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ARTIGO DE REVISÃO

POTENCIAL DE USO DA GOMA DA MANGA (*MANGIFERA INDICA*) EM SISTEMAS FARMACOLÓGICOS

POTENTIAL USE OF MANGO GUM (*MANGIFERA INDICA*) IN PHARMACOLOGICAL SYSTEMS

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RESUMO

A possibilidade do uso de polímeros naturais ou modificados para formulação de nanocápsulas contendo fármacos é uma opção farmacêutica para casos em que é necessário o aumento de meia vida de medicações no organismo e diminuição dos efeitos colaterais, podendo serem usados também para melhor direcionamento farmacológico ao sítio alvo, relacionados a baixo custo de produção com estas características e disponibilidade renovável. Gomas e mucilagens têm sido estudadas para uso em sistemas anternativos naturais de administração de medicamentos. A goma proveniente do tronco da *Mangifera indica* tem poucos estudos direcionados a este propósito, apesar de ter apresentado resultados promissores em trabalhos anteriores. Caracterização das vias de formação da goma são explanadas, assim como sua extração e purificação. Foi confirmada a semelhança das propriedades da goma Acácia amplamente utilizada em blendas de comprimidos. A goma de M. indica também foi utilizada para liberação acelerada de fármacos. A versatilidade desta goma associa-se com a presença de mucilagem. Modificações químicas da goma M. indica e misturas entre outras gomas podem ser realizadas para adaptar suas propriedades às diversas formas de liberação controlada de fármacos. Vários compostos isolados com propriedades farmacêuticas são demonstrados. Características físico químicas de vários artigos sobre esta goma foram compilados. As técnicas já utilizadas para a formação de nanocápsulas através da goma de M. indica estão apresentadas. São relatadas várias pesquisas utilizando especificamente a goma de M. indica provinda do tronco da mangueira utilizada como liberação de fármacos . Estes estudos justificam um resumo das propriedades farmacêuticas para entrega de fármacos já realizados com esta goma. Estudos complementares para aproveitamento e valorização do cultivo da mangueira são sugeridos.

Palavras-chave: *Mangifera indica*, goma, polissacarídeos, nanocarreador, liberação controlada

ABSTRACT

The possibility of using natural or modified polymers to formulate drug-containing nanocapsules is a pharmaceutical option for cases in which an increase in the half-life of medications in the body and a decrease in side effects is required, and may also be used for better pharmacological targeting of the site. Related to low production costs with these characteristics and renewable availability. Gums and mucilages have been studied for use in natural alternative drug delivery systems. The gum from the trunk of *Mangifera indica* has few studies aimed at this purpose, although it has shown promising results in previous studies. Characterization of the gum formation pathways are explained, as well as their extraction and purification. The similarity of properties of Acacia gum widely used in tablet blends has been confirmed. *Mangifera indica* gum was also used for accelerated drug release. The versatility of this gum is associated with the presence of mucilage. Chemical modifications of the *Mangifera indica* gum and mixtures among other gums may be made to adapt their properties to the various forms of controlled drug release. Several isolated compounds with pharmaceutical properties are demonstrated. Physical chemical characteristics of several articles on this gum have been compiled. The techniques already used for the formation of nanocapsules through *Mangifera indica* gum are presented. Several studies have been reported specifically using *Mangifera indica* gum from the Mango trunk used as drug release. These studies justify a summary of the pharmaceutical properties for drug delivery

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already performed with this gum. Complementary studies for utilization and valorization of Mango cultivation are suggested.

Key-words: *Mangifera indica, gum, polysaccharide, nanocarrier, controlled release*

1. INTRODUCTION

Plant gum and mucilage have been studied as an alternative to obtain natural polymers to reduce side effects and improve drug distribution to the target site, in addition to the therapeutic properties of polysaccharides present in species that can be absorbed by the body (KULKARNI *et al*., 2011). When a polymer is great studied, and a lot of data is produced, it becomes easier for it to be approved by regulatory authorities (NGWULUKA; OCHEKPE; ARUOMA, 2014). Polymers can be found in microorganism, algal, and plant metabolism products in the form of parts of cotyledons, mucilage or gum (ROCHA, G. M.; CÉSAR, P.; SOUZA, A., 2017; RAJESWARI; GOKA, 2017; RODRIGUES; PAULA; COSTA, 1993; SHARMA *et al*., 2016).

Vegetable gums are composed of heteropolysaccharides, generally (PINHEIRO A.C. *et al*., 2010). A still little explored gum comes from the stem of *M. indica*, a plant typical of tropical countries whose fruit is Mango (BIRDWOOD, 1862). Gums dissolve in water through the formation of hydrogen bridges. In solution, polymer molecules can be organized into an orderly structure called the micelle, which is stabilized by hydrogen bonds. The micelle immobilizes the water, and as the intermolecular association extends, the viscosity is increased, or there is conversion to a gel that has liquid-solid-like characteristics or viscoelasticity (HAMDANI; WANI; BHAT, 2019; TORCHILIN, 2006). Most gums reduce the surface tension of water (FACCIO, 2015).

Mucilage is usually produced in seed-coat cells, in leaves, in the bark, in the middle lamella, and some roots. They are part of a physiological process of the plant (KHAN; PARVEZ; SHARMA, 2015; U. RAGHU *et al*., 2019). Mucilage is a hydrocolloid that does not dissolve in water because it is partially hydrophilic, little branches (SARKAR *et al*., 2018). As a result, in contact with water forms gels and viscous substances. They are formed by more linear polymers and gums by branched polymers (HIRST; JONES, 1958; KHAN; PARVEZ; SHARMA, 2015). Both gum and mucilage are involved in the composition of hemicelluloses. These consist of sugars such as glucoses, mannose, and xylose, while those produced by gum and mucilage are galactose and arabinose (PRAJAPATI *et al*., 2013).

Mucilage is formed by neutral sugars of L-arabinose, D-galactose, L-rhamnose, and D-xylose and may even contain galacturonic acid. Pectin is an acidic polysaccharide and the main component of mucilage (PILETTI, 2011).

The gums are the result of the pathological reaction of the plant in response to microorganism attacks, water stress, or pre-healing of cuts (ASPINALL, 1970; JOEL; FAHN, 1980). *M. indica* produces both as resinous gum and mucilage. Up to now, the studies carried out have characteristics compatible as much drug delivery formulations as high solubility and delayed distribution time (CHOUDHARY; PAWAR, 2014).

Studies have reported that mango gum has antiviral (SILVA; DUARTE; VIEIRA FILHO, 2014), anthelmintic (MARIMUTHU, 2001; MUTHUKUMARAN, 2017), and antibacterial properties (BAYONA, 2016; SHARMA *et al*., 2016). This property is due to the presence of alkyl groups of the aromatic compound. The more halogenated, the greater the antimicrobial power and position substituents enhance the effect (GONZAGA, 2008). It has also been suggested that lipophilia affects this property (SILVA *et al*., 2010). They can be used in binders with Arabica-like gum effectiveness (MOGOŞANU; GRUMEZESCU, 2015), diluents (NAYAK *et al*., 2011), tablet disintegrants (HEMALATHA; SRIKANTH; SAI, 2017), suspended colloidal protectors, gel gelling agents, oral liquid thickeners, suppository, and nanoparticles (DUFRESNE; LIN, 2015; GHAYEMPOUR *et al*., 2015; HAMDANI; WANI; BHAT, 2019; OGAJI *et al*., 2012; THAKUR; THAKUR, 2015).

2. CHEMICAL COMPOSITION OF GUM AND MUCILAGE

To identify the polymer, one must determine its structure. Its properties depend on its chemical composition and chain conformation (NGWULUKA; OCHEKPE; ARUOMA, 2014). A comprehension of the morphology, size, and surface chemistry of natural polymers is essential

to define their properties and possible uses for pharmaceutical purposes (KUMAR DHAKA *et al*., 2017; KUMAR *et al*., 2010).

In the case of gums, this determination is complex, as there are several chains of different intertwined properties, on the other hand, there is a range of techniques to feature and to identify these chains (BHATIA, 2016; SELLÉS *et al*., 2002; VINOD *et al*., 2008; YANG; ZHANG, 2009). Natural polymers are generally amorphous or semicrystalline (GONZÁLEZ-MARTÍNEZ *et al*., 2017; OLAYEMI; SALIHU; ALLAGH, 2013). They have a higher solubility than highly crystalline polymers (PATHAK *et al*., 2014).

Gum and mucilage have an undefined number of monosaccharides in hydrolysis. These may be pentoses if derived from xylan, or hexoses if derived from starch and cellulose. Gum-forming polysaccharides have pyranosidic (hexagonal) rings and furanosidic (pentagonal) rings, with different types of glycosidic bonds and several forms of D and L enantiomers. Sucrose, for example, is a non-reducing sugar composed of a pyranosidic ring with a furasidic ring attached by carbons 1 and 2 (HIRST; JONES, 1958). Gum has its composition significant amounts of calcium, potassium and magnesium salts present in uronic acids (HIRST; JONES, 1958). The mucilage is made up of ester groups of sulfuric acid (ASPINALL, 1970). Both gum and mucilage have galactose and arabinose. The resins have terpenes (GIGANTE, 2005) and do not dissolve in water, becoming glassy in contact with air after their viscous formation in the stem. These data may direct the isolation and characterization of the main gum compounds (CHOUDHARY; PAWAR, 2014; KULKARNI *et al*., 2011; RAVINDRAKULLAI REDDY; MANJUNATH, 2013; SHARMA *et al*., 2016). Most gums dissolve in water and are, therefore, hydrophilic. This feature allows the binding with active principles of also hydrophilic drugs (LACCHIA; GUERREIRO, 2009; LÓPEZ-COBO *et al*., 2017). So, for the introduction and release of these drugs in the body, depending on the target site, there must be an affinity for lipophilic substances. Because such adaptations are necessary, the structure of certain polymers is modified. Modification of a polymer may alter its degree of crystallinity (SANTOS *et al*., 2016). Figure 1 shows the metabolism pathways of mucilage, gum, and resin formation.

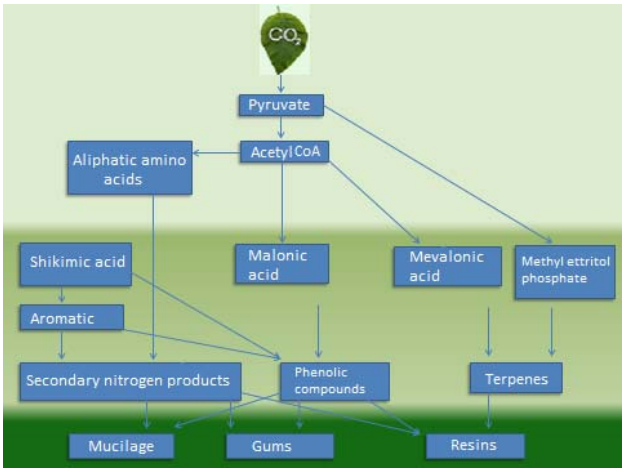

Figure 1: *Pathways of exudates plant metabolism*

All in all, gum and mucilage differ to branches their chains, ability to gel and form solution-insoluble masses, and presence of terpenes. Table 1 brief the differences between gum, mucilage, and resin.

Table 1: *Main characteristics of gum, mucilage, resins, and latex. (Adapted from LANGENHEIN, 2003)*

	Primary components	**Solubility**	**Secretor tissue**
Gums	Polysaccharides	Water soluble	Cavities
Mucilage	Polysaccharides	Water soluble	Epidermal cells, trichomes, ducts cavities
Resin	Terpenoids, phenolic compounds	Liposoluble	Canals, Blisters, Cavities, Trichomes, Epidermal cells
Latex	Terpenoids, phenolic compounds, carbohydrates	Liposoluble	Laticifers

3. MIXTURES AND CHEMICAL MODIFICATION

Modification methods include grafting, crosslinking, derivative formation, and polymer mixing, changing their physicochemical properties. However, this modification should not alter biological properties (NGWULUKA; OCHEKPE; ARUOMA, 2014).

The polymer-polymer mix is easier and more convenient, as chemical reactions are not necessary for the synthesis of new polymers (NOKHODCHI *et al*., 2015; RIBEIRO *et al*., 2017). Bonding occurs by Van der Waals forces,

hydrogen bonds, dispersion forces, covalent bonding (crosslinking), or ionic bonding. Grafting involves covalent adhesion of monomers in the polymer chain. SAH (2016) defines polymerization as “Curing” in which there is the polymerization of oligomers to form structures that adhere to the substrate by physical forces.

There is polymer mixture to increase retention and retard drug release, for example, alginate and carob gum in the manufacture of microspheres and mixtures of natural and synthetic gums such as carboxymethylcellulose with carob gum and methacrylate for hydrogel production (KHAN; PARVEZ; SHARMA, 2015). Another example is the addition of Guar gum and Xanthan gum on *M. indica* seed polymer to improve both gums, or alone to grow the viscosity of the *M. indica* seed gum (NAWAB *et al*., 2016).

Methods of modification by chemical reactions may increase solubility through carboxymethylation, carbamoylation, or cyanoethylation. Otherwise, they can increase solvent affinity through acetylation or deacetylation (LIMA *et al*., 2018), incorporate drugs through phosphorylation (SANTOS *et al*., 2016), produce analogs, depolymerize, add properties antivirals, anticoagulants through sulfation (MARQUES *et al*., 2017), and add sensitivity to radiation through esterification for diagnostic detection (SANTOS *et al*., 2016; NGWULUKA; OCHEKPE; ARUOMA, 2014; PATHAK *et al*., 2014). These are methods that modify viscosity and alter absorption (ROCHA, G.; CÉSAR, P.; SOUZA A., 2017; SIERAKOWSKI, 1988). Natural polymers such as cashew gum, locust bean gum, starch, hemicellulose, xylan, guar gum was carboxymethylated (FEDELI *et al*., 2015; MONTEIRO *et al*., 2015), Guar gum and *Cassia tora* gum were carbamoylated (SARKAR *et al*., 2018), Tamarind seed gum and *C. tora* were cyanoethylated (NGWULUKA; OCHEKPE; ARUOMA, 2014).

It is possible to modify a gum to alter adhesive and mucilaginous properties while maintaining the hydrophilic capacity with a viscosity at low concentrations. Separating the mucilaginous part would lead to the loss of the possibility of alteration (PRAJAPATI *et al*., 2013). Hydrocolloids are used for rheological and sensory modifications in foods in order to change their texture and physical stability (ROCHA, 2017). Plasticizers added to the galactomannan/starch blend alter the hydration of the formed films (SOARES, 2009). Okra mucilage was modified by acrylamide graft for the development of polymeric materials in wastewater treatment (MISHRA; CLARK; PAL, 2008). Modification of Hibiscus mucilage for a suspending agent (EDWIN J, EDWIN S, DOSI S, RAJ A, 2007). Increased adhesive capacity of *Manilkara zapota* seed (SUDARSHAN; SUNIL B, 2015).

4. CHARACTERIZATION METHODS

As gum can come mixed with mucilages and resins, there are techniques for characterizing these mixtures (LEAL, 2014). Chemically most gum is recognized to contain hydroxyl (OH-), ether (COC), acetyl (CH3CO-), carboxyl (-COO-), aliphatic groups, and carbonyl (-C = O) groups (PADIL *et al*., 2018).

Some simple tests can be performed to assess the presence of other substances in the gum. Nadi reagent indicates the presence of blue-colored terpenes. Lipophilic substances become colorless in a mix of chloroform and ethanol. The test with tannic acid and iron (III) chloride detects the presence of mucilage, as long as it is rich in proteins. Schiff's reagent (PAS) for neutral polysaccharides (RODRIGUES, 2007). Molish's test confirms the presence of carbohydrate with a violet color present using 100 mg of dry gum or mucilage powder added to Molisch's reagent and sulfuric acid solution (SANT '*et al*., 2006). The Ruthenium test detects pectin, and plant mucilage with the presence of pink in a simple mixture of the reagent with the mucilaginous gum observed under the microscope. Most mucilages are derived from uronic acids (galacturonic and glucuronic). The 0.2 N iodine test with 10 mg gum becomes colorless if there are polysaccharides in the gum and the enzyme assay with 0.5 ml benzidine in alcohol with a gum solution in 20 ml water detects enzyme in the presence of a blue color (RAVINDRAKULLAI REDDY; MANJUNATH, 2013).

The term resin is used to define gums using the indication that resins have terpenes (FIGUEIREDO *et al*., 2007).

Techniques may be used to determine the structure, chain conformation, sugar identification, molecular weight, degree of polydispersity and crystallinity. These characteristics influence properties such as solubility, stability, and drug release (ALBUQUERQUE, 2017; ROCHA, G.; CÉSAR P.; SOUZA A., 2017; MARQUES *et al*., 2017; SANTOS *et al*., 2016). X-ray diffraction is the

main technique used to determine the degree of crystallinity of a polymer. The presence and position of the characteristic peaks in the diffractogram indicate the degree of crystallinity and the type of crystalline structure obtained. The adsence characteristic peaks in the spectrum are indicative of the complete amorphous nature of the polymer (GHALANDARI *et al*., 2014; LIU *et al*., 2007).

Structural characterizations are performed with Fourier transform infrared spectroscopy (FTIR), liquid nuclear magnetic resonance (NMR) (one and two dimensions), solid-state NMR, Raman spectroscopy, gas chromatography (GC), mass spectroscopy GC (MS), and high-performance liquid chromatography (NDINGA; JM, 2015). Techniques such as gel electrophoresis, differential scanning calorimetry, wide-angle X-ray diffraction, and X-ray diffraction are used for polymorphism determination (WANG *et al*., 2015).

Molecular weights and polydispersity of gum and mucilage can be determined by size exclusion by chromatography (SEC), gas chromatography (GC), and viscometry/rheometry (YANG; ZHANG, 2009). Viscosity can be used to estimate molecular weight as it is a direct reflection of molecular weight. Waters® is promoting a chromatographic technique called Advanced Polymer Chromatography System (APC™) that offers a better resolution for molecular weight determination, but only for low molecular weight samples (NGWULUKA; OCHEKPE; ARUOMA, 2014). Polysaccharides of different molecular weights and sizes may be separated using precipitants such as ethanol, methanol, and acetone, or by performing gel chromatography. Sephadex, Sephacryl, and Sepherose are mostly used gels. Polysaccharides may be acidic or basic and can be separated with cetyltrimethylammonium bromide (CTAB) or cetylpyridinium chloride (CPC), which may form a complex precipitate with the acid polysaccharide. They can also be separated by ion-exchange cellulose chromatography, for example, DEAE-Cellulose column, DEAE-Sepharose column (WANG *et al*., 2015). The combination of techniques provides more accurate data such as chemical and morphological structures on a molecular scale (NGWULUKA; OCHEKPE; ARUOMA, 2014). Any modification on the polymer surface influences the degree of encapsulation and drug release, as well as the interaction with cells (YANG; ZHANG, 2009).

Thermal analyses such as differential exploratory calorimetry (DSC) elucidate physical and chemical changes during thermal processes (EMEJE *et al*., 2009; HOMBREIRO PEREZ *et al*., 2000; SANTOS *et al*., 2016). By exposing a polymer to a temperature range, it is possible to identify glass transition temperatures, crystallization, melting and decomposition (EMEJE *et al*., 2009; MOHAN, 2017; PATHAK *et al*., 2014). Materials behave differently below and above their glass transition temperatures (LIN; DUFRESNE, 2015). The mechanical properties of a polymer depend on the glass transition temperature, and it depends on the molecular weight (FATHI; MOHEBBI; KOOCHEKI, 2016; SANTOS *et al*., 2016; YANG; ZHANG, 2009). Other less commonly used thermal techniques are dynamic mechanical thermal analysis (DMTA), thermally simulated current spectroscopy (TSC), and dilatometry (DIL) (NGWULUKA; OCHEKPE; ARUOMA, 2014).

Rheological behavioral analyses such as the viscoelastic behavior of a polymer also depend on molecular weight, directly influencing the later ability of the polymer formed either in tablets, scaffolds, micro, or nanocapsules to release the drug (MOHAN, 2017; THAKUR; THAKUR, 2015; TORCHILIN, 2006). The influence is around hardness, compression, suspendability, zeta potential capacity, flow shear effects, frequency and temperature effects on polymers, ability to behave like gel, paste, viscous liquid, depending on the chosen polymer use and measured through a rheometer (NGWULUKA; OCHEKPE; ARUOMA, 2014). Intrinsic viscosity decreases with increasing ionic strengths of the solution (VASQUEZ *et al*., 2015).

The ability of the polymer to gel depends on the ionic strength, pH, and temperature (RIBEIRO *et al*., 2016; WU *et al*., 2009). Polysaccharide gums may exhibit neutral charge, negative charge, or positive charge according to the presence of various chemical groups attached to individual monosaccharide units (FISZMAN; VARELA, 2013).

The forming of the polymers is up to on the polysaccharides. They may exhibit some conformations in solutions, such as coils, semi-flexible currents, stiff currents, and helical currents, including single, double, and triple-helical chains and describe the flexibility of polymeric chains in solutions (YANG; ZHANG, 2009). An example is the conformational change of Gellan gum in the face of temperature changes. Its polysaccharide has a repeat unit helix shapes, 1,3-b-D-glucose, 1,4-b-D-glucuronic acid, 1,4-b-D-glucose and 1,4-a-L-rhamnose. The

ellipticity at 202 ηm decreases with cooling and increases with heating (YANG; ZHANG, 2009).

In vivo testing of toxicological and histopathological reactions is required for safe drug use (PATHAK *et al*., 2014). It is a primary part of drug research. The classification of the tests depends to on the purpose of the drug administration route. The need for sterility of the drug produced, for example, intravenously, is not the same for oral use (JAKKI *et al*., 2016; KROKIDA, 2017; MORA-HUERTAS; FESSI; ELAISSARI, 2010; MUSYANOVYCH; LANDFESTER, 2014; Ribeiro *et al*., 2017). Characteristics for the polymer-drug conjugate to be practical is that the polymeric carrier is non-toxic and non-immunogenic, MW high enough to ensure long circulation times, but <40 kDa for non-biodegradable polymers to ensure renal elimination upon release of the drug adequate loading capacity, potency of the conjugate throughout transport, but easily cleaved upon arrival at the target and the ability to reach intended tissue by active as well as passive means (LIECHTY *et al*., 2010).

5. PHARMACEUTICAL USE OF GUM OF *M. INDICA*

The *M. indica* gum, Anacardeaceae family, has amorphous and semicrystalline parts and has shown both hydrophilicity and hydrophobicity when diluted in both water and alcohol and precipitates the polymers (AHMED; ABBAS, 2018; GARG *et al*., 2018; NAYAK *et al*., 2011, 2012; SHINGALA *et al*., 2010). Only the work by Singh *et al*., 2010, reported the initial alcohol extraction to form diclofenac sodium delayed-release tablets.

Mango gum has been sold by Indians to heal cracked feet (ANJANEYULU; RADHIKA, 2000). It was used by Filipinos to cure parasitic skin disease, Syphilis, and Herpes (NUSSINOVITCH, 2009).

M. indica gum polymer has rare data obtained though promising for drug delivery because of its lower toxicity, higher biodegradability, responsiveness, and adaptability to nanotechnology (ALAM; PARVEZ; SHARMA, 2014; CHANDRAJITH; MARAPANA, 2018; MARIMUTHU JAYAKUMAR, 2001; RAI *et al*., 2007). *M. indica* gum has already been used for metformin immediate release tablets (HEMALATHA; SRIKANTH; SAI, 2017).

In 1965 it was isolated from the gum, a cyclotriterpenoid that is a viral cycle blocker (SILVA; DUARTE; VIEIRA FILHO, 2014), which became known as mangiferolic acid (CORSANO; MINCIONE, 1965).

In turn, the work of Vinod *et al*. (2013) reported the gum to be slightly soluble in water, forming a thick gel, practically insoluble in alcohol, chloroform, and acetone.

6. PHYTOLOGY IN GUM PRODUCTION OF *M. INDICA*

Gum is produced in response to infection or healing by tissue injury. (MENESTRINA *et al*., 1998). They are formed in ducts within which there are pseudo vacuoles that produce and store proteins. (BHOSALE; OSMANI; MOIN, 2014; SHARMA *et al*., 2016) Polysaccharides are transported to the vacuoles by Golgi vesicles. Proteins form spherical or crystalline structures. Polypeptides tend to form hexamers because the vacuolar pH value is low (SCHNIZL, 2001).

Gum formation was studied by MARIMUTHU *et al*. In his conclusion he showed that there is a large increase in ATP molecules, the concentration of mitochondria near the exudate ducts, higher carbohydrate concentration in the months March to May, when gum and resin exudates are produced (MARIMUTHU, 2001).

Carbohydrates are lysed into monomers by the large concentrated enzymatic activity at the site. The secreted lipids are oxidized and form aromatic resins. There is increased lipase activity at the sites near the ducts. With the action of ATP on mevalonic acid, there is the incorporation of acetate to isoprenes, terpenes, and fatty acids. The amount of resin was verified about increased cytoplasm peroxidase activity, cell nucleus position, and lipid location (JOEL, 1980; JOEL; FAHN, 1980).

7. EXTRACTION AND PURIFICATION

The extraction of *M. indica* gum is done by slashing the trunk of the tree during the rainless months. Gum production can be enhanced by the use of Etefon, a plant stimulator (LIMA *et al*., 2001). Gum can be produced near mucilage, which makes separation difficult and can be detected by chemical tests using red Ruthenium that detects mucilage if it is red (CHOUDHARY; PAWAR, 2014; HEMALATHA; SRIKANTH; SAI, 2017 ; NAYAK *et al*., 2012; PATHAK *et al*., 2014; PRADO; DEMARCO, 2018; WET; ROBBERTSE; COETZEE, 2016). This mucilage is pinkish-yellow, unlike the white matter that comes out of

the fruit stalk. This white substance is called latex and has 5- [2 (Z) -heptadecenyl] resorcinol, skin irritant (BANDYOPADHYAY; GHOLAP; MAMDAPUR, 1985).

Some authors found the gum to be whitish (NAYAK *et al*., 2012), other browns (AHMED; ABBAS, 2018), and others are yellowish. The consistency also varies, being viscous or more hardened (ALAM; PARVEZ; SHARMA,2014;CHANDRAJITH;MARAPANA,2018; HEMALATHA; SRIKANTH; SAI, 2017; NAYAK *et al*., 2011; NDINGA; JM, 2015; SARKAR *et al*., 2018).

The form of gum purification also has slight variations. Most dry the gum first, then grind it and use continuous extraction with water. Others pass through sieve no. 80 before diluting with water (AHMED; ABBAS, 2018; RODRIGUES; PAULA; COSTA, 1993). But alcohol extraction has also been done (SHINGALA *et al*., 2010). Right after dilution, partial or not, most add twice the amount of acetone to the solution formed (GHAYEMPOUR; MONTAZER; MAHMOUDI RAD, 2015; HEMALATHA; SRIKANTH; SAI, 2017; LIMA *et al*., 2018; MARIMUTHU; JAYAKUMAR, 2001; RIBEIRO *et al*., 2016; VASANTRAO PATIL *et al*., 2014). After precipitation, the precipitate is centrifuged to recover the precipitate and dried at 50 ° C (JAKKI *et al*., 2016; VINOD R, [s.d]). Some prefer to dry the solution without centrifugation and still others dry before acetone is added (KUMAR AYAK; SWAMY, 2011).

Figure 2 was obtained from the work of Kahanzada *et al*. (2004), and collaborators from Pakistan. Shows gummy mango in response to the attack of *Botryodiplodia theobromae* fungi purposely inoculated for study.

8. *MANGIFERA INDICA* GUM ISOLATED COMPOUNDS

Volatile terpene compounds, mostly unoxygenated sesquiterpenes such as beta-elemene (6.7%), beta-caryophyllene (9.8%) (Figure 2-A), alpha-humolene (3.4%), beta-chamigrene (4.5%), and alpha (31.9%) and beta-selinene (31.3%) (Figure 2-B) were found in samples of M. Indica resin gums by Kovats retention index and by solid-phase microextraction (NDINGA; JM, 2015). Also found were amylose, α-arabinofuranosyl, β-galactopyranosyl (Figure 2-C) (PATHAK *et al*., 2014). Viradabine (Figure 2-D) is an anti-viral, anti-herpetic drug whose active ingredient is arabinofuranosil.

As much in leaf as fruit and gum were found: β-pinene, α-felandrene, 3-carene, β-elemene, α-gurjunene, β-caryophyllene, α-humulene, α-selinene, β-selinene, and caryophyllene oxide. Elemene has apoptosis antiproliferative activity, and beta caryophyllene has antibacterial activity (ANJANEYULU; RADHIKA, 2000; CHANDRAJITH; MARAPANA, 2018). Elemene and selinene contribute to the floral and hibernal aroma, respectively (NDINGA; J-M, 2015). As their compositions are low in exudates, they do not have odorous characteristics but are in greater proportion in leaves and fruits (NDINGA; J-M, 2015).

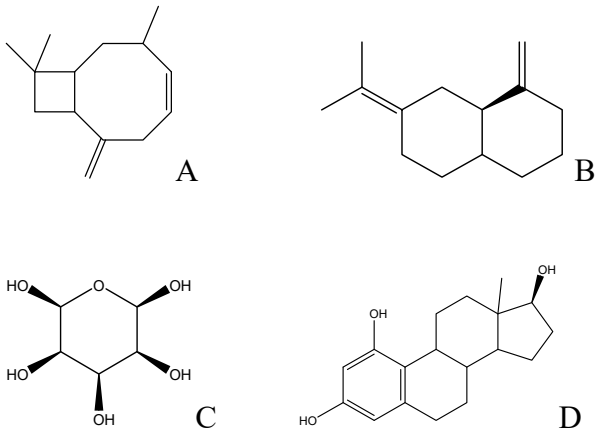

Figure 2: *Some compounds isolated from Mangifera indica gum.*

CORSANO and MINCIONE (1965), isolated from the acidic part of *Mangifera* gum, indicates a compound they named manguiferolic acid (Figure 3), which was the first example of triterpenic acid with a cyclopropane ring.

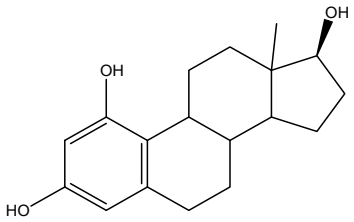

Figure 3: *Manguiferolic acid chemical structure*

In 1968 the same authors isolated ambonic acid from the same acidic part of the resin (Figure 4) (CORSANO; MINCIONE, 1968).

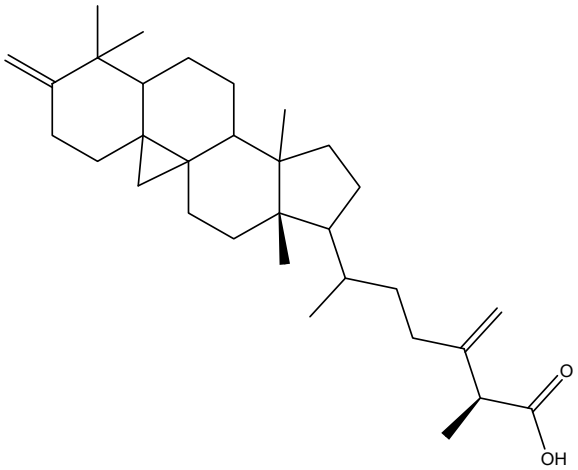

Figure 4: *Ambonic acid chemical structure*

In 1980 Joel and Fahn isolated tannic acid (Figure 5) from Mango gum (LIN; DUFRESNE, 2015). The property of acid is to be a binder used as a collagen cross-linkage agent in orthodontic restorations (OLIVEIRA *et al*., 2017).

In the work of Elouma *et al*. (2015), there is a difference between the gum samples obtained from the several plants about the percentage of the main elements. The samples were obtained from trees from the same region and at the same time. The analyzes were repeated two years after the first one, and the variance did not change. Therefore, the difference of the proportion of the elements between the samples is not due to the volatility of the compounds. According to the author, it may be due to a chemical transformation of some components of gum exudates under thermodynamically specific conditions. And β-elemene presents up to 64% has an anti-proliferative effect on cancer cells (PURI; SHARMA; NAGPAL, 2016). There are also reports of nonvolatile compounds ethers, aldehydes, ketone acids, lactones and phenols (NDINGA; J-M, 2015).

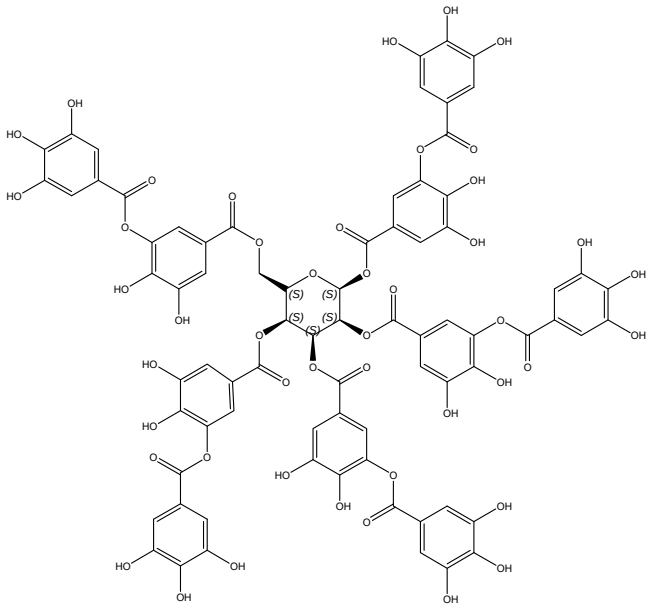

Figure 5: *Tannic acid chemical structure*

Manguiferin (Figure 6) was isolated from the bark of the *M. indica* tree. Being the active ingredient of VIMANG®, it promises to avoid oncogenesis (TREVISAN *et al*., 2008). A study conducted with Cuban and Brazilian cultivars revealed data confirming the presence of high proportion of manguiferin in the bark of the trees (71.40 g / kg of dry material), with no benzoic acid in Brazilian cultivars, which encourages the research of xanthan derivatives to from Manga by-products (SELLÉS *et al*., 2002).

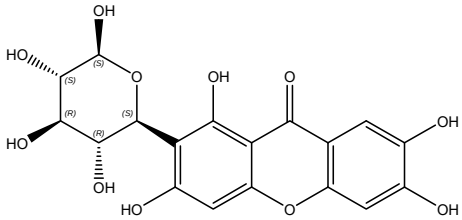

Figure 6: *Manguiferin*

9. PHYSICAL-CHEMICAL CHARACTERISTICS OF *MANGIFERA INDICA* GUM

Alkali metal salts of linear polysaccharides are highly ionized in water, and the distribution of the ionic charge throughout the molecule tends to keep it in an extended form because of Coulomb repulsion. This repulsion between carboxylate anions repels polysaccharide molecules and promotes a high degree of solution stability (ASPINALL, 1970; BASKAR, 2013; BHOSALE; OSMANI; MOIN, 2014). Extended independent polysaccharide chains produce highly viscous solutions, so hydration of the particular carboxylate anion leads to solution stability and solution viscosity (AMORIM *et al*., 2007).

In the presence of multivalent cations (such as

calcium), intra and intermolecular saline bridges are established. The interconnection between polysaccharide molecules leads to gel formation and, if extensive, precipitation. As salts formed from monovalent cations are stable over the range of the pH scale, molecular instability occurs at very high pH values due to the normal alkalosis degradation process. As the pH is reduced to about 3, carboxylic acid groups are formed, and as the hydrogen ion concentration of the solution increases, this ionization is passed on. Under repressed ionization conditions, uncharged carboxylic acid groups lose large amounts of associated water, polysaccharide molecules do not repel and, being linear, readily associate from a gel or precipitate (WANG; ELLIS; ROSS-MURPHY, 2000).

The properties of Mango gum presented a real density of 0.74 g / ml (CARR, 1965) considered low about other natural gums. The lower the density, the greater the porosity of the substance (HABIBI; LUCIA, 2012; SIERAKOWSKI, 1988).

The link between the compressibility index and flowability is inversely proportional (CARR *et al*., 1965). Being low compressibility between 11 to 15%, high between 16 to 20%, and very high above 31% (CARR, 1965). Bulk mass and bulk density give insight into particle packing and disposition and the compaction profile of a material (SARKAR *et al*., 2018). Solubility may be explained by the nature of the gum's molecular structure and mixtures as certain proteins or monosaccharide structures. The less linear the polymer, the more soluble (ABDULLAH, 2010; GARG *et al*., 2017; SIRISHA; DSOUZA, 2016). Linear polysaccharides take up more space and are more viscous than highly branched compounds of the same molecular weight. The gels are easier formed as of branched compounds and uniform because extensive interaction along chains is not possible (BHOSALE; OSMANI; MOIN, 2014).

Water holding capacity (WHC) and oil holding capacity (OHC) depend on the protein fraction present in the structure. It was found among 14 natural gums that WHC ranged from 34.66 to 1024.66 (g water / 100 g gum) (SARKAR *et al*., 2018). WHC varies depending on factors such as the hydrophilic - hydrophobic balance of amino acids in the protein molecule, as well as protein-associated carbohydrate and lipid fractions. There is no direct correlation between solubilization and water retention capacity, as each parameter is dependent on a different structural aspect of the biopolymer chain (MOGHIMI *et al*., 2015; MONTEIRO *et al*., 2015; RAJESWARI; GOKA, 2017). A 6% concentration of Mango gum has the same binding power as 10% starch and 5% is comparable to the binding power of Arabian gum (RAI *et al*., 2007; SINGH *et al*., 2010). Most gum does not dissolve if they are in a concentration greater than 5% (CHOUDHARY; PAWAR, 2014).

Rest angle is a measure of the resistance of dust to flow under gravity due to frictional forces resulting from the surface properties of the granules (ABDULLAH, 2010; OLAYEMI; SALIHU; ALLAGH, 2013). Different gum showed different angles of rest, ranging from 38.13 to 39.80°. As the angle of repose decreases, the binding level of the granules increases. This may be due to the reduction in the cohesive forces of larger granules formed at the highest bonding level (SARKAR *et al*., 2018; ABDULLAH, 2010). VINOD, 2013, found that Mangifera gum has good compressibility with moderate flow.

Chemical stimuli (pH, redox potential, ionic strength, and chemical agents) induce a response by altering the molecular interactions between polymer and solvent (by adjusting the hydrophobic/hydrophilic balance) or between the polymer chains (influencing crosslinking or the integrity of the polymer main chain, by propensity for hydrophobic association or electrostatic repulsion). Changes may occur in transitions in solubility, hydrophilic-hydrophobic balance, and conformation (ACHILLEOS; HATTON; VAMVAKAKI, 2012; GU *et al*., 2018; SALIM *et al*., 2014). These changes manifest themselves in a number of ways, such as the transition from polymer chains (collapse of a macromolecule from an expanded coil state to an ideal coil state to a collapsed globule state, or vice versa It is also analogous to behavior swelling of a cross-linked polymer gel), swelling / depletion of covalently cross-linked hydrogels, sol-gel transition of physically cross-linked hydrogels and self-assembly of amphiphilic polymers (FISZMAN; VARELA, 2013; MEMIOLU *et al*., 2002; PURI; SHARMA; NAGPAL, 2016; TIWARI *et al*., 2012; YANG; ZHANG, 2009).

The variation in pH in the body allows a selectivity of polymer / target site interaction. The stomach has pH 2.5, in the intestine, the pH is 6.2-7.5. Within cells, in endosomes, the pH is between 5.0 to 6.8, in lysosomes between 4.5 and 5.5. In the vicinity of cancer cells, tissue pH becomes more acidic (6.5) (CHANG *et al*., 2017; GU *et al*., 2018; LIECHTY *et al*., 2010). Delivery of nanoparticles or microparticles through the gastrointestinal tract occurs through passive absorption at a concentration gradient on the

intestinal surfaces, as determined by three primary factors: ionization extent, molecular weight, and oil/water partition coefficient of the drug (LIECHTY *et al*. al., 2010).

Scientists have devoted an effort to develop or find polymers that can exploit these pH variations to selectively provide drugs for specific intracellular or extracellular sites of action (BANIK; BROWN, 2014). Jakki *et al*. (2016) obtained anionic polymer nanoparticles from Manga gum for drug delivery in the treatment of Alzheimer's. NAYAK *et al*. (2012), found that *Mangifera indica* gum is a pH sensitive polymer, therefore, an intelligent polymer that can be used in controlled drug release. Kuppusamy *et al*. (2013) confirmed that *M. indica* gum is a non-toxic anionic polymer suitable for ocular drug delivery system

10. GUM NANOCAPSULES

Polymeric nanoparticles can be made of various polymers and can be modified in hydrophilicity and lipophilia, size and functionalized with different molecules to meet therapeutic needs (BHATIA, 2016), (LIN; DUFRESNE, 2015; RANA *et al*., 2011; SAH *et al*., 2016; TOWLE; WHISTLER, 2012).

The aim of using nanocapsules as drug carriers is to make the therapeutic dose as constant as possible (BASTO *et al*., 2016; BIZERRA; SILVA, 2016; KOTHAMASU *et al*., 2012; LIECHTY *et al*., 2010; MORA- HUERTAS; FESSI; ELAISSARI, 2010; PRABHAKAR; TAPAN; RATAN, 2013), enabling fewer drug doses and reducing side effects, either by substituting excipients or by directing the drug to the target site (YI *et al*., 2018). As shown in figure 7, there are several types of technologies for modifying drug release kinetics at the plasma level.

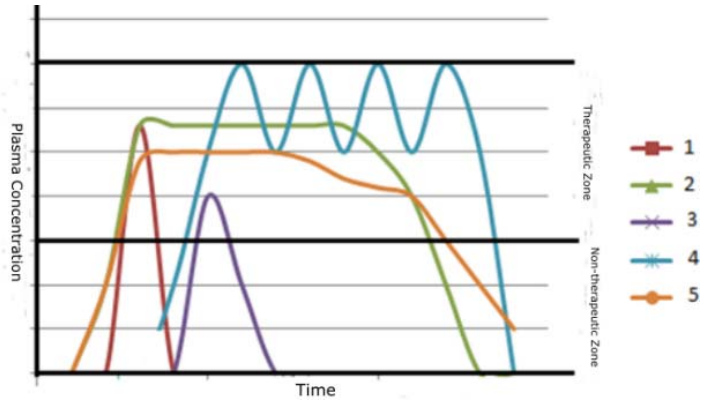

Figure 7: *Plasma Profile at 1: Conventional Release 2: Sustained Release 3: Delayed Release 4: Repeated Release 5: Extended Release. (Adapted from VEIGA, 1988).*

A means of targeted drug delivery by the body, reducing the interference of the individual's chemical and physiological barriers on the drug and reducing side effects was found through nanotechnology (FEDELI *et al*., 2015; MARQUES *et al*., 2017; MOSQUEIRA; SANTOS MAGALHAES, 2007; MUSYANOVYCH; LANDFESTER, 2014). With nanocarriers it is possible to distribute aliquots smaller than 100 nanometers of drug without being degraded or modified by the body's natural defense systems and fluids, being able to reach the target site (ACHILLEOS; HATTON; VAMVAKAKI, 2012; ANTON *et al*., 2007; GU *et al*., 2018; SALIM *et al*., 2014; WANG; WANG, 2013).

The objective of the technique is to obtain capsules of uniform size, good biodispersibility (BRUM JUNIOR, 2011; KOTHAMASU *et al*., 2012) resistant when far from the target site and with easy release directed to the action site or with gradual release of content, in both cases, with no release peaks within the therapeutic range, maintaining constant release over a longer period of time (BASTO *et al*., 2016; IVERSEN; SKOTLAND; SANDVIG, 2011; MOGOŞANU; GRUMEZESCU, 2015). To achieve this goal, microscopic drug encapsulation techniques were formulated with a pH-resistant sheath that could easily pass between or encompassed cell membranes and release the pharmaceutical content either near or within the target cell, prevent recognition of the body's defenses and allow surface changes to conjugate proteins that function as a molecular targeting site (CARDOSO; LIMA; QUEIROZ, C, 2013; COUVREUR *et al*., 2002; LEAL, 2014; NAWAZ ; ROHAN; GOWDA, 2011; OGAJI; NEP; AUDU-PETER, 2012; SILVA *et al*., 2003; YALAVARTHI; CHOWDARY VADLAMUDI, 2012).

The first patent registered with the nanocapsule technique was filed in 1963 and accepted in 1969 developed by Henn Ruus in the United States. The author cites some substances chosen to formulate nanocapsules from 0.1 to 450 microns: "Cellulose and synthetic polymers, including polyethylene, polypropylene, polymethyl methacrylate, polymethacrylate" (HENN RUUS, 1969). The objects of the invention include a simple method for encapsulating water or hydrophobic substances with an insoluble and infusible high molecular weight polymer shield with high uniformity of thickness, dry, and free

flow. For substances for pharmacological purposes, the author comments on the need for the chosen materials to be non-toxic. In prior U.S. Patent No. 2,712,507 of 1955, filed in 1953, Green (1955) obtained microcapsules with Arabica coacervation shell but worked only for hydrophobic and acid-resistant substances.

The active drug release system can also be used at the nanoscale through monolithic erosion systems such as nanospheres (EMEJE *et al*., 2009; GHALANDARI *et al*., 2014).

In this case, there are no reservoirs, and the drug becomes involved in the polymer constituent web, adsorbed on the surface or inside, being distributed by erosion (HOLKEM *et al*., 2015; VRIGNAUD; BENOIT; SAULNIER, 2011). In nanocapsules, the drug may be in the nucleus or polymeric membrane (CAMARGO *et al*., 2013; COUVREUR *et al*., 2002; KOTHAMASU *et al*., 2012).

11. NANOCAPSULE FORMATION TECHNIQUES USING PRE-FORMED POLYMERS

Emulsification-solvent, evaporation, salting-out, emulsification-solvent diffusion, solvent displacement (nanoprecipitation) are the main techniques for obtaining nanoparticles used for their ease of operation, speed, and lower cost. However, the solvent displacement technique allows nanocapsules and nanospheres to be obtained. Nanoparticle characterization analyzes include pH, toxicity, mean size distribution, surface charge (Zeta potential), absorbed drug content, and infrared spectroscopy (FTIR), chemical stability, physical stability, and toxic capacity (FRANCO, 2013; JOSÉ, J.; CORRÊA, 2015; RIBAS, 2013).

12. SUMMARY OF PHARMACOLOGICAL RESEARCH CARRIED OUT ABOUT MANGO GUM

12.1. AHMED & ABBAS (2018)

Extraction and evaluation of *Mangifera indica* gum as a sustained release polymer in Glinbenclamide matrix tablets

It has been found that M. indica gum collected at low cost has the good swelling capacity, good flow and suitability for Glinbenclamide controlled release tablet matrix formulations, the more concentrated the gum purity, the higher the delay in drug release time, between 9,55% and 10,89% in 24 hours. The formulations were evaluated for various parameters such as weight uniformity, friability, percent content, hardness, and in vitro dissolution studies.

12.2. HEMALATHA *et al*. (2017)

Formulation and evaluation of bilayered tablets containing an immediate release layer of Glimepiride complexed with Mangifera indica gum and sustained release layer containing Metformin HCl by using HPMC as release retardant.

Development of a two-layer Glimepiride and Metformin tablet using *M. gum* as immediate release polymers and HPMC as a sustained release layer. Glimepiride and metformin are oral hypoglycemic drugs. Bilayer tablets were evaluated by parameters such as thickness, diameter, weight variation, hardness, friability, disintegration, and in vitro release studies. The drug content uniformity study showed uniform drug dispersion throughout the formulation.

12.3. NAWAB *et al*. (2016)

Effect of Guar and Xanthan gums on functional properties of mango (*Mangifera indica*) kernel starch.

This research was done on gum extracted from *M. indica* seed. The effects of different concentrations of Guar gum and Xanthan gum on the functional properties of Mango seed gum were studied. Both gums increased the water absorption of the seed gum. The addition of Xanthan gum appeared to reduce swelling power and solubility at higher temperatures, while Guar gum increased solubility and swelling. The addition of both gums produced an increase in the viscosity peak of the seed gum. The binding temperature of the seed gum was higher than that of the gum-modified seed gum, indicating the ease of gelatinization. Guar gum accelerated retreat, but Xanthan gum delayed the phenomenon during seed gum cooling.

12.4. JAKKI *et al*. (2016)

A novel anionic polymer as a carrier for CNS delivery of an anti-Alzheimer drug.

Herbal polymers can be used for controlled drug release and also help direct the drug to the site of action. Mango gum polymeric nanoparticles (NPs) were a vehicle for the central nervous system (CNS) administration using the drug Donepezil (DZP). NPs were prepared by modified ion gelation and emulsion cross-linking method. The diameter of the NPs was 90-130

nm. DZP-loaded NPs were almost spherical in shape, without hemolysis at therapeutic doses. In vivo studies have shown that the brain target has been reached. Thus, based on the above results, the water-soluble fraction extracted from mango gum is a suitable nanoparticle candidate for brain-targeted drug delivery.

12.5. BAYONA (2016)

Evaluación de la actividad antibacteriana in vitro de la resina de *Mangifera indica* sobre cepas de *Escherichia coli, Staphylococcus aureus*, y *Pseudomonas aeruginosa.*

The antibacterial activities were satisfactory, suggesting the natural safety of this resin as a drug formulation.

12.6. MAHAMMED & GOWDA (2014)

Formulation and evaluation of mango gum microspheres as targeted drug delivery to colon.

Mango phosphate reticular microspheres were emulsified using sodium phosphate as a cross-linking agent for the treatment of colon cancer by encapsulating the drug Methotrexate. Particle size was increased as polymer concentration increased and with increasing agitation rate decreased particle size.

12.7. VINOD (2013)

Formulation and evaluation of Nicorandil sustained release matrix tablets using natural gum *Mangifera indica* as a release modifier.

Tablets are having as a gum *M. indica* was used for the controlled release of Nicorandil. The physicochemical and phytochemical properties were evaluated. The granules were evaluated for resting angle, bulk density, density, compressibility index, weight uniformity, active ingredient content, thickness, friability, hardness and dissolution *in vitro*. The prepared tablets showed 86.5% to 97.8% erosion release at stable 12h for 3 months.

12.8. NAYAK *et al*. (2012)

A novel binding agent for pharmaceutical formulation from *Mangifera indica* tree.

The gum extracted from *M. indica* was subjected to toxicity and pre-formulation studies as to its suitability as a tablet binding agent compared to starch using Lornoxicam as a drug. The prepared granules were evaluated for percentage average particle size, total porosity, compressibility index and dispersion properties, content uniformity, hardness, friability, disintegration time, and dissolution in vitro. The pills had good physicochemical properties, and drug release was over 90% in 90 minutes.

12.9. NAYAK *et al*. (2011)

An in vitro evaluation of *Mangifera indica* gum as a potential excipient for oral controlled-release matrix tablet.

The propose was to develop Lornoxicam tablets with *M. indica* gum for sustained release once a day, in different proportions of the drug. *M. indica* gum was used as matrix-forming material, and microcrystalline cellulose was used as diluent. As the proportion of gum in the matrix was increased, there was a corresponding decrease in drug release, reaching 98%. A swelling study was also performed to study the dispersibility of gums at different concentrations. Formulation stability was observed for 3 months.

12.10. NAYAK *et al*. (2011)

The exploitation of *Mangifera indica* gum as a novel natural gelling agent in the designing of gel formulation.

To study the gelling properties of *M. indica* gum, gels were prepared using Ceclofenac as a model drug. The gels were evaluated for drug content, viscosity determination, in vitro permeability (across the dialysis membrane), irritation tests, and skin stability. They did not produce dermatological reactions and were well tolerated by the guinea pig. Stability study revealed that the gel formulations were physically stable and without syneresis. Briefly, *M. indica* gum can be used as a pharmaceutical excipient in gel formulations by replacing some synthetic gelling polymers after modifications.

12.11. SIVAKUMAR *et al*. (2010)

Design and characterization of Diclofenac sodium tablets containing *Mangifera indica* resin as release retardant.

M. indica gum was used as a retardant in the development of sustained-release drug formulation employing diclofenac sodium as a drug model. The manufactured tablets were made physicochemical analysis and in vitro release studies. *M. indica* resin exhibited an excellent retarding effect on drug release even at its low concentrations (4% w / w). They showed drug release for more than 12 houres.

12.12. SINGH *et al*. (2010)

Evaluation of *Mangifera indica* gum as a tablet binder.

Tablets using *M. indica* gum as a binder with the drug Paracetamol were prepared and

evaluated for physicochemical characteristics. The friability of the tablets ranged from 1.12 to 0.26%, and the disintegration time was from 3 to 8 minutes. Arabica gum was compared at a concentration of 5% (w/w).

12.13. DIXIT *et al*. (2014)

Characterization of tabletting properties of mango gum.

Data on physical, thermal, and sorption properties of *M. indica* gum were performed. These data were identical to those obtained in Singh's work (2010). The aim of the research by Dixit *et al.* was to analyze in vitro release capacity using 2.5% Mango gum for ketoprofen tablet manufacture, which obtained a release rate of 95.07% within 30 minutes, indicating that a fast release and binder property in the conventional matrix.

Research on the anticancer potential with *M. indica* seed extract was conducted by Wu *et al*. (2015), indicating the effectiveness of rectal colon cancer treatment and prevention.

13. CONCLUSIONS

The properties of Mango stem gum have been little explored, but with the results already analyzed, it is possible to direct some possibilities of use.

A great number of researchs were conducted in Asian countries. Much of the research has been limited to physicochemical research and tableting, not delving into the potential for nanocapsule formation.

It is verified that *M. indica* gum has polymers with properties for the controlled release of drugs, both fast and delayed. Indeed, physicochemical characteristics indicate that nanocapsules can be formulated for controlled oral drug release. Besides the regional differences that characterize the *M. indica* gum polymers, the period of collection, the temperature to which the gum is subjected can interfere in the composition of the obtained polymers.

The common characteristics between Mango gum and Arabian gum (Acacia gum) can be explored by testing the same associations between gums for modification of the required characteristics.

Modification of the gum by association with other gums can be tested among other regional gums, such as Cashew gum, Tamarind seed gum or even with *M. indica* mucilage itself at various concentrations.

The physicochemical characteristics of regional gums present differences found in the literature that can be used, such as the difference in the percentage of polysaccharides and mucilage in the gum, whose characteristic may allow, for example, the development of nanocapsules for the release of hydrophilic and hydrophobic drugs same time, using modified *M. indica* gum. In addition to the pH-responsive gum, it is possible to isolate both its hydrophilic and hydrophobic parts for the different mechanisms of controlled drug release.

14. REFERENCES

1. ABDULLAH. Cohesiveness and Flowability Properties of Silica Gel Powder. Physics International, v. 1, n. 1, p. 16–21, 2010.
2. ACHILLEOS, D. S.; HATTON, T. A.; VAMVAKAKI, M. Light-regulated supramolecular engineering of polymeric nanocapsules. Journal of the American Chemical Society, v. 134, n. 13, p. 5726–5729, 4 abr. 2012.
3. AHMED, E. S. Y.; ABBAS, E. S. E. Extraction and Evaluation of *Mangifera indica* Gum as a Sustained Release Polymer in Glibenclamide Matrix Tablets. UK Journal of Pharmaceutical Biosciences, v. 6, n. 4, p. 01, 1 ago. 2018.
4. ALAM, M. T.; PARVEZ, N.; SHARMA, P. K. FDA-Approved Natural Polymers for Fast Dissolving Tablets. Journal of Pharmaceutics, v. 2014, p. 1–6, 27 abr. 2014.
5. ALAMGIR, A. N. M. Phytoconstituents—Active and inert constituents, metabolic pathways, chemistry and application of phytoconstituents, primary metabolic products, and bioactive compounds of primary metabolic origin. In: Progress in Drug Research. [s.l.] Birkhauser Verlag AG, 2018. v. 74p. 25–164.
6. ALBUQUERQUE, P. Avaliação de atividades biológicas de membrana e gel da galactomanana extraída das sementes de Cassia grandis com biomoléculas imobilizadas. [s.l.] Universidade Federal de Pernambuco, 2017.
7. AMORIM, L. V. *et al*. Influence of ionic strength on the viscosities and water loss of bentonite suspensions containing polymers. Materials Research, v. 10, n. 1, p. 53–56, 29 set. 2007.
8. ANJANEYULU, V.; RADHIKA, P. Triterpenoids and Steroids from *Mangifera indica Linn.* Indian Journal of Chemistry, v. 39B, p. 883–893, 2000.
9. ANTON, N. *et al*. Nano-emulsions and nanocapsules by the PIT method: An investigation on the role of the temperature cycling on the emulsion phase inversion. International Journal of Pharmaceutics, v. 344, n. 1–2, p. 44–52, 1 nov. 2007.
10. ASPINALL, G. O. Gums and Mucilages. Advances in Carbohydrate Chemistry and Biochemistry, v. 24, n. C, p. 333–379, 1970.

11. BANDYOPADHYAY, C.; GHOLAP, A. S.; MAMDAPUR, V. R. Characterization of Alkenylresorcinol in Mango (*Mangifera indica L*.) Latex. J. Agric. Food Chem, v. 33, n. 3, p. 377–379, 1985.
12. BANIK, B. L.; BROWN, J. L. Polymeric Biomaterials in Nanomedicine. In: Natural and Synthetic Biomedical Polymers. [s.l.] Elsevier Inc., 2014. p. 387–395.
13. BASKAR, D. Plant, exudates and mucilages. J. Adv. Pharm. Edu. & Res., v. 03, n. 04, p. 387–402, 2013.
14. BASTO, S. *et al*. Emulsão e microemulsão: novos sistemas de liberação controlada de fármacos no tratamento veterinário. UFRPE, v. 10, n. 1–4, p. 25–33, 2016.
15. BAYONA, Q. F, J. Evaluación de la actividad antibacteriana in vitro de la resina de *Mangifera indica* sobre cepas de *Escherichia coli*, *Staphylococcus aureus*, y *Pseudomonas aeruginosa*. Universidad de Santander, Cucuta, 2016.
16. BHATIA, S.; Plant Derived Polymers, Properties, Modification & Applications. In: Natural Polymer Drug Delivery Systems. [s.l.] Springer International Publishing, 2016. p. 119–184.
17. BHOSALE, R. R.; OSMANI, R. A. M.; MOIN, A. Natural gums and mucilages: A review on multifaceted excipients in pharmaceutical science and research. International Journal of Pharmacognosy and Phytochemical Research, v. 6, n. 4, p. 901–912, 2014.
18. BIRDWOOD, G. Catalogue of the economic products of the presidency of Bombay. A catalogue of the government central museum.pp:386, 1862.
19. BIZERRA, A.; SILVA, V. Sistemas de liberação controlada: Mecanismos e aplicações. Revista Saúde e Meio Ambiente-RESMA, v. 3, n. 2, p. 1–12, 2016.
20. BRITO, G. F. *et al*. Biopolímeros, Polímeros Biodegradáveis e Polímeros Verdes. n. 2, p. 127–139, 2011.
21. BRUM JUNIOR, L. Desenvolvimento e avaliação da atividade e farmacocinética de nanopartículas lipídicas sólidas contendo a associação de Quinina e Doxiciclina. PortoAlegre, 2011.
22. CAMARGO, Z. *et al*. Nanocápsulas poliméricas deformáveis no encapsulamento de bioativos.Brasil, 2013.
23. CARDOSO, M.; LIMA, P.; QUEIROZ, R. P. Nanomedicina: Aplicação da nanotecnologia na medicina. 2013.
24. CARR, R. L. Evaluating flow properties of solids. Chem Eng J , v. 72, p. 163–168, 1965.
25. CHANDRAJITH, V. G.; MARAPANA, R. Physicochemical and Phytochemical Characters of Bark Exudates of *Mangifera indica*. Chemistry Research Journal, v. 3, n. 3, p. 88–91, 2018.
26. CHANG, R. *et al*. Amphiphilic peptide nanoparticles for use as hydrophobic drug carriers and antibacterial agentsUS, 2017.
27. CHOUDHARY, P. D.; PAWAR, H. A. Recently Investigated Natural Gums and Mucilages as Pharmaceutical Excipients: An Overview. Journal of Pharmaceutics, v. 2014, p. 1–9, 7 abr. 2014.
28. CORSANO, S.; MINCIONE, E. Triterpenoids from *Mangifera indica*: I. The structure of mangiferolic acid. Tetrahedren Letters, v. 28, p. 2377–2381, 1965.
29. CORSANO, S.; MINCIONE, E. The absolute configuration of ambonic acid at C-25. Chemical Communications (London), n. 13, p. 738–739, 1968.
30. COUVREUR, P. *et al*. Nanocapsule technology: a review. Crit. Rev. Therapeutic Drug Carrier Systems, v. 19, n. 2, p. 99–134, 2002.
31. DIXIT, M. *et al*. Characterization of Tabletting Properties of Mango Gum. Research & Reviews: A Journal of Drug Formulation, Development and Production, v. 1, n. 1, 2014.
32. DUFRESNE, A.; LIN, N. 7 Characterization of Polysaccharide Nanocrystal-Based Materials.Polysaccharide-Based Nanocrystals: Chemistry and Applications, First Edition. Edited by Jin Huang, Peter R. Chang, Ning Lin and Alain Dufresne. by Chemical Industry Press. Published by Wiley-VCH Verlag GmbH & Co. KGaA, 2015.
33. EDWIN J, EDWIN S, DOSI S, RAJ A, G. S. Application of hibiscus leaves mucilage as suspending agent. Indian. J Pharm Educ Res, v. 41, p. 373–375, 2007.
34. EMEJE, M. *et al*. Isolation, characterization and formulation properties of a new plant gum obtained from Cissus refescence . International Journal of Green Pharmacy, v. 3, n. 1, p. 16, 15 abr. 2009.
35. FACCIO, C. Caracterização e uso da mucilagem do jaracatiá [Carica quercifolia (a. st.-hil.)Hhieron] na adsorção de papaína. Santa Catarina, 2015.
36. FATHI, M.; MOHEBBI, M.; KOOCHEKI, A. Introducing Prunus cerasus gum exudates: Chemical structure, molecular weight, and rheological properties. Food Hydrocolloids, v. 61, 2016.
37. FEDELI, E. *et al*. Nanoobjects formed by ionic PAMAM dendrimers: hydrophilic/lipophilic modulation and encapsulation properties. Soft Matter, v. 11, n. 30, p. 6009–6017, 14 ago. 2015.
38. FIGUEIREDO, A. *et al*. Histoquímica e citoquímica em plantas: princípios e protocolos. Lisboa, 2007.
39. FISZMAN, S.; VARELA, P. The role of gums in satiety/satiation. A review. Food Hydrocolloids, v. 32, n. 1, p. 147–154, 2013.
40. FRANCO, N. Nanopartículas e suas Aplicações em Ciências Farmacêuticas O Estado da Arte. Porto, 2013.
41. ROCHA, G. M.; CÉSAR, P.; SOUZA, A. Inovação tecnológica em fármacos e

medicamentos. 1. ed. Olinda: Livro Rápido, 2017.
42. GARCES, J.; MUÑOZ, A.; ANTON, J. Pharmaceutical preparation for improving the bioavalability of drugs which are difficult to absorband a procedure for obtaining it United States Patent, n. 5,736,161. 1998.
43. GARG, A. *et al*. Nanomedicine: Emerging Trends in Treatment of Malaria. In: Antimicrobial Nanoarchitectonics: From Synthesis to Applications. [s.l.] Elsevier Inc., 2017. p. 475–509.
44. GARG, A. *et al*. Applications of natural polymers in mucoadhesive drug delivery: An overview. Advance Pharmaceutical Journal, v. 3, n. 2, p. 38–42, 26 jun. 2018.
45. GHALANDARI, B. *et al*. The new insight into oral drug delivery system based on metal drugs in colon cancer therapy through β-lactoglobulin/oxali-palladium nanocapsules. Journal of Photochemistry and Photobiology B: Biology, v. 140, p. 255–265, 2014.
46. GHAYEMPOUR, S.; MONTAZER, M.; MAHMOUDI RAD, M. Tragacanth gum as a natural polymeric wall for producing antimicrobial nanocapsules loaded with plant extract. International Journal of Biological Macromolecules, v. 81, p. 514–520, 1 nov. 2015.
47. GIGANTE, B. Natural Resins. Conservar Patrimônio, v. 1, p. 33–46, 2005.
48. GONZAGA, W. A. Preparação e Avaliação Farmacológica de Derivados dos Lipídios Fenólicos do Líquido da Casca da Castanha de Caju. Brasília, 2008.
49. GONZÁLEZ-MARTÍNEZ, D. A. *et al*. Characterization of a novel complex coacervate based on whey protein isolate-tamarind seed mucilage. Food Hydrocolloids, v. 72, 2017.
50. GOSWAMI, S.; NAIK, S. Natural gums and its pharmaceutical application. Journal of Scientific and Innovative Research, v. 3, n. 1, p. 112–121, 2014.
51. GU, M. *et al*. Applications of stimuli-responsive nanoscale drug delivery systems in translational researchDrug Discovery TodayElsevier Ltd, , 1 maio 2018.
52. HABIBI, Y.; LUCIA, L. A. Polysaccharide building blocks : a sustainable approach to the development of renewable materials. [s.l.] John Wiley & Sons, 2012.
53. HAMDANI, A. M.; WANI, I. A.; BHAT, N. A. Sources, structure, properties and health benefits of plant gums: A review. International Journal of Biological Macromolecules, v. 135, p. 46–61, ago. 2019.
54. HEMALATHA, S.; SRIKANTH, P.; SAI, M. Formulation and Evaluation of Bilayered Tablets Containing Immediate Release Layer of Glimepiride Complexed with *Mangifera indica* Gum and Sustained Release Layer Containing Metformin HCL by Using HPMC as Release Retardant. International Journal of Pharmaceutical and Clinical Research, v. 9, n. 6, 17 ago. 2017.
55. HENN RUUS. Method of encapsulation. Niagara Falls, , 1969.
56. HIRST, E. L.; JONES, J. K. N. The gums and mucilages of plants. In: Aufbau · Speicherung · Mobilisierung und Umbildung der Kohlenhydrate / Formation · Storage · Mobilization and Transformation of Carbohydrates. [s.l.] Springer Berlin Heidelberg, 1958. p. 500–517.
57. HOLKEM, A. T. *et al*. Preparation techniques of nanotechnology systems applied to food. Ciência e Natura, v. 37, n. Ed. Esp., p. 87–96, 2015.
58. HOMBREIRO PEREZ, M. *et al*. The preparation and evaluation of poly(e-caprolactone) microparticles containing both a lipophilic and a hydrophilic drug. Journal of Controlled Release. v. 65, p. 429-438, 2000.
59. IVERSEN, T. G.; SKOTLAND, T.; SANDVIG, K. Endocytosis and intracellular transport of nanoparticles: Present knowledge and need for future studies. Nano Today, v.6, n. 2. p.176-185.abr. 2011.
60. JAKKI, S. L. *et al*. Novel anionic polymer as a carrier for CNS delivery of anti-Alzheimer drug. Drug Delivery, v. 23, n. 9, p. 3471–3479, 21 nov. 2016.
61. JOEL, D. M.; FAHN, A. Ultrastructure of the Resin Ducts of *Mangifera indica L*. (Anacardiaceae). 2. Resin. Secretion in the Primary Stem Ducts. Annals of Botany, v. 46, n. 6, p. 779–783, 1980a.
62. JOEL, D. M.; FAHN, A. Ultrastructure of the Resin Ducts of *Mangifera indica L*. (Anacardiaceae). 3. Secretion of the Protein-polysaccharide Mucilage in the Fruit. Annals of Botany, v. 46, n. 6, p. 785–790, 3 fev. 1980b.
63. JOSÉ, J.; CORRÊA, L. Copal do Brasil: Ocorrência e caracterização físico-química da resina Jutaicica de Santarém. Santarém, 2015.
64. KASGARD, T.; DRUMMOND, C. J. Ordered 2-D and 3-D nanostructured amphiphile self-assembly materials stable in excess solventPhysical Chemistry Chemical Physics, 2006.
65. KHAN, S.; PARVEZ, N.; SHARMA, K. Novel natural mucoadhesive polymers. World Journal of Pharmacy and Pharmaceutical Sciences, v. 4, n. 12, p. 374–388, 2015.
66. KOTHAMASU, P. *et al*. Nanocapsules: The weapons for novel drug delivery systems. BioImpacts, v. 2, n. 2, p. 71–81, 2012.
67. KROKIDA, M. K. Thermal and nonthermal encapsulation methods. [s.l.] CRC Press, 2017.
68. KULKARNI, P. *et al*. Brief introduction of natural gums, mucilages and their applications in novel drug delivery systems-a review. International Journal of Drug Formulation and Research , v. 2, n. 6, p. 54–71, 2011.
69. KUMAR AYAK, R. *et al*. An in vitro evaluation of *Mangifera indica* gum as a potential excipient for oral controled-release matrix tablet.

Pharmacologyonline, v. 2, p. 360–391, 2011.
70. KUMAR AYAK, R.; SWAMY, A. V. Explotation of *Mangifera indica* gum as novel natural geling agent in the desing of formulations. Pharmacologyonline, v. 2, p. 522–541, 2011.
71. KUMAR DHAKA, R. *et al*. Conservation and Scientific Techniques for Improvement of Gum and Resin Yielding Tropical Tree Species.Trends in Biosciences. v. 10, n. 1, p. 64-67, 2017
72. KUMAR, V. *et al*. Dissertação de Mestrado. Feasibility of plant based natural polysaccharide as release modifier for the sustained release preparation of diclofenac sodium tablet. Rajiv Gandhi University of Health Sciences, Bangalo re, Karnataka, 2010.
73. LACCHIA, A. P. S.; GUERREIRO, S. M. C. Aspectos ultra-estruturais dos canais secretores em órgãos vegetativos e reprodutivos de Anacardiaceae. Acta Botanica Brasilica, v. 23, n. 2, p. 376–388, 17 set. 2009.
74. LANGENHEIM, J. H. Plant Resins: Chemistry, Evolution, Ecology, and Ethnobotany. 1. ed. Portland: Timber Press, 2003.
75. LEAL, M. G. Tese de Doutorado. Parámetros fisicoquímicos y rasgos estructurales vinculados con el potencial industrial de dos gomas de Anacardiaceae. Facultad Experimental de Ciencias, Maracaibo, 2014.
76. LETCHFORD, K.; BURT, H. A review of the formation and classification of amphiphilic block copolymer nanoparticulate structures: micelles, nanospheres, nanocapsules and polymersomes. Eu. J. Pharm. Biopharm., 65(3):259-69, mar. 2007.
77. LIECHTY, W. B. *et al*. Polymers for Drug Delivery Systems. Annual Review of Chemical and Biomolecular Engineering, v. 1, n. 1, p. 149–173, 11 jun. 2010.
78. LIMA, A. *et al*. Estimulantes químicos na extração da goma de cajueiro (Anacardium occidentale, l.) Chemical stimulants in the extraction of the gum of cashew tree. Ciência Rural, v. 31, n. 3, p. 409–415, 2001.
79. LIMA, M. R. *et al*. Hydrophobization of cashew gum by acetylation mechanism and amphotericin B encapsulation. International Journal of Biological Macromolecules, v. 108, p. 523–530, 1 mar. 2018.
80. LIN, N.; DUFRESNE, A. Surface Modification of Polysaccharide Nanocrystals. In: Polysaccharide-Based Nanocrystals: Chemistry and Applications, Publisher: Wiley Blackwell (ISBN:9783527336197) p. 63–108. Doi: 10.1002/9783527689378.ch3, 2015.
81. LIU, M. *et al*. Synthesis, characterization, and evaluation of phosphated cross-linked konjac glucomannan hydrogels for colon-targeted drug delivery. Drug Delivery, v. 14, n. 6, p. 397–402, ago. 2007.
82. LÓPEZ-COBO, A. *et al*. Use of HPLC- and GC-QTOF to determine hydrophilic and lipophilic phenols in mango fruit (*Mangifera indica L*.) and its by-products. Food Research International, v. 100, p. 423–434, 1 out. 2017.
83. MAHAMMED, N.; GOWDA, D. V. Formulation and evaluation of mango gum microspheres as a targeted drug delivery to colon. Int J Pharm Bio Sci, v. 5, n. 4, p. 126–137, 2014.
84. MARIMUTHU, J.; JAYAKUMAR, M. Gum-Resinosis in *Mangifera indica*. Korean J. Ecol., v. 24, n. 2, p. 121–123, 2001.
85. MARQUES, J. *et al*. Adaptation of targeted nanocarriers to changing requirements in antimalarial drug delivery. Nanomedicine: Nanotechnology, Biology, and Medicine, v. 13, n. 2, p. 515–525, 1 fev. 2017.
86. MEMIOLU, E. *et al*. Amphiphilic β-cyclodextrins modified on the primary face: Synthesis, characterization, and evaluation of their potential as novel excipients in the preparation of nanocapsules. Journal of Pharmaceutical Sciences, v. 91, n. 5, p. 1214–1224, 2002.
87. MENESTRINA, J. M. *et al*. Similarity of monosaccharide, oligosaccharide and polysaccharide structures in gum exudate of Anacardium occidentale. Phytochemistry, v. 47, n. 5, p. 715–721, mar. 1998.
88. MISHRA, A.; CLARK, J. H.; PAL, S. Modification of Okra mucilage with acrylamide: Synthesis, characterization and swelling behavior. Carbohydrate Polymers, v. 72, n. 4, p. 608–615, 10 jun. 2008.
89. MOGHIMI, S. M. *et al*. Polymeric Nanoparticles as Drug Carriers and Controlled Release Implant Devices. In: Nanoparticulates as Drug Carriers. Deakin University: Imperial College Press, 2015. p. 29–42.
90. MOGOŞANU, G. D.; GRUMEZESCU, A. M. Pharmaceutical Natural Polymers: Structure and Chemistry. In: Handbook of Polymers for Pharmaceutical Technologies. [s.l.] Wiley, 2015. v. 1p. 477–519.
91. MOHAN, S. Physicochemical characterisation and binding property of polysaccharide of Solanum betaceum cav in tablet formulation. Chennai, 2017.
92. MONTEIRO, A. A. DE S. *et al*. Efeito da modificação química na solubilidade e intumescimento de microesferas à base de goma do cajueiro carboximetilada e quitosana. Polímeros, v. 25, n. spe, p. 31–39, dez. 2015.
93. MORA-HUERTAS, C. E.; FESSI, H.; ELAISSARI, A. Polymer-based nanocapsules for drug delivery International Journal of PharmaceuticsElsevier B.V., 29 jan. 2010.
94. MOSQUEIRA, V. C. F.; SANTOS-MAGALHAES, N. Application of pharmaceutical nanotechnology to the treatment of malaria. Revista Brasileira de Ciências Farmacêuticas.Vol. 43, n. 4, out./dez., 2007
95. MUSYANOVYCH, A.; LANDFESTER, K. Polymer micro- and nanocapsules as biological carriers with multifunctional properties. Macromolecular Bioscience. Vol. 14, n. 4, p. 458-477, 2014.

96. MUTHUKUMARAN, M. Natural gums, mucilage's and their applications in novel drug delivery systems – A comprehensive review. World Journal of Pharmacy and Pharmaceutical Sciences, v. 6, n. 4, p. 921–937, 24 abr. 2017.
97. NAWAB, A. *et al*. Effect of guar and xanthan gums on functional properties of mango (*Mangifera indica*) kernel starch. International Journal of Biological Macromolecules, 2016.
98. NAWAZ, M.; ROHAN, D. D.; GOWDA, D. V. Modified polysaccharide as drug delivery: review. JSS College of pharmacy, v. 11, n. 1, 2011.
99. NAYAK, R. K. *et al*. Aninverto evaluation of *Mangifera indica* gum as a potential excipient for oral controlled - release matrix tablet. Pharmacologyonline, 2011.
100. NAYAK, R. K. *et al*. A Novel Binding Agent For Pharmaceutical Formulation From *Mangifera Indica* Tree. Asian Journal of Biochemical and Pharmaceutical Research Issue, v. 2, n. 1, p. 2012, 2012.
101. NDINGA, E. A.; J-M, O. Characterization of volatile compounds from the gum-resin of *Mangifera indica L*. trunk bark using HS-SPME-GC/MS. Série Pharm. Méd. Trad. Afr, v. 17, n. 2, p. 1–7, 2015.
102. NGWULUKA, N. C.; OCHEKPE, N. A.; ARUOMA, O. I. Naturapolyceutics: The science of utilizing natural polymers for drug deliveryPolymersMolecular Diversity Preservation International, , 2014.
103. NOKHODCHI, A. *et al*. Application of Polymer Combinations in Extended Release Hydrophilic Matrices. In: Handbook of Polymers for Pharmaceutical Technologies. [s.l.] Wiley, 2015. v. 1p. 23–49.
104. NUSSINOVITCH, A. Plant Gum Exudates of the World. Plant Gum Exudates of the World, 2009.
105. OGAJI, I. J.; NEP, E. I.; AUDU-PETER, J. D. Advances in Natural Polymers as Pharmaceutical Excipients. Pharmaceutica Analytica Acta, v. 03, n. 01, 29 fev. 2012.
106. OLAYEMI, O.; SALIHU, B.; ALLAGH, S. Evaluation of the binding properties of Spondias purpurea gum in metronidazole tablet formualtions. International Journal of Pharmacy and Pharmaceutical Sciences, v. 5, n. SUPPL. 2, p. 584–589, 2013.
107. OLIVEIRA, M. D. B. *et al*. Ácido Tânico nos Procedimentos Restauradores. J. Health, v. 19, p. 4–290, 2017.
108. PADIL, V. V. T. *et al*. Tree gum-based renewable materials: Sustainable applications in nanotechnology, biomedical and environmental fieldsBiotechnology AdvancesElsevier Inc., , 15 nov. 2018.
109. PAIPHANSIRI, U.; TANGBORIBOONRAT, P.; LANDFESTER, K. Polymeric nanocapsules containing an antiseptic agent obtained by controlled nanoprecipitation onto water-in-oil miniemulsion droplets. Macromolecular Bioscience, v. 6, n. 1, p. 33–40, 5 jan. 2006.
110. PATHAK, D. *et al*. Physicochemical characterization and toxicological evaluation of plant-based anionic polymers and their nanoparticulated system for ocular delivery. Nanotoxicology, v. 8, n. 8, p. 843–855, 2014.
111. PILETTI, R. Dissertação de Mestrado. Extração da mucilagem da tuna (Cereus hildmaniannus k. Schum) para aproveitamento industrial. Universidade Federal de Santa Catarina. Florianópolis, 2011.
112. PINHEIRO A. C. *et al*.Utilização de revestimentos/filmes edíveis para aplicações alimentares. http://hdl.handle.net/1822/16725.(ISSN: 1645-5878). Braga, 2010.
113. PRABHAKAR, V.; TAPAN, A.; RATAN, R. Magic Bullets - Nanocapsules in Future Medicine. http://ijps.aizeonpublishers.net/content/2013/4/ijps303-308.pdf International Journal of Pharma Sciences , v. 3, n. 4, p. 303–308, 2013.
114. PRADO, E.; DEMARCO, D. Laticifers and Secretory Ducts: Similarities and Differences. Ecosystem Services and Global Ecology, 2018.
115. PRAJAPATI, V. D. *et al*. Pharmaceutical applications of various natural gums, mucilages and their modified forms Carbohydrate Polymers, 15 fev. 2013.
116. PURI, V.; SHARMA, P.; NAGPAL, M. An Update on Some Recent Solubility Enhancers as Pharmaceutical Excipients. Journal of Pharmaceutical Technology, Research and Management, v. 4, n. 1, p. 45–62, 5 maio 2016.
117. RAI, S. *et al*. Oriental medicine *Mangifera indica*. Oriental pharmacy and experimental medicine, v. 7, n. 1, p. 1–10, 2007.
118. RAJESWARI, S.; GOKA, V. Natural polymers: A recent review. World Journal of Pharmacy and Pharmaceutical Sciences, v. 6, n. 8, p. 472–494, 9 ago. 2017.
119. RANA, V. *et al*. Modified gums: Approaches and applications in drug deliveryCarbohydrate Polymers, 30 jan. 2011.
120. RAVINDRAKULLAI REDDY, M.; MANJUNATH, K. Pharmaceutical Applications of Natural Gums, Mucilages and Pectins-A Review. International Journal of Pharmaceutical and Chemical Sciences, v. 2, n. 3, p. 1233–1239, 2013.
121. RIBAS, D. A.Tese de Doutorado. Desenvolvimento de nanocápsulas contendo Cetoprofeno e avaliação in vitro da citotoxicidade. Universidade Federal de Santa Maria, Santa Maria, 2013.
122. RIBEIRO, A. J. *et al*. Gums' based delivery systems: Review on cashew gum and its derivatives Carbohydrate Polymers, 2016. vol. 147, p.188-200. Doi: 10.1016/j.carbpol.2016.02.042.
123. RIBEIRO, L. N. M. *et al*. Advances in Hybrid Polymer-Based Materials for Sustained Drug Release. International Journal of Polymer

Science, v. 2017, p. 1–16, 1 nov. 2017.
124. ROCHA, M. C. Dissertação de Mestrado. Extração, propriedades físico -químicas e utilização de mucilagem de chia (*Salvia hispanica l*.) como substituto de gordura em biscoitos. Universidade Federal de Lavras, Lavras, 2017.
125. RODRIGUES, J.; PAULA, R.; COSTA, S. Métodos de Isolamento de Gomas Naturais: Comparação Através da Goma do Cajueiro (Anacardiumoccidentale L). Polímeros: Ciência e Tecnologia -, p. 31–36, 1993.
126. RODRIGUES, R. G. Tese de Doutorado. Análise morfológica e fitoquímica da Fava d'Anta (Dimorphandra mollis Benth). UFV, 2007.
127. SAH, S. K. *et al*. Natural Gums Emphasized Grafting Technique: Applications and Perspectives in Floating Drug Delivery SystemAsian Journal of Pharmaceutics. V. 10 n.2 p. 72-83, 2016.
128. SALIM, M. *et al*. Amphiphilic designer nano-carriers for controlled release: From drug delivery to Diagnostics Med Chem Comm Royal Society of Chemistry,vol. 5, n.11, p. 1602-1618,1 nov. 2014.
129. SANT', B. F. *et al*. Anatomia e histoquímica das estruturas secretoras do caule de Spondias dulcis forst. f. (Anacardiaceae). Sociedade de investigações florestais, v. 30, n. 3, p. 481–489, 2006.
130. SANTOS, P. P. *et al*. Biodegradable polymers as wall materials to the synthesis of bioactive compound nanocapsules. Trends in Food Science and Technology Elsevier Ltd, , 1 jul. 2016.
131. SANTOS, V. M. R. *et al*. Síntese e caracterização de novos copolímeros fosforilados. Polímeros, v. 25, n. spe, p. 19–24, 17 jan. 2016.
132. SARKAR, P. C. *et al*. Studies on physico-chemical and functional properties of some natural Indian gums. Asian Journal of Dairy and Food Research, v. 37, n. 02, 6 jun. 2018.
133. SCHNIZL, Z. The infrastructure of Mucilage Secreting Trichomes of. v. 41, n. 2, p. 227–245, 2001.
134. SELLÉS, A. *et al*. Isolation and quantitative analysis of phenolic antioxidants, free sugars, and polyols from mango (*Mangifera indica L*.) stem bark aqueous decoction used in Cuba as a nutritional supplement. Journal of agricultural and food chemistry, v. 50, n. 4, p. 762–766, 2002.
135. SHARMA, D. R. *et al*. Herbal gums and mucilage as excipients for Pharmaceutical Products. Research Journal of Pharmacognosy and Phytochemistry, v. 8, n. 3, p. 145, 18 out. 2016.
136. SHINGALA, V. K. *et al*. Design and characterization of diclofenac sodium tablets containing *Mangifera indica* resin as release retardant. International Journal of PharmTech Research, v. 2, n. 3, p. 2107–2111, jul. 2010.
137. SIERAKOWSKI, M. R. Tese de Doutorado. Aspectos Estruturais da mucilagem de Pereskia aculeata, Mill (ora-pro-nobis). Curitiba: Universidade Federal do Paraná, 1988.
138. SILVA, F. C.; DUARTE, L. P.; VIEIRA FILHO, S. A. Celastráceas: Fontes de triterpenos pentacíclicos com potencial atividade biológica. Revista Virtual de Quimica, v. 6, n. 5, p. 1205–1220, 2014.
139. SILVA, L. L. *et al*. Composição química, atividade antibacteriana in vitro e toxicidade em Artemia salina do óleo essencial das inflorescências de Ocimum gratissimum L., Lamiaceae. Brazilian Journal of Pharmacognosy, v. 20, n. 5, p. 700–705, out. 2010.
140. SINGH, A. K. *et al*. Evaluation of *Mangifera indica* gum as tablet binder. International Journal of PharmTech Research, v. 2, n. 3, p. 2098–2100, jul. 2010.
141. SINGH, A. K.; PANNER, S.; SIVAKUMAR, T. Isolation, characterization and formulation properties of a new plant gum obtained from *Mangifera indica*. International Journal of Pharmaceutical and Biomedical Research (IJPBR), v. 1, n. 2, p. 35, 2010.
142. SIRISHA, V. L.; DSOUZA, J. S. Polysaccharide-based nanoparticles as drug delivery systems. In: Marine OMICS: Principles and Applications. CRC Press, 2016. p. 643–682.
143. SOARES, C. E. A. Tese de Doutorado. Caracterização estrutural e potencial da galactomana de Adenanthera pavonina L. como produção de filmes comestíveis bioativos. Universidade Federal do Ceará, Fortaleza, 2009.
144. SOUTO, E. B.; SEVERINO, P.; SANTANA, M. H. A. Preparação de nanopartículas poliméricas a partir de polímeros pré-formados: parte II. Polímeros, v. 22, n. 1, p. 101–106, 27 jan. 2012.
145. SUDARSHAN, S.; SUNIL B, B. In vivo mucoadhesive strength appraisal of gum Manilkara Zapota. Brazilian Journal of Pharmaceutical Sciences, v. 51, n. 3, p. 689–698, 1 jul. 2015.
146. THAKUR, V. K.; THAKUR, M. K. Handbook of Polymers for Pharmaceutical Technologies. [s.l.] Wiley, 2015. v. 2
147. TIWARI, G. *et al*. Drug delivery systems: An updated review. International journal of pharmaceutical investigation, v. 2, n. 1, p. 2–11, jan. 2012.
148. TORCHILIN, V. Nanoparticules as Drug Carriers. 1. ed. Londres: Imperial College Press, 2006.
149. TOWLE, G. A.; WHISTLER, R. L. Chemical Modification of Gums. In: Industrial Gums: Polysaccharides and Their Derivatives: Third Edition. [s.l.] Elsevier Inc., 2012. p. 53–67.
150. TREVISAN, M. T. S. *et al*. Characterization and Quantitation of Polyphenolic Compounds in Bark, Kernel, Leaves, and Peel of Mango (

Mangifera indica L.) . Journal of Agricultural and Food Chemistry, v. 56, n. 14, p. 5599–5610, 2008.
151. U. RAGHU, A. A. HINDUSTAN, K. HARITHA, J. ANJI, G. SUDHAKAR, G. V. Review Article Quick Reference to the Matrix Forming Gums and Mucilage. Journal, International Science, Modern Sciences, Pharmaceutical Pharmacy, Industrial Education, Pharmaceutical, v. 4, n. 3, p. 61–66, 2019.
152. VASANTRAO PATIL, S. *et al*. Natural binders in tablet formulation. International Journal of PharmTech Research, v. 6, n. 3, p. 1070–1073, 2014.
153. VASQUEZ, E. *et al*. Influence of the Ionic Strength in the Intrinsic Viscosity of Xanthan Gum. An Experimental Review. Journal of Polymer and Biopolymer Physics Chemistry, v. 3, n. 1, p. 12–18, 2015.
154. VEIGA, F. J. G. Medicamentos orais de liberação controlada: comprimidos matriciais hidrófilos. Boi. Fac. Farm. Coimbra, v. 12, n. 2, p. 17–87, 1988.
155. VINOD R. Formulation and Evaluation of Nicorandil Sustained Release Matrix Tablets Using Natural Gum *Mangifera Indica* as Release Modifier. Asian Journal of Biomedical and Pharmaceutical Sciences; vol. 3, n.18, p. 54-60, 2013.
156. VINOD, V. T. P. *et al*. Compositional analysis and rheological properties of gum kondagogu (*Cochlospermum gossypium*): A tree gum from India. Journal of Agricultural and Food Chemistry, v. 56, n. 6, 2008.
157. VRIGNAUD, S. *et al*. Aqueous core nanocapsules: A new solution for encapsulating doxorubicin hydrochloride. Drug Development and Industrial Pharmacy, v. 39, n. 11, p. 1706–1711, nov. 2013.
158. VRIGNAUD, S.; BENOIT, J. P.; SAULNIER, P. Strategies for the nanoencapsulation of hydrophilic molecules in polymer-based nanoparticles Biomaterials, nov. 2011. Doi:10.1016/j.biomaterials.2011.07.057.
159. WANG, A.; WANG, W. Gum-g-copolymers: Synthesis, properties, and applications. In: Polysaccharide Based Graft Copolymers. Springer-Verlag Berlin Heidelberg. ISBN: 9783642365669 p. 149–203, 2013.
160. WANG, C. Z. *et al*. Chemical constituents and structural characterization of polysaccharides from four typical bamboo species leaves. Molecules, v. 20, n. 3, p. 4162–4179, 1 mar. 2015.
161. WANG, H.; HALAS, N. J. Mesoscopic au “meatball” particles. Advanced Materials, v. 20, n. 4, p. 820–825, 18 fev. 2008.
162. WANG, Q.; ELLIS, P. R.; ROSS-MURPHY, S. B. The stability of guar gum in an aqueous system under acidic conditions. Food Hydrocolloids, v. 14, n. 2, p. 129–134, 2000.
163. WET, E.; ROBBERTSE, P. J.; COETZEE, J. Ultrastructure of the stigma and style of *Mangifera indica L*. South African Journal of Botany, v. 56, n. 2, p. 206–213, 2016.
164. WU, C.-Y. *et al*. Different Mechanisms of Seed Kernel Extract from *Mangifera indica* on the Growth of Two Colon Cancer Cell Lines. Food and Nutrition Sciences, v. 06, n. 04, p. 421–428, 23 mar. 2015.
165. WU, Y. *et al*. An investigation of four commercial galactomannans on their emulsion and rheological properties. Food Research International, v. 42, n. 8, 2009.
166. YALAVARTHI,P.R.;CHOWDARY VADLAMUDI, H. Design and Assessment of Colon Specific Drug Delivery of Mefenamic Acid using Modified Pulsincap Technique and Hupu Gum. Indo American Journal of Pharmaceutical Research. (ISSN: 2231-6876) v. 2, n. 9, 2012.
167. YANG, L.; ZHANG, L. M. Chemical structural and chain conformational characterization of some bioactive polysaccharides isolated from natural sources. Carbohydrate Polymers, v. 76, n. 3, p. 349-361, 9 abr. 2009.
168. YI, Q. *et al*. Bioreducible nanocapsules for folic acid-assisted targeting and effective tumor-specific chemotherapy. International Journal of Nanomedicine, v. 13, p. 653–667, 31 jan. 2018.