in regions of East Nigerian tribes. Moringa gum is exudate product of the stems of *Moringa olifer*. The gum released from stem is initially white in color which on long exposures turns to reddish brown color or brownish black in color. The pharmaceutical and other industrial applications of the gum gauged as Stabilizers, Binders, Mucoadhesive, disintegrates, Sustained and Controlled Release Matrix (Wang *et al.*, 2005) and moreover, globally it has been esteemed as Nutraceutics, Therapeutic and Cost-effective properties. In other countries such as Africa the *Moringa olifer* is commonly called by the name as the "Miracle Tree" or "Never Die Tree" and this has been honored as "Botanical of The Year-2017" through the National Institute of Health (NIH) which cures MT 300 diseases.

Advantages of Natural Gums:

Biodegradable

These polysaccharides signify the accessibility of biodegrable polymers which naturally have no adverse effect on the natural resources such as humans, environmental health factor.

Example: Eye and skin irritation

Biocompatible and non-toxic

The naturally occurring plant materials compromises of vitamins, fatty acids, minerals and carbohydrates which tranquil the repeating sugar units as polysaccharides, lactose, glucose, rhamnose, fructose, monosaccharaides and sucrose and therefore, are innocuous.

Low cost

The synthetic material when compared over the natural polymers the most preference is given to the natural resources due to the easy accessibility, economic in nature and the production cost is much cheaper.

Environmental-friendly processing

Gums from different sources are easily collected in different seasons in large quantities due to the simple production processes involved (Mehta *et al.*, 2011).

Local availability

The wide bids in developing country for a diverse nature of applications in industries, manufacturing, RandD the worldwide management helps in the production of naturally occurring sources as plant materials like tragacanth, guar gum, xanthum gum, cashew gum, etc (Seshadri *et al.*, 2003).

Better patient tolerance

When natural resouces compared with the synthetic materials there is few gamble of adverse events/ effects and side effects seen.

Example: Cross-povidone, PMMA and Povidone, etc.

Pharmaceutical Applications

Food industry

Polysaccharides have a broad application in various types of gums which includes the stabilizing agent such as (Carob gum and Guar gum), immediate Pudding (Carrageenan's), Stabilizers for ice-cream, Food and Beverages, Baked products, Confectionaries, water retention, meat (agar) and dairy stuffs and sauces (Xanthum gum, Alginates, Pectin, Moi gum, Tragacanth, Gum Arabic) (Morton *et al.*, 1991).

Binder

Moringa olifer gum is mined from the bark exudate which is used for the evaluation and manufacturing of tablets and capsules for its binding properties (Mahmood *et al.*, 2010).

Detoxification or water purification

Moringa olifera is mined from the seeds which consist of the water soluble proteins have the ability to remove the harmful ingredients and deeds as effective coagulants for the purification of water. For purifying water the natural polymers have charged molecules of proteins which are able

to settle the organics, mineral particles and allow the seeds for coagulation effect to alum. This is able to flocculate the bacterial cells as gram positive and negative and also used as biosorbant for the abstraction of cadmium (Ramachandran *et al.*, 1980).

Cosmetic use

The main chiefly parts of *Moringa olifer* has two components Purisoft TM and Puricare TM are based on the botanical peptides which helps in purifying the skin, hairs and protection against the pollution and dirt. This mainly used as carrier oil in the preparation and well-known by the name Behn oil (Mahmood *et al.*, 2010).

Nutritional value

The olifera gum in nutrition plays a lead role in the dietary supplements due to its high amount of the nutrition, vitamins (B2, B6 and C), magnesium, calcium, proteins, iron, carotenoids, provitamin A (Mehta *et al.*, 2011; Pandey *et al.*, 2012). The olive oil is the refined seed oil obtained from *Moringa olifera* which has essential fatty acids in it and the lipid composition of these seeds are even greater than that of soyabean which makes it more nutritionally significant (Abdull *et al.*, 2014).

This tree serves as a sustainable and economically nutrient rich food supplement, for those who are suffering from malnutrition.

Table 2: Comparison of nutrient content in Moringa and other food (Jarald *et al.*, 2012)

Content of	Moringa	Other Food
Vitamin A	6,780 mg	Carrot- 1,890 mg
Vitamin C	220 mg	Orange- 30 mg
Calcium	440 mg	Cow milk- 120 mg
Potassium	259 mg	Banana- 88 mg
Protein	6.6 g	Cow milk- 32 g

From ancient times the *Moringa olifer* is used for numerous purposes as these compromises of the nutritional content which includes the Proteins, Calcium, Potassium, Vitamins such as Vitamin A and C which are in the human consumption. Different nutrition plays different role in human life to cure the illness, disorders. This includes calcium which helps in preventing the osteoporosis and makes the teeth strong where potassium is the essential content for the functioning of the brain and nerve cells. Similarly vitamin A deed protection against the diarrhea, skin rashes, orthopedics disease and heart ailment as well vitamin C act as antibiotic which fight against the flu and cold (Jarald *et al.*, 2012).

Pharmaceutical value

Since primeval times the medicinal merits of *M. oleifera* are well recognized over its usage as a traditional remedy for a number of syndromes and ailments (Panda *et al.*, 2013). This tree has been popularly used as a folk medicine for anemia, arthritis and rheumatism, asthma, constipation, diarrhea, stomach pain, ulcers, intestinal spasms, headache and sore gums (Panda *et al.*, 2008; Patel *et al.*, 2012) also possess abortifacient, anti-inflammatory, bactericidal, diuretic activities and also serves as antidote, emetic, purgative, stimulant, tonic, vermifuge (anthelmintic medicine). In drug delivery the gum mined not only treats various chronic disorders, but also being used as a prospective ancillary to binders, stabilizers, foaming and suspending agents (Basawaraj *et al.*, 2010; Si *et al.*, 2004; Shah *et al.*, 2011; Bhende *et al.*, 2012). There are different types of preformulation studies were performed for the suitability of olefiera gum as mucoadhesive properties, disintegrant and binding agent (Cáceres *et al.*, 1992). Several physicochemical parameters were improved which include the dissolution rate, disintegration and stabilities studies were evaluated for the safety and efficacy of the olifer gum comprise of in-vitro assay for both topical and non-topical preparation (Ruckmani *et al.*, 1998; Araújo *et al.*, 2013; Onsare *et al.*, 2015; Rajesh *et al.*, 2012) by this we render that this gum is non-toxic. Moreover, the formulated gum enhances the therapeutic efficiency such as ibuprofen, meloxicam and felodipine (Kumar *et al.*, 2012).

Therapeutic uses

Moringa contains a range of fairly unique phytochemicals containing the simple sugar, rhamnose, and it is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates. A variety of detoxication and antioxidant enzymes and biomarkers as a result of treatment with Moringa or with phytochemicals isolated from this have shown, antiulcer, effect on immune response, spasmolytic activities, hypocholesterolemic effects , antibacterial activity.

Pharmacological applications

In blindness and eye sight

Beneficality of *Moringa olifer* is that by eating the leaf powder, pods and the leaves encloses the high amount of Vitamin A which preclude the darkness, night blindness in children (Morton *et al.*, 1991).

Cardic and circulatory stimulant

Moringine acts on the sympathetic nervous system and a cardiac stimulant (Morton *et al.*, 1991).

Antihypertensive, diuretic and cholesterol lowering activities

The activities of olifera gum comprises of the numerous parts which are beneficial in various ways such as the roots, leaves, flowers, seeds, fruit and leaf juice all these have specific role. The compounds Thiocarbamate glycoside, Mustard oil found the molifer leaves to be liable in blood lowering effect as well leaf juice of the Moringa have a stabilizing effect. All these measures of *Moringa olifer* subpart plays a harmonizing effects in retaining the diuretic activity [76, 91], lowers the phospholipids, serum cholesterol, Very Low Density Lipoproteins (VLDL), Low Density Lipoproteins (LDL), Atherogenic Index Lipid, reduction in lipid profile of heart where all these are the functions of fruits and the seeds of the this plant have the diuretic property.

Antispasmodic, antiulcer and hepatoprotective activities

The hepato-protective and antispasmodic activities have the significant role which is due to the presence of quercitin which is a well-known flavonoid found in the Moringa roots (Mahajan *et al.*, 2007).

Antibacterial and antifungal activities

Antibacterial activity has been potently observed with the help of the morgania roots, substituting as a potent anti-

microbial agent. Petrygospermin is the principle compound helping it to be anti-microbial agent and anti-fungal properties (Gupta *et al.*, 2012).

Antitumor and anticancer activities

Anti-tumor and anti- malignancy cytotoxicity behavioural activity could be observed in the extract derived from the stems and seeds (Anwar *et al.*, 2007; Sreelatha *et al.*, 2011; Atawodi *et al.*, 2010). Accompanying, the activity against the tumors and the malignant cells could also be seen from the extract of Moringa leaves. Moringa seed's extract actively affects hepatic carcinogenesis, metabolism of enzymes and antioxidant parameters.

Antioxidant activity

Different aerial and root system parts of *M. oleifera* mainly attributes to chemical constituents like ascorbic acid (Vit. C), β-carotene (Charoensin *et al.*, 2014; 2012), quercetin, kaempferol (Ogbunugafor *et al.*, 2012), and phenolic acids (Siddhuraju *et al.*, 2003; Vongsak *et al.*, 2013; Satish *et al.*, 2013). Different extract solvent system's like ethanol, methanol and acetone has been investigated for its anti-oxidative properties (Gupta *et al.*, 2012; Kumbhare *et al.*, 2012; Abalaka *et al.*, 2012; Doughari *et al.*, 2007; Kekuda *et al.*, 2010; Bhattacharjee *et al.*, 2006; Moyo *et al.*, 2012; Oluduro *et al.*, 2012). To support the findings different in-vivo and in-vitro assays against the different part of plant have been done by the researchers.

Antimicrobial activity

A wide activity against the different bacteria has been reported previously reported for the different parts of plant including leaves (Rahman *et al.*, 2009; Thilza *et al.*, 2010; Thilza *et al.*, 2010) and pods (Arora *et al.*, 2014). Different bacteria includes some examples like *E. coli, S. typhi, P. aeruginosa, E. cloace, P. vulgaris, S. aureus, M. kristinae, E. aerogenes, Shigella, B. cereus, Streptococcus-B-haemolytica, B. subtilis, K. pneumonia, B. megaterium, S. lutea, B. sterothermophilus, S. pyogenes, V. cholera, S. entridis, enteropathogens* and wound bacteria. In addition, the antiviral activities of seeds against HSV-1 (Ali *et al.*, 2004; Lipipun *et al.*, 2003; Nworu *et al.*, 2013; Sudha *et al.*, 2010; Stohs *et al.*, 2015) and that of leaves against Epstin Barr Virus (EBV), HIV and HSV-1 (Waterman *et al.*, 2014; Coppin *et al.*, 2013; Cheenpracha *et al.*, 2010; Inbathamizh *et al.*, 2012;) have also been tested successfully.

Anti-inflammatory activity

Playing an important role as anti-inflammatory agents including 4-[(α-L-rhamnosyloxy) benzyl] isothiocyanate, 4-[(4′-O-acetyl-α-L-rhamnosyloxy)benzyl]isothiocyanate (Maheshwari *et al.*, 2014; Pandey *et al.*, 2012;), quercetin, kaempferol glucosides, 4-[2-O-acetyl- α-L-rhamnosyloxy) benzyl]isothiocyanate, 4-[(3-O-acetyl-αrhamnosyloxy) benzyl]isothiocyanate, 3,5-dihydroxy-6-methyl-2,3dihydro-4H-pyran-4-1, 9-octadecenamide, aurantiamide acetate and 1,3-dibenzyl urea (Sulaiman *et al.*, 2008; Lee *et al.*, 2013; Muangnoi *et al.*, 2012; Farooq *et al.*,2012) in different parts of M. oleifera have been reported. Further investigation in references to the anti inflammatory activity of leaves of *M. olifera* has been reported. Further (Bose *et al.*, 2007; Dangi *et al.*, 2002; Kumar *et al.*, 2012), it was concluded that's the anti inflammatory activity could be seen at molecular level by inhibiting the inflammation signaling pathways. The role of leaf and root extracts in treatment of inflammation and that of pod extracts in amelioration of inflammation associated disorders have been extensively studied (Nandave *et al.*, 2009).

Cardio-protective activity

As a potent cardio protective dug it actively alters the circulatory system/capillaries and reduce mortality and morbidity as a consequence of coronary heart diseases which is due to the presence of gossypetin, quercetagenin and proanthocyanidins (Rachmawati *et al.*, 2014; Gupta *et al.*, 2012). Main components responsible for the cardio protective action are O-[2′-hydroxy-3′-(2″-heptenyloxy)]-propyl undecanoate, O-ethyl-4-[(α-L (rhamnosyloxy)-benzyl] carbamate, methyl p-hydroxybenzoate [130, 124], and 4-(α -L-rhamnosyloxy benzyl)-O-methyl thiocarbamate (Sudha *et al.*,2010; Hannan *et al.*, 2014) (correspond to the hypotensive nature of the plant as a whole, while N- α-L-rhamnopyranosyl vincosamide from the bark is reported to exhibit cardioprotective effects. The hypotensive and bradycardiac activities of leaves are attributed to niazinin, niazimicin, niaziminin, niazimin, niazirin, niazicin, niazirinin, niazirin 4-[(4′-O-acetyl-α-rhamnosyloxy) benzyl] isothiocyanate (Ganguly *et al.*, 2008; Divi *et al.*, 2012; Jain *et al.*, 2010) and glucomoringine. Due to the presence of alkaloids and Flavonoids it potently effects the blood pressure and AGE (angiotensin converting enzymes).

Immunomodulatory activity

Immunomodulaters activity is observed mainly by the leaves of the plant as it doesn't only exhibit the immunomodulaters activity it does also possess immune stimulatory activities. The activity of the plant is mediated the reduction of cyclophosphamide which is responsible for the immunosuppression as it mediates the cellular and Humoral immunity (Jaiswal *et al.*, 2009).

Neuroprotective Effect

Ashok *et al.*, 2003 revealed that leaves exert a neuroprotective effect by promoting neuronal survival and outgrowth. The extracts of leaves reported to exhibit a protective effect against Alzheimer's disease by altering the brain monoamine levels and electrical activity.

Treatment of Metabolic disorders

Plant leaf extracts are reported to possess hypocholesterolemic, antihyperglycemic, antihyperlipidemic and hepatoprotective activities (Ndong *et al.*, 2007; Pari *et al.*, 2002). It was affirmed the occurrence of antihyperthyroidism and anti-atherosclerotic activities in leaves (Chumark *et al.*, 2008).

For the treatment of diabetes, different studies revealed the presence of hypoglycaemic agent such as plant proteins in leaf extracts. The study has been recently rumored for treatment of polygenic disorder (Paula *et al.*, 2017). This rumored the presence of a unique compound niaziridin which supports the canal absorption of vitamins and nutrients.

Other activities

Natural plants comprises of different parts like leaves, seeds and roots etc. *Moringa oleifera* has been testified to have wound remedial actions. Heady wound therapeutic mediators such as vicenin-2, quercetin, kaempferol and phytosterols are also described as mining of leaves from ethyl acetate. These plants require various supplementary

actions, such as schizonticidal, antiulcerogenic (Hukkeri *et al.*, 2006; Dahiru *et al.*,2006), antiurolithiatic and anti-ulcerative colitis (Patel *et al.*, 2010; Gholap *et al.*, 2012; Karadi *et al.*, 2006).

Future potential

Numerous studies are accompanied for diverse portions of Moringa oliefera. There is outrageous need to isolation and identification of new compound from various parts of plant which having the hindering properties. In future prospective, it is well estimated that natural polymers will be used as additional end product into the new expansion of novel drug delivery system, which is owing to various agents such as, coating agent, gel forming agents, controlled release and sustained release matrix. The Moringa oliefera is most expensive and reliable substitute intended for not individually provided the good nourishment and cure formerly, it prevents several diseases. There are desirable properities of this gum as the mucoadhesion, permeation enhancer which will improve the oral bioavailability of a drug.

Conclusions

The review potentially focuses on the modified gums named as morgina gum. This would potentially tell you the modifications and the application of modified morgina gum. As it also tell you in a comprehensive way all the applications and its physiochemical properties.

Acknowledgements:

The authors are grateful to the Chitkara College of Pharmacy, Chitkara University, Rajpura, Patiala, Punjab, India for providing the necessary facilities to carry out the research work.

Financial Support and Sponsorship:

Nil.

Conflicts of Interest:

There are no conflicts of interest.

References

Abalaka, M. E., Daniyan, S. Y., Oyeleke, S. B., and Adeyemo, S. O. (2012). The antibacterial evaluation of *Moringa oleifera* leaf extracts on selected bacterial pathogens. Journal of Microbiology Research, 2(2), p. 1-4.

Abdull Razis, A. F., Ibrahim, M.D., and Kntayya, S. B. (2014). Health benefits of Moringa oleifera. Asian Pacific Journal of Cancer Prevention, 15(20), p. 8571-8576.

Alam, A. S., and Parrott, E. L. (1971). Effect of aging on some physical properties of hydrochlorothiazide tablets. Journal of pharmaceutical sciences, 60(2), 263-266.

Al-husnan, L. A. and Alkahtani, M. D. (2016). Impact of Moringa aqueous extract on pathogenic bacteria and fungi in vitro. Annals of Agricultural Sciences, 61(2), 247-250.

Ali, G. H., el-taweel, G. E., and Ali, M. A. (2004). The cytotoxicity and antimicrobial efficiency of *Moringa oleifera* seeds extracts. International Journal of Environmental Studies, 61(6), p. 699-708.

Aminabhavi, T.M, Toti, U.S. (2004). Modified guar gum matrix tablet for controlled release of diltiazem hydrochloride. Journal of Controlled Release 95, p. 567 – 577.

Anwar, F., Latif, S., Ashraf, M., and Gilani, A. H. (2007). Moringa oleifera: a food plant with multiple medicinal uses. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 21(1), p. 17-25.

Araújo, L. C. C., Aguiar, J. S., Napoleão, T. H., Mota, F. V. B., Barros, A. L. S., Moura, M. C., ... and Paiva, P. M. G. (2013). Evaluation of cytotoxic and anti-inflammatory activities of extracts and lectins from *Moringa oleifera* seeds. PLoS One, 8(12).

Arora, D. S., and Onsare, J. G. (2014). In vitro antimicrobial evaluation and phytoconstituents of *Moringa oleifera* pod husks. Industrial Crops and Products, 52, p. 125-135.

Arora, D.S., Onsare, J. G., and Kaur, H. (2013). Bioprospecting of Moringa (Moringaceae): microbiological perspective. J Pharmacog Phytochem, 1(6), p. 193-215.

Ashok Kumar, N., and Pari, L. (2003). Antioxidant action of *Moringa oleifera* Lam.(drumstick) against antitubercular drugs induced lipid peroxidation in rats. Journal of Medicinal Food, 6(3), p. 255-259.

Ashton, W. R., Jefferies, M., Morley, R. G., Pass, G., Phillips, G. O., and Power, D. M. (1975). Physical properties and applications of aqueous solutions of Albizia zygia gum. Journal of the Science of Food and Agriculture, 26(5), 697-704.

Atawodi, S. E., Atawodi, J. C., Idakwo, G. A., Pfundstein, B., Haubner, R., Wurtele, G., and Owen, R. W. (2010). Evaluation of the polyphenol content and antioxidant properties of methanol extracts of the leaves, stem, and root barks of *Moringa oleifera* Lam. Journal of Medicinal Food, 13(3), p. 710-716.

Barsbay, M., Guven, O., Davis, T.P., Barner-Kowollik, C. (2009). RAFT-mediated polymerization and grafting of sodium 4-styrenesulfonate from cellulose initiated via gamma-radiation. Polymer 50(4), p 973 – 982.

Basawaraj, S. P., Srinivas, R. S., Kulkarni, U., and Prakassh, G. K. (2010). Evaluation of *Moringa oleifera* gum as a binder in tablet formulation. International Journal of Research in Ayurveda and Pharmacy (IJRAP), 1(2), p. 590-596.

Bhattacharjee, I., Chatterjee, S. K., Chatterjee, S., and Chandra, G. (2006). Antibacterial potentiality of Argemone mexicana solvent extracts against some pathogenic bacteria. Memórias do Instituto Oswaldo Cruz, 101(6), p. 645-648

Bhattacharya, A., Rawlins, J.W., Ray, P. (Eds.). (2008). Polymer grafting and crosslinking. New York: John Wiley and Sons.

Bhende, S., and Jadhav, N. (2012). Moringa coagulant as a stabilizer for amorphous solids: part I. AAPS PharmSciTech, 13(2), p. 400-410.

Bhosale, R. R., Osmani, R. A. M., and Moin, A. (2014). Natural gums and mucilages: a review on multifaceted excipients in pharmaceutical science and research. International Journal of Pharmacognosy and Phytochemical Research, 15(4).

Bose, C. K. (2007). Possible role of *Moringa oleifera* Lam. root in epithelial ovarian cancer. Medscape General Medicine, 9(1), p. 26.

Cáceres, A., Saravia, A., Rizzo, S., Zabala, L., De Leon, E., and Nave, F. (1992). Pharmacologie properties of Moringa oleifera. 2: Screening for antispasmodic, antiinflammatory and diuretic activity. Journal of ethnopharmacology, 36(3), p. 233-237.

Castro, G.R, Bosio, V.E, Basu, S, Abdullha, F, *et al.* (2014). Encapsulation of Congo Red in carboxymethylation guar gum- alginate gel microspheres. Reactive and Functional Polymers 82, p. 103-110.

Charoensin, S. (2014). Antioxidant and anticancer activities of *Moringa oleifera* leaves. J. Med. Plants Res, 8(7), p. 318-325.

Cheenpracha, S., Park, E. J., Yoshida, W. Y., Barit, C., Wall, M., Pezzuto, J. M., and Chang, L. C. (2010). Potential anti-inflammatory phenolic glycosides from the medicinal plant *Moringa oleifera* fruits. Bioorganic and medicinal chemistry, 18(17), p. 6598-6602.

Chodavarapu, N. P., Yendluri, R. B., Haritha, S., Prabhakar, R., and Pranati, C. (2011). Formulation and evaluation of Abelmoschus esculentus mucilage-based metformin hydrochloride floating matrix tablets. International Journal of Pharmacy and Technology, 3(2), p. 2725-2745.

Choudhary, P. D., and Pawar, H. A. (2014). Recently investigated natural gums and mucilages as pharmaceutical excipients: An overview. Journal of pharmaceutics, 2014.

Chumark, P., Khunawat, P., Sanvarinda, Y., Phornchirasilp, S., Morales, N. P., Phivthong-ngam, L., ... and Klai-upsorn, S. P. (2008). The in vitro and ex vivo antioxidant properties, hypolipidaemic and antiatherosclerotic activities of water extract of *Moringa oleifera* Lam. leaves. Journal of ethnopharmacology, 116(3), p. 439-446.

Coppin, J. P., Xu, Y., Chen, H., Pan, M. H., Ho, C. T., Juliani, R., Wu, Q. (2013). Determination of flavonoids by LC/MS and anti-inflammatory activity in Moringa oleifera. Journal of Functional Foods, 5(4), p. 1892-1899.

Dahiru, D., Onubiyi, J. A., and Umaru, H. A. (2006). Phytochemical screening and antiulcerogenic effect of *Moringa oleifera* aqueous leaf extract. African Journal of Traditional, Complementary and Alternative Medicines, 3(3), p. 70-75.

Dangi, S. Y., Jolly, C. I., and Narayanan, S. (2002). Antihypertensive activity of the total alkaloids from the leaves of Moringa oleifera. Pharmaceutical biology, 40(2), p. 144-148.

Dekker M. "Edward MR: Modern Pharmaceutics". (2002). New York, 287-298.

Deng, J., Wang, L., Liu, L., and Yang, W. (2009). Developments and new applications of UV-induced surface graft polymerizations. Progress in polymer science, 34(2), 156-193.

Deogade, U. M., Deshmukh, V. N., and Sakarkar, D. M. (2012). Natural Gums and Mucilage's in NDDS: Applications and Recent approaches. International Journal of PharmTech Research, 4(2), p .799-814.

Divi, S. M., Bellamkonda, R. A. M. E. S. H., and Dasireddy, S.K. (2012). Evaluation of antidiabetic and antihyperlipedemic potential of aqueous extract of *Moringa oleifera* in fructose fed insulin resistant and STZ induced diabetic wistar rats: A comparative study. Asian J Pharm Clin Res, 5(1), p. 67-72.

Doughari, J. H., Pukuma, M. S., and De, N. (2007). Antibacterial effects of Balanites aegyptiaca L. Drel. and *Moringa oleifera* Lam. on Salmonella typhi. African Journal of biotechnology, 6(19).

Farooq, F., Rai, M., Tiwari, A., Khan, A. A., and Farooq, S. (2012). Medicinal properties of Moringa oleifera: An overview of promising healer. Journal of Medicinal Plants Research, 6(27), p. 4368-4374.

Ganguly, R., and Guha, D. (2008). Alteration of brain monoamines and EEG wave pattern in rat model of Alzheimer's disease and protection by Moringa oleifera. Indian Journal of medical research, 128(6).

Geresh, S., Gdalevsky, G.Y., Gilboa, I., Voorspoels, J. (2004). Bioadhesive grafted agar copolymers as platforms for peroral drug delivery: A study of theophylline release". Journal of Controlled Release 94, P. 391–399.

Gholap, P. A., Nirmal, S. A., Pattan, S. R., Pal, S. C., and Mandal, S. C. (2012). Potential of *Moringa oleifera* root and Citrus sinensis fruit rind extracts in the treatment of ulcerative colitis in mice. Pharmaceutical biology, 50(10), p. 1297-1302.

Ghosh, A., Kaity, S. (2015). Compartaive bio-safety and in vivo evaluation of native or modified Locust Bean gum-PVA IPN microspheres". International Journal of Biological Macromolecules 72, p. 883-893.

Gowthamarajan, K., Jawahar, N., Wake, P., Jain, K. (2012). Development of buccal tablets for curcumin using Anacardium occidentale gum. Carbohydrate Polymers 88, p. 1177–1183.

Gupta, R., Mathur, M., Bajaj, V. K., Katariya, P., Yadav, S., Kamal, R., and Gupta, R. S. (2012). Evaluation of antidiabetic and antioxidant activity of *Moringa oleifera* in experimental diabetes. Journal of diabetes, 4(2), p. 164-171.

Hannan, M. A., Kang, J. Y., Mohibbullah, M., Hong, Y. K., Lee, H., Choi, J. S., ... and Moon, I. S. (2014). *Moringa oleifera* with promising neuronal survival and neurite outgrowth promoting potentials. Journal of ethnopharmacology, 152(1), p. 142-150.

Helin, H.U.A., Na, L.I., Linlin, W.U., ZHONG, H., Guangxia, W.U., Zonghuan, Y.U.A.N., Xiangwei, L.I.N. and Lianyi, T.A.N.G. (2008). Anti-fouling ultrafiltration membrane prepared from polysulfone-graft-methyl acrylate copolymers by UV-induced grafting method. Journal of Environmental Sciences, 20(5), pp.565-570.

Huanbutta, K., Sittikijyothin, W. (2017). Development and characterization of seed gums from Tamarindus indica and Cassia fistula as disintegrating agent for fast disintegrating Thai cordial tablet". Asian journal of pharmaceutical sciences 12(4), p. 370-7.

Huang, R.Y.M, Immergut, B., Immergut, E.H., Rapson, W.H. (2003) Grafting vinyl polymers onto cellulose by high energy radiation. I. High energy radiation□induced graft copolymerization of styrene onto cellulose. Journal of Polymer Science part A: General Papers 1(4). P. 1257-1270.

Hukkeri, V. I., Nagathan, C. V., Karadi, R. V., and Patil, B. S. (2006). Antipyretic and wound healing activities of *Moringa oleifera* Lam. in rats. Indian journal of pharmaceutical sciences, 68(1), p. 124.

Inbathamizh, L., and Padmini, E. (2012). Gas chromatography-mass spectrometric analyses of

methanol extract of *Moringa oleifera* flowers. International Journal of Chemical and Analytical Science, 2(5).

Jain, P. G., Patil, S. D., Haswani, N. G., Girase, M. V., and Surana, S. J. (2010). Hypolipidemic activity of *Moringa oleifera* Lam., Moringaceae, on high fat diet induced hyperlipidemia in albino rats. Revista Brasileira de Farmacognosia, 20(6), p. 969-973.

Jaiswal, D., Rai, P. K., Kumar, A., Mehta, S., and Watal, G. (2009). Effect of *Moringa oleifera* Lam. leaves aqueous extract therapy on hyperglycemic rats. Journal of ethnopharmacology, 123(3), p. 392-396.

Janaki B, Sashidhar R.B. Subchronic. (2000) Toxicity study in rats fed gum kondagogu (*Cochlospermum Gossypium*). Food and Chemical Toxicology 38(6), p. 523–534.

Jarald, E. E., Sumati, S., Edwin, S., Ahmad, S., Patni, S., and Daud, A. (2012). Characterization of *Moringa oleifera* Lam. gum to establish it as a pharmaceutical excipient. Indian Journal of Pharmaceutical Education and Research, 46(3), p. 211-216.

Kalia, S., and Sabaa, M. W. (Eds.). (2013). Polysaccharide based graft copolymers (Vol. 22). Berlin: Springer.

Karadi, R. V., Gadge, N. B., Alagawadi, K. R., and Savadi, R. V. (2006). Effect of *Moringa oleifera* Lam. root-wood on ethylene glycol induced urolithiasis in rats. Journal of ethnopharmacology, 105(1-2), p. 306-311

Kekuda, T. P., Mallikarjun, N., Swathi, D., Nayana, K. V., Aiyar, M. B., and Rohini, T. R. (2010). Antibacterial and Antifungal efficacy of steam distillate of *Moringa oleifera* Lam. Journal of Pharmaceutical Sciences and Research, 2(1), p. 34.

Küçüköner E, Kıvrak N.E, Aşkın B. (2015) Comparison of Some Physicochemical Properties of Locust Bean Seeds Gum Extracted by Acid and Water Pre-Treatments. Food and Nutrition Sciences 6, p. 278-286.

Kumar, V., Pandey, N., Mohan, N., and Singh, R. P. (2012). Antibacterial and antioxidant activity of different extract of *Moringa oleifera* Leaves–an in vitro study. International Journal of Pharmaceutical Sciences Review and Research, 12(1), p. 89-94.

Kumbhare, M. R., Guleha, V., and Sivakumar, T. (2012). Estimation of total phenolic content, cytotoxicity and in–vitro antioxidant activity of stem bark of Moringa oleifera. Asian Pacific Journal of Tropical Disease, 2(2), p. 144-150.

Lazzari, A., Kleinebudde, P., Knop, K. (2018). Xanthan gum as a rate-controlling polymer for the development of alcohol resistant matrix tablets and mini-tablets. International Journal of Pharmaceutics 536(1), p. 440-9.

Lee, H. J., Jeong, Y. J., Lee, T. S., Park, Y. Y., Chae, W. G., Chung, I. K., and Moon, S. K. (2013). Moringa fruit inhibits LPS-induced NO/iNOS expression through suppressing the NF-κ B activation in RAW264. 7 cells. The American journal of Chinese medicine, 41(05), p. 1109-1123.

Lima, R.D.N, Lima, J.R, Salis, C.R, Moreira, R.A. (2002) Cashew-tree (Anacardium occidentale L.) Exudate gum: a novel bioligand tool". Biotechnology and Applied Biochemistry 35(1), p 45–53.

Lipipun, V., Kurokawa, M., Suttisri, R., Taweechotipatr, P., Pramyothin, P., Hattori, M., and Shiraki, K. (2003). Efficacy of Thai medicinal plant extracts against herpes simplex virus type 1 infection in vitro and in vivo. Antiviral research, 60(3), p. 175-180.

Mahajan, S. G., and Mehta, A. A. (2007). Inhibitory action of ethanolic extract of seeds of *Moringa oleifera* Lam. on systemic and local anaphylaxis. Journal of immunotoxicology, 4(4), p. 287-294.

Maheshwari, R. K., Yadav, R. K., Malhotra, J., Dhawan, N. G., and Mohan, L. (2014). Fascinating nutritional, prophylactic, therapeutic and socio-economic reconcile attributable to drum stick tree (*Moringa oleifera* Lam.). Global Journal of Medical Research.

Mahmood, K. T., Mugal, T., and Haq, I. U. (2010). Moringa oleifera: a natural gift-A review. Journal of Pharmaceutical Sciences and Research, 2(11), p. 775.

Martins, E., Christiana, I., Olobayo, K. (2008). Effect of Grewia gum on the mechanical properties of Paracetamol tablet formulations". African Journal of Pharmacy and Pharmacology 2, p. 1–6.

Mehta, J., Shukla, A., Bukhariya, V., and Charde, R. (2011). The magic remedy of *Moringa oleifera:* an overview. Int J Biomed Adv Res, 2(6), 215-227.

Morkhade D.M. (2017). Evaluation of gum mastic (Pistacia lentiscus) as a microencapsulating and matrix forming material for sustained drug release. Asian Journal of Pharmaceutical Sciences 12(5), p. 424-32.

Morton, J. F. (1991). The horseradish tree, Moringa pterygosperma (Moringaceae)—a boon to arid lands? Economic botany, 45(3), p. 318-333.

Moyo, B., Masika, P. J., and Muchenje, V. (2012). Antimicrobial activities of *Moringa oleifera* Lam leaf extracts. African Journal of Biotechnology, 11(11), 2797-2802.

Moyo, B., Oyedemi, S., Masika, P. J., and Muchenje, V. (2012). Polyphenolic content and antioxidant properties of *Moringa oleifera* leaf extracts and enzymatic activity of liver from goats supplemented with *Moringa oleifera* leaves/sunflower seed cake. Meat science, 91(4), p. 441-447.

Muangnoi, C., Chingsuwanrote, P., Praengamthanachoti, P., Svasti, S., and Tuntipopipat, S. (2012). *Moringa oleifera* pod inhibits inflammatory mediator production by lipopolysaccharide-stimulated RAW 264.7 murine macrophage cell lines. Inflammation, 35(2), p. 445-455.

Nagpal, M., Aggarwal, G., Jain, U. k., and Madan, J. (2017). Extraction of gum from Abelmoschus esculentus: Physicochemical peculiarity and antioxidant prepatent. Asian J Pharm Clin Res. aNandave, M., Ojha, S. K., Joshi, S., Kumari, S., and Arya, D. S. (2009). *Moringa oleifera* leaf extract prevents isoproterenol-induced myocardial damage in rats: evidence for an antioxidant, antiperoxidative, and cardioprotective intervention. Journal of medicinal food, 12(1), p. 47-55.

Ndong, M., Uehara, M., Katsumata, S., Sato, S., and Suzuki, K. (2007). Preventive effects of *Moringa oleifera* (Lam) on hyperlipidemia and hepatocyte ultrastructural changes in iron deficient rats. Bioscience, biotechnology, and biochemistry, 0707060468-0707060468.

Nworu, C. S., Okoye, E. L., Ezeifeka, G. O., and Esimone, C. O. (2013). Extracts of *Moringa oleifera* Lam. showing inhibitory activity against early steps in the infectivity of HIV-1 lentiviral particles in a viral vector-based screening. African Journal of Biotechnology, 12(30).

Odeku, O. A., and Fell, J. T. (2005). *In vitro* evaluation of khaya and albizia gums as compression coatings for drug targeting to the colon. Journal of Pharmacy and Pharmacology, 57(2), p. 163-168.

Ogbunugafor, H., Igwo-Ezikpe, M., Igwilo, I., Ozumba, N., Adenekan, S., Ugochukwu, C., and Ekechi, A. (2012). In vitro and in vivo evaluation of antioxidant properties of *Moringa oleifera* ethanolic leaves extract and effect on serum lipid indices in rat. Macedonian Journal of Medical Sciences, 5(4), p. 397-403.

Okafor, I.S, Chukwu, A, Duala, K. (2001). Some physicochemical properties of grewia gum. Nigeria Journal of Polymer Science and Technology 2(1), p. 161–167.

Oluduro, A. O. (2012). Evaluation of antimicrobial properties and nutritional potentials of *Moringa oleifera* Lam. leaf in South-Western Nigeria. Malaysian Journal of Microbiology, 8(2), p. 59-67.

Oluwatoyin A.O. (2005). Assessment of Albizia zygia gum as a binding agent in tablet formulations". Acta Pharmaceutica 55, p. 263–276.

Onsare, J. G., and Arora, D. S. (2015). Antibiofilm potential of flavonoids extracted from *Moringa oleifera* seed coat against Staphylococcus aureus, Pseudomonas aeruginosa and Candida albicans. Journal of applied microbiology, 118(2), p. 313-325.

Osete-Cortina, L., and Doménech-Carbó, M. T. (2005). Analytical characterization of diterpenoid resins present in pictorial varnishes using pyrolysis–gas chromatography–mass spectrometry with on line trimethylsilylation. Journal of Chromatography A, 1065(2), 265-278.

Panda, D. S., and Ansari, S. A. (2013). Preformulation study on the gum of Moringa Oleifera. Malaysian Journal of Pharmaceutical sciences, 11(2),p. 41.

Panda, D. S., Choudhury, N. S. K., Yedukondalu, M., Si, S., and Gupta, R. (2008). Evaluation of gum of *Moringa oleifera* as a binder and release retardant in tablet formulation. Indian journal of pharmaceutical sciences, 70(5), p. 614.

Pandey, A., Pandey, R. D., Tripathi, P., Gupta, P. P., Haider, J., Bhatt, S., and Singh, A. V. (2012). *Moringa oleifera* Lam.(Sahijan)–A plant with a plethora of diverse therapeutic benefits: an updated retrospection. Medicinal and Aromatic Plants 1, p. 101.

Pandey, S. (2016). Turning to nanotechnology for water pollution control: applications of nanocomposites. Focus On Medical Sciences Journal, 2(3).

Pandey, S., and Mishra, S. B. (2012). Microwave synthesized xanthan gum-g-poly (ethylacrylate): an efficient Pb2+ ion binder. Carbohydrate polymers, 90(1), p. 370-379.

Pandey, S., Mishra, S.B. (2011). Graft copolymerization of Ethyl acrylate onto Xanthan Gum Using Potassium Peroxydisulphate as an Initiator". International Journal of Biological macromolecules 49, p. 527–535.

Pandey, S., Ramontja, J. (2016). Natural bentonite clay and its composites for dye removal: current state and future potential. American Journal of Chemistry and Applications, 3(2), p. 8-19.

Pandey, S., Tiwari, S. (2015) Facile approach to synthesize chitosan based composite—Characterization and cadmium (II) ion adsorption studies". Carbohydate Polymers 134, p. 646–656.

Pari, L., and Kumar, N. A. (2002). Hepatoprotective activity of *Moringa oleifera* on antitubercular drug-induced liver damage in rats. Journal of Medicinal Food, 5(3), p. 171-177.

Patel, B. V., and Patel, D. (2011). Study of disintegrant property of *Moringa oleifera* gum and its comparison with other superdisintegrants. International Journal of ChemTech Research, 3(3), 1119-1124.

Patel, J. P., Gami, B., and Patel, K. (2010). Evaluation of in vitro schizonticidal properties of acetone extract of some Indian medicinal plants. Advances in Biological Research, 4(5), p. 253-258.

Patel, M. T., Patel, J. K., and Upadhyay, U. M. (2012). Assessment of various pharmaceutical excipient properties of natural *Moringa oleifera* gum [Mucoadhesion, disintegration, binder]. International journal of pharmacy and Life sciences, 3(7).

Patil, D.N. (2011) Application of Chemical Modified Herbal Gums in Delivery of Drug. KLE University College of Pharmacy, Belgaum-590010.

Paula, P. C., Oliveira, J. T. A., Sousa, D. O. B., Alves, B. G. T., Carvalho, A. F. U., Franco, O. L., and Vasconcelos, I. M. (2017). Insulin-like plant proteins as potential innovative drugs to treat diabetes—The *Moringa oleifera* case study. New biotechnology, 39, p. 99-109.

Peter, F.K, Alistair, M.S, Shirley, C.C. (1993) Molecular structures of gum exudates from Hakea specie. Phytochemistry 34 (3), p. 709–713.

Rachmawati, I., and Rifa'i, M. (2014). In vitro immunomodulatory activity of aqueous extract of *Moringa oleifera* Lam. leaf to the CD4+, CD8+ and B220+ cells in Mus musculus. The Journal of Experimental Life Science, 4(1), p. 15-20.

Rahman, M. M., Sheikh, M. M. I., Sharmin, S. A., Islam, M. S., Rahman, M. A., Rahman, M. M., and Alam, M. F. (2009). Antibacterial activity of leaf juice and extracts of *Moringa oleifera* Lam. against some human pathogenic bacteria. CMU J Nat Sci, 8(2), p. 219.

Rajesh, A. S., Kiran, N. S. S., Tripathi, P. C., and Verma, K. (2012). In vitro cytotoxicity of *Moringa oleifera* against different human cancer cell lines. Asian Journal of Pharmaceutical and Clinical Research, 5(4), p. 271-272.

Ramachandran, C., Peter, K. V., and Gopalakrishnan, P. K. (1980). Drumstick (Moringa oleifera): a multipurpose Indian vegetable. Economic botany, p. 276-283.

Rana, V., Kamboj, S., Sharma, R., Singh, K. (2015). Modification of Gums: Synthesis Techniques and Pharmaceutical Benefits". Handbook of Polymers for Pharmaceutical Technologies 3, p. 299–364.

Rani, P., Sen, G., Mishra, S., Jha, U. (2012) Microwave assisted synthesis of polyacrylamide grafted gum ghatti and its application as flocculan. Carbohydrate Polymers Volume 89(1), p. 275-281.

Ruckmani, K., Kavimani, S., An, R., and Jaykar, B. (1998). Effect of *Moringa oleifera* Lam on paracetamol-induced hepatotoxicity. Indian Journal of Pharmaceutical Sciences, 60(1), p. 33.

Salaheldeen, M., Aroua, M. K., Mariod, A. A., Cheng, S. F., and Abdelrahman, M. A. (2014). An evaluation of Moringa peregrina seeds as a source for bio-fuel. Industrial Crops and Products, 61, p. 49-61.

Salaheldeen, M., Aroua, M. K., Mariod, A. A., Cheng, S. F., and Abdelrahman, M. A. (2014). An evaluation of

Moringa peregrina seeds as a source for bio-fuel. Industrial Crops and Products, 61, p. 49-61.

Sarojini., S, Kunam., S.D, Manavalan., R, Jayanthi., B. (2010) Effect of natural gum as a binder in the formulation of diclofenac sodium tablet. International Journal of Pharmaceutical Sciences and Research 1 (3), p. 55–60.

Sarojini., S, Rubashree, Jayanthi., B. (2016) Formulation and characterization of Almond gum loaded Cefopodoxime Proxetil floating microbead. European Journal of Pharmaceutical and Medical Research 3(5), p. 366-374.

Sashidhara, K. V., Rosaiah, J. N., Tyagi, E., Shukla, R., Raghubir, R., and Rajendran, S. M. (2009). Rare dipeptide and urea derivatives from roots of *Moringa oleifera* as potential anti-inflammatory and antinociceptive agents. European journal of medicinal chemistry, 44(1), p. 432-436.

Satish, A., Kumar, R. P., Rakshith, D., Satish, S., and Ahmed, F. (2013). Antimutagenic and antioxidant activity of Ficus benghalensis stem bark and *Moringa oleifera* root extract. International Journal of Chemical and Analytical Science, 4(2), p. 45-48.

Seshadri, S., and Nambiar, V. S. (2003). Kanjero (Digera arvensis) and drumstick leaves (Moringa oleifera): nutrient profile and potential for human consumption. World review of nutrition and dietetics, 91, p. 41-59.

Shah, D. P., Jain, V. C., Dalvadi, H. P., Ramani, V. D., Patel, K. G., Saralai, M. G., and Jani, G. K. (2011). A Preliminary Investigation of *Moringa oleifera* Lam Gum As a Pharmaceutical Excipient. International Journal, 1(1), p. 12-16.

Shanmugharaj, A. M., Kim, J. K., and Ryu, S. H. (2006). Modification of rubber surface by UV surface grafting. Applied Surface Science, 252(16), p. 5714-5722.

Si, S., Swain, S., Kanungo, S. K., and Gupta, R. (2006). Preparation and evaluation of gels from gum of Moringa oleifera. Indian journal of pharmaceutical sciences, 68(6), p. 777.

Siddhuraju, P., and Becker, K. (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. Journal of agricultural and food chemistry, 51(8), p. 2144-2155.

Silva, D.A., Paula, R.C.M, Feitosa, J.P.A. (2007). Graft copolymerisation of acrylamide onto cashew gum. European Polymer Journal 43(6), p. 2620-2629.

Singh, V., Kumari, P. L., Tiwari, A., and Pandey, S. (2010). Alumina-supported microwave synthesis of Cassia marginata seed gum-graf-polyacrylamide. Journal of applied plymer science, 117(6), p. 3630-3638.

Singh, V., Pandey, S., Singh, S.K., Sanghi, R. (2009). Removal of cadmium from aqueous solutions by adsorption using poly (acrylamide) modified guar gum-silica nanocomposite. Separation and Purification Technology 67(3). p251-261.

Singh, V., Tiwari, A., Pandey, S., and Singh, S. K. (2006). Microwave accelerated Synthesis and Characterization of Potato Starch-g-poly (acrylamide). Starch-Stärke, 58(10), p. 536-543.

Singh, V., Tiwari, A., Pandey, S., and Singh, S. K. (2007). Peroxydisulfate initiated synthesis of potato starch-graft-poly (acrylonitrile) under microwave irradiation. Express Polymer Letters, 1(1), p. 51-58.

Sorour, M., El-Sayed, M., El Moneem, N.A, Talaat, H., *et al.* (2013) Free radical grafting kinetics of acrylamide onto a blend of starch/chitosan/alginate. Carbohydrate Polymers 98, p. 460-464.

Sreelatha, S., Jeyachitra, A., and Padma, P. R. (2011). Antiproliferation and induction of apoptosis by *Moringa oleifera* leaf extract on human cancer cells. Food and Chemical Toxicology, 49(6), p. 1270-1275.

Stohs, S. J., and Hartman, M. J. (2015). Review of the safety and efficacy of Moringa oleifera. Phytotherapy Research, 29(6), p. 796-804.

Sudha, P., Asdaq, S. M., Dhamingi, S. S., and Chandrakala, G. K. (2010). Immunomodulatory activity of methanolic leaf extract of *Moringa oleifera* in animals. Indian J Physiol Pharmacol, 54(2), p. 133-140.

Sulaiman, M. R., Zakaria, Z. A., Bujarimin, A. S., Somchit, M. N., Israf, D. A., and Moin, S. (2008). Evaluation of *Moringa oleifera* aqueous extract for antinociceptive and anti-inflammatory activities in animal models. Pharmaceutical biology, 46(12), p. 845.

Surjana N, Valluru R, Kumar P.T.M, Vinay S, *et al.* (2011) Polysacchride gum (Kondagogu gum) Matrix Tablets for Oral Sustained Delivery of Metoprolol succinate". International Journal of Research in Ayurveda and Pharmacy 2(4), p. 1218-1224.

Sutirman, Z.A, Sanagi, M.M, Karim K.J.A, Ibrahim W.A.W. (2016) Preparation of methacrylamide-functionalized crosslinked chitosan by free radical polymerization for the removal of lead ions . Carbohydrate Polymers 151, p. 1091-1099.

Sutirman, Z.A, Sanagi, M.M, Karim K.J.A, Ibrahim W.A.W. (2016). Preparation of methacrylamide-functionalized crosslinked chitosan by free radical polymerization for the removal of lead ions . Carbohydrate Polymers 151, p. 1091-1099.

Thilza, I. B., Sanni, S., Isah, Z., Sanni, F., Talle, M., and Joseph, M. (2010). In vitro antimicrobial activity of water extract of *Moringa oleifera* leaf stalk on bacteria normally implicated in eye diseases. Academia arena, 2(6), p. 80-82.

Unerand, .M, Altinkurt T. (2004) Evaluation of honey locust (Gleditsia triacanthos Linn.) Gum as sustaining material in tablet dosage forms. IlFarmaco 59(7), p. 567–573.

Uphadek, B., Shinkar, D. M., Patil, P. B., and Saudagar, R. B. (2018). *Moringa oleifera* as a pharmaceutical excipient. Int. J. Curr. Pharm. Res, 10, p. 13-16.

US National Academy of Sciences, (1979) Tropical Legumes, National Academy of Sciences. Washington, DC, USA.

Valarmathy, K., Gokulakrishnan, M., Kausar, M. S., and Paul, K. (2010). A study of antimicrobial activity of ethanolic extracts of various plant leaves against selected microbial species. International Journal of Pharma Sciences and Research, 1(8), p. 293-295.

Venkaiah, K, Shah, J. J. (1984). Distribution, development and structure of gum ducts in Lannea coromandelica (Houtt.) merri . Annals of Botany 54(2), p. 175–186

Venkatarajua M.P, Gowdaa D.V, Rajeshb K.S, Shivakumara H.G. (2007) Xanthan and locust bean gum (from Ceratonia siliqua) matrix tablets for oral controlled delivery of propranolol hydrochloride. Asian Journal of Pharmaceutical Sciences 2 (6), p. 239–248.

Vongsak, B., Sithisarn, P., Mangmool, S., Thongpraditchote, S., Wongkrajang, Y., and Gritsanapan, W. (2013).

Maximizing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. Industrial crops and products, 44, p. 566-571.

Wang, Q., and Cui, S. W. (2005). Understanding the physical properties of food polysaccharides. Food carbohydrates: chemistry, physical properties, and applications, 162-214.

Waterman, C., Cheng, D. M., Rojas-Silva, P., Poulev, A., Dreifus, J., Lila, M. A., and Raskin, I. (2014). Stable, water extractable isothiocyanates from *Moringa oleifera* leaves attenuate inflammation in vitro. Phytochemistry, 103, p. 114-122.

Zeng, .H, Moroni A, Baichwal A, Goliber P, *et al.* (2007) Inventors: Penwest Pharmaceuticals Co, assignee. Controlled-release emulsion composition. United States patent application US 11, p. 594,329.

Zhang, L.M, Tan, Y.B, Huang, S.J, Chen, D.Q. (2000) Water soluble ampholytic grafted polysaccharides. Grafting of the zwitter ionic monomer 2-(2-methacryloethyldimethylammonio) ethanoate onto hydroxyethyl cellulose. Journal of Polymer Science and Polymer Chemistry 37, p. 1247–1260.

Zheng, S.Y, Cen, Z.C, Lu, D.S, Wu, Q. (2005). Graft copolymerization of watersoluble monomers containing quaternary ammonium group on poly (vinyl alcohol) using ceric ions". Journal Applied Polymers Science 97, p 2186–91.