Review Article

Natural Polymers: Use As Superdisintegrants

Kiran Aphale*, Sneha Patil
Department of Pharmaceutics, PES Modern College of Pharmacy, Moshi (for Ladies), Pin code- 412105, Pune, India.
Savitribai Phule Pune University, Maharashtra, Pune, India.
***Corresponding author's E-mail:** aphalekiran1312@gmail.com

Received: 12-04-2024; **Revised:** 25-06-2024; **Accepted:** 06-07-2024; **Published on:** 15-07-2024.

ABSTRACT

Drugs are best administered orally since it is simpler to swallow, less likely to cause discomfort, more adaptable, and most importantly better for patient compliance. Many patients have trouble swallowing pills and capsules, which causes them to stop taking their medications as directed. An estimated 50% of the population is thought to be impacted by this issue, which ultimately raises the risk of noncompliance and poor treatment. These factors have led to a great deal of interest in pills that dissolve in the mouth. These days, both pediatric and geriatric patients accept the novel dosage form known as "fast dissolving tablet," since it doesn't require water to swallow. The current article's goal is to investigate the natural polymers found in quickly dissolving pills. natural polymers that enhance tablet qualities and can be used as binder, diluents, or superdisintegrant. They can also be used to shorten the disintegration time, increase the solubility of poorly water-soluble drugs, and provide nutritional supplements. Natural polymers are inexpensive, non-toxic, biodegradable, environmentally friendly, free of side effects, renewable, and a source of additional nutrients. They can be easily obtained from their natural origin. Studies have demonstrated this.

Keywords: Natural, Superdisintegrants, Mouth Dissolving Tablets, Natural Polymers, Orodispersible Tablets, Gums, Mucilages.

INTRODUCTION

Fast-disintegrating tablets with better patient compliance and convenience were recently developed by researchers. Fast-dissolving tablets are solid dosage forms that dissolve quickly in saliva without the need for extra water or chewing. The drawbacks of traditional dosage forms are mitigated by fast-disintegrating tablets, particularly in cases of dysphagia (difficulty swallowing) in older and pediatric patients. Natural materials are more advantageous than synthetic ones because they are widely available, nontoxic, chemically inert, and biodegradable[1].

Since natural superdisintegrants demonstrate disintegrating properties comparable to those of synthetic agents or dispersible tablets, they can be used in place of synthetic superdisintegrants.

It has been suggested that the rate-limiting stage of quicker medication release is tablet disintegration. Many studies have been conducted on natural gums and mucilages as medicinal excipients. These find extensive application in the pharmaceutical sector as film formers, disintegrants, gelling agents, thickeners, emulsifiers, stabilizers, granulating agents, suspending agents, binder, and sustained release matrix. There is a growing market for these natural resources, and more are being created. In the realm of drug delivery, natural gums and mucilages are chosen over semi-synthetic and synthetic excipients due to their affordability, accessibility, calming effect, and nonirritating nature.[2]

- **Ideal Properties of Fast-Dissolving Tablets**

1. When put in the mouth, they ought to dissolve in a matter of seconds. Water ought not to be required in order for them to dissolve.
2. They should provide an accurate dosage since they are unit dosage forms.
3. Quick disintegration and absorption in the mouth Simple to explain.
4. Low-cost conventional equipment is used in the production of tablets.
5. Less susceptible to temperature and humidity fluctuations in the environment.
6. They ought to retain their hardness and be less brittle[3].

- **Superdisintegrants**

Disintegrating agents are chemicals that are frequently added to tablet formulations to help the compacted mass break apart in a fluid environment. They facilitate the tablet matrix's dispersion and moisture penetration. "Superdisintegrants" are a new class of agents that have been developed in recent years. These more recent materials have higher mechanical strength and disintegration efficiency, making them more effective at lower concentrations. The superdisintegrants undergo a disruptive change in the tablet upon coming into contact with water. They hydrate, swell, and change in volume or form. Superdisintegrants that are effective offer enhanced compressibility and compatibility to formulations containing high-dose drugs without compromising their mechanical strength. Gums, mucilages, and other naturally occurring substances are among the natural

superdisintegrants. These substances exhibit superior disintegrating efficiency and mechanical strength at lower concentrations. The creation of FDTs has involved the use of agar, modified starch, and gum karaya, among other natural ingredients. Natural mucilage is favored over semisynthetic and synthetic varieties due to its abundance, relative affordability, lack of irritability, and nontoxic properties.

- **Standards of Selection for Superdisintegrants**
    1. The size of the particle should be small.
    2. non-toxic.
    3. compatible with the medication and other excipients
    4. Good ability to hydrate
    5. Good flow characteristics
    6. pleasant mouthfeel. [4,5]
- **Types of Superdisintegrants and Their Examples**
- There are two types of superdisintegrants:
  A) Synthetic superdisintegrant
  B) Natural superdisintegrant

Natural superdisintegrant

These naturally occurring superdisintegranting agents are chosen over synthetic substances due to their abundance, relative affordability, lack of irritation, and nontoxic nature. Gums and mucilages are examples of natural materials that are widely used in the drug delivery field because they are easily obtainable, economical, environmentally friendly, emollient and nonirritating by nature, non-toxic, capable of a wide range of chemical modifications, potentially biodegradable, and compatible because of their natural origins. [6]

1. ***Ficus indica* Fruit Mucilage:** The pulp of the *Ficus indica* fruit is used to extract the mucilage, which is then used as an extremely disintegrant. The Ficus India tree grows astronomically quickly, reaching heights of up to three meters, and features spread branches and aerial roots. The *Ficus indica* plant yields cherry-sized fruits. It is beneficial both medicinally and nutritionally. For every 100 grams, or 3.5 ounces, of dried and raw *Ficus indica* fruit, there are 230 kcal (963 KJ) of energy. It is used to treat fever, pain, inflammation, wound healing, blood problems, and urinary problems[7].

2. ***Cucurbita maxima* pulp powder:** The fruit of *Cucurbita maxima* was cleansed with water to get rid of dirt and contaminants before the skin was removed. After removing the seed, the pulp was added to a juicer mixer to create a very viscous liquid. To create a solid, porous mass, the viscous liquid underwent additional lyophilization. Powder was gathered after size reduction was completed. After being filtered using an 80-# sieve, the powder was collected and stored for later research. Cucurbita maxima pulp powder, derived naturally, is a good candidate to function as a super-disintegrant because it also has comparable hardness and friability. This polymer 21 can be used to develop promising ODTs [8] .

3. ***Portulaca oleraceae* mucilage:** It is also known as red root and pursely. It belongs to the family Portulacaceae. The leaf contains omega-3-fatty acids and dietary minerals. It is used as a natural disintegrant in the formulation of fast-dissolving tablets; studies have revealed that the results obtained from the *Portulaca oleraceae* mucilage are better than those of conventional commercial formulations [9].

4. ***Arachis hypogaea* shell powder (AHSP**): Other names for peanuts include goober, monkey nut, and groundnut. *Arachis hypogaea*, a member of the Fabaceae (Leguminosae) family, is the taxonomically classified name for peanuts. A light, sandy loam soil with a pH of 5.9–7 is ideal for peanut growth. In addition to dietary fiber, phytosterols, polyunsaturated and monosaturated fats, and polyphenols are present. Resveratrol can be found in peanut skins. The process of preparing AHSP involves cleaning peanut shells with water to get rid of any dirt and then sun-drying them for a day. Subsequently, the shells are separated and heated to 100 °C for 30 minutes. Afterward, they are ground in a grinder and filtered through #60 mesh. AHSP was used in different concentrations to prepare the tablets using the direct compression method. The AHSP has a large super-disintegrant potential and a disintegration time of 9 to 22 seconds[10].

5. **Abelmoschus gum:** The fresh fruits of the *Abelmoschus esculentus* plant (family Malvaceae) are used to make okra gum. With some fractions of glucose, mannose, arabinose, and xylose, the major polysaccharide component of okra polysaccharide varies greatly in the molar ratios of galactose, galacturonic acid, and rhamnose[11]. The safety and suitability of Abelmoschus esculentus pod mucilage as a suspending agent are assessed. After being shown to be nontoxic, the extracted mucilage was utilized to create a suspension of paracetamol. It was discovered that mucilage was a more effective suspending agent than tragacanth, with a suspending efficiency that was comparable to sodium CMC [12].

6. **Albizia gum:** The incised trunk of the *Albizia zygia* tree (Family Leguminosae) is the source of albizia gum. The composition is made up of some ß1-6-linked D-galactose units mixed with β-1-3-linked D-galactose units. Research has been done on albizia gum as a potential natural emulsifier for food and medicine, replacing gum arabic[13,14] . These gums were used as filler in compression-coated tablets, which the colonic microbiota broke down, releasing the medication [15] .

7. **Tamarind Seed Polysaccharide:** The endosperm of the seed of the tamarind tree, *Tamarindus indica* (family Fabaceae), yields tamarind xyloglucan. The

polysaccharide known astamarind gum is made up of glucosyl, xylosyl, and galactosyl in a 3:1:2:1 ratio. Using the wet granulation method, the polysaccharide extracted from tamarind seeds was incorporated into matrix tablets, and its drug release properties were assessed [16] . The polymer was prepared in various concentrations to create tablets. Drug release was reduced by an increase in polymer content. The potential of tamarind seed polysaccharide as a biodegradable drug delivery agent targeted at the colon was investigated. It was discovered that the tamarind gum-prepared matrix tablets could largely transport the medication to the colon and limit its release in the upper gastrointestinal tract [17] .

8. ***Honey locust* Gum:** The gum is made from the seeds of the Leguminosae family plant, *Gleditsia triacanthos*. Proteins, fats, carbohydrates, and fibers are all present in seeds. By using the wet granulation method, honey locust gum has been used to create matrix tablets at two different concentrations (5% and 10%) [18].

9. **Tara Gum:** The endosperm of *Caesalpinia spinosa* seeds (family: Fabaceae or Leguminosae) is used to make tara gum. The primary ingredient in the gum is galactomannans. Even at 1% concentration, tara gum's 3:1 mannose-to-galactose ratio results in extremely viscous solutions [19] . Because of gum swelling, tara gum is used as a controlled release carrier in the formulation of gastroretentive controlled release tablets. Combining tara gum lengthens the dosage form's floating period, demonstrating good gastroretentive properties [20] . The formulation of the emulsion also involved the use of tala gum [21] .

10. **Gum Damar:** A white to yellowish natural gum, gum damar, is made by tapping *Shoreawies neri* (Family: Dipterocarpaceae) trees. It has roughly 40% alcohol-soluble alpha-resin, 22% water, 23% dammarol acid, and 22% beta-resin. Gum damar's ability to form a sustained release matrix has been studied. The matrix's drug release demonstrated continuous drug delivery for more than ten hours [22] . The gum's microencapsulating ability was also assessed. Particle size, encapsulation effectiveness, and drug release rate all decreased as the gum-drug ratio increased. Because of its strong binding qualities, it has also been used in the dental and pharmaceutical industries, as well as for water-resistant coatings[23].

11. **Gum Copal:** The natural resinous gum copal is derived from the *Bursera bipinnata* plant (Burseraceae family). In addition to agathic acid, copal resin also contains agatholic acid, acetoxy agatholic acid, sandaracopimaric acid, ciscommunic acid, transcommunic acid, polycommunic acid, agathalic acid, and monomethyl ester of agathalicacid. Copal gum has been considered a matrix-forming substance to support the delivery of drugs. Copal resin was employed as a film-forming agent in a separate study. Videos demonstrated good swell properties. It was determined that it could be applied as a coating material for colon-targeted and sustained-release drug delivery. Gum copal was used to prepare the film, and its swelling was examined in three different phosphate buffers (pH 4.5, pH 6.0, and pH 7.4). Significant swelling was discovered at pH 7.4, so the colon can be targeted[24].

12. **Moi Gum:** The bark, fruits, leaves, and stems of the *Lanneacoro mandelica* plant (Anacadaceae family) are used to make moi gum. When this gum is new, it is yellowish-white in color; as it dries, it turns dark. Gum ducts can be found in leaves, stems, and fruits, with the stem's bark having the greatest concentration of them [25]. Cluytylferulate is found in the roots; lanosterol is found in the heartwood; dlepi-catechin, bark, and (+)-leucocyanidin; and quercetin, ellagic acid, and quercetin-3 arabinoside are found in the flowers and leaves. Morin and isoquercetin are also found in flowers. Moreover, leucocyanidin, leucodelphinidin, and beta-sitosterol are found in leaves. Moi gum was assessed as a material for controlling release rate and as a microencapsulating agent. The process of solvent evaporation was used to create microspheres. Moi gum generates microspheres with a suitable morphology and size. Compared to guar gum, microspheres formulated with moi gum demonstrated sustained release for longer than 10 hours; however, microspheres with a 1:1 ratio demonstrated more sustained release [26].

13. **Phoenix Mucilage:** The dried fruit of *Phoenix dactylifera* (family Palmaceae) is used to make phoenix mucilage. 44–88% of the fruit is composed of carbohydrates, which are primarily reduced sugars like fructose, sucrose, mannose, glucose, and maltose. There are also trace amounts of polysaccharides like pectin (0.5–3.9%), starch, and cellulose. The date palm mucilage's binding qualities were effectively assessed. It was discovered that tablets made with phoenix mucilage were less friable than those made with tragacanth and acacia. Good uniformity in the weight and hardness of the tablets was produced by the improved binding ability of the gum as its concentration increased[27].

14. **Bhara Gum:** The bark of *Terminalia bellerica*, a plant in the Combretaceae family, yields bhara gum, a naturally occurring gum with a yellowish hue. The primary chemical components are tannins, which are primarily composed of chebulaginic acid, gallic acid, ellagic acid, ß-sitosterol, ethyl gallate, and galloyl glucose. Bhara gum is used in a novel, sustained-release microencapsulated drug delivery system that has been suggested. Famotidine was used as the model drug in the ionic gelation technique used to create the microcapsules. A comparison was made between the drug release profiles of bhara gum and guar gum to assess the impact of various drugs. Bhara gum-based

microcapsules demonstrated a 10-hour famotidine release that was gradual[28].

15. **Mimosa Mucilage:** The *Mimosa pudica* seed (Mimosaceae family) is used to make gum. D-glucuronic acid and D-xylose make up seed mucilage. When mimosa seed mucilage comes into contact with water, it quickly hydrates and swells. The mucilage of Mimosa seeds was investigated as a potential controlled delivery system for diclofenac sodium. Several tablet batches were prepared for this study, and the drug releases from each batch were examined. It was found that the amount of mucilage in Mimosa pudica seeds decreases with increasing mucilage content. For tablets with a higher mucilage content, the mechanism of release is diffusion; for tablets with a lower mucilage content, it is a combination of matrix erosion and diffusion. Research revealed that the percentage of tablets that swelled and the percentage that eroded decreased in proportion to the amount of mucilage present[29] .

16. **Dendrophthoe Mucilage:** The dried and fresh stem parasite of *Dendrophthoe falcate* (family Loranthaceae) on *Magnifera indica* (family Anacardiaceae) is used to make dendrophthoe mucilage. Dendrophthoe falcata's mucilage was tested as a binder for pill forms in medicine. Dendrophthoe-falcate mucilage was combined with wet granulation to create tablets. Various mucilage concentrations were employed in the formulation process. As a tablet binder, it was found that 6% w/w binder concentration produced more ideal outcomes[30].

17. **Cocculus Mucilage:** The leaves of the Menispermaceae family plant *Cocculus hirsute* are used to make mucilage. Polysaccharides and a gelatinous substance are found in mucilage. Leaves have topical applications as a demulcent and emollient. Human skin has not been harmed by it. This mucilage's gelling property was investigated. It was a comparative investigation. To formulate the gel, flurbiprofen was utilized as a model medication. The anti-inflammatory properties of gel made from powdered Cocculus hirsute leaf and gel made from flurbiprofen that is sold were compared. The amount of drug released from the prepared test gel was found to have greater anti-inflammatory activity than the gel that was marketed [31].

18. **Hakea Gum:** Dried exudate from the *Hakea gibbosa* plant (family Proteaceae) is known as hakea gum. Gum contains the following sugars: 12:43:32:5:8 glucuronic acid, galactose, arabinose, mannose, and xylose. Only a portion of the exuded gum dissolves in water[32] . The use of gum in buccal tablets as a mucoadhesive and sustained-release ingredient has been studied. These findings show that Hakea gibbosa has the ability to function as a bioadhesive polymer in addition to being a viable means of sustaining release. The time needed to take 90% of the medication was used as a baseline for comparison in this study. It was noted that a formulation without hakea gum demonstrated a 90% drug release in roughly 14 minutes. However, 90% of the drug was released in approximately 165 minutes when hakea gum was used at a concentration of 32 mg per tablet. Moreover, 90% release occurred in 405 minutes when tablets were directly compressed with 32 mg of hakea gum [33].

19. **Grewia Gum:** Grewia gum is a type of polysaccharide that is obtained from the inner bark of the Tiliaceae family plant *Grewia mollis*, which is edible. The primary monosaccharide components of gum are glucose and rhamnose, while the primary sugar acid is galacturonic acid [34]. Research has been done on the binding and compressional properties of grewia gum. The results of this study showed that formulations with grewia gum had a higher degree of packing than formulations with PVP. It was discovered that grewia gum, as opposed to PVP, improved fluidity in granules. Research was also done on this gum's ability to form matrices. In this investigation, tablets with varying grewia gum concentrations were evaluated after being compressed using the direct compression technique. Growdia gum can regulate the release of cimetidine from tablets for up to 12 hours, according to in vitro drug release studies. Growdia gum and HPMC worked in concert to delay the release of cimetidine from tablets and to enhance their film-forming properties[35].

20. **Olibanum gum:** Olibanum gum is a gummy, dried exudate derived from the Burseraceae family plant *Boswellia serrate*. Gum olibanum is used as an anti-inflammatory, and new research on rheumatism has shown that olibanum has a beneficial effect. Its three main places of origin—Aden/Somalia, Eritrea, and India—determine its chemical makeup and characteristics. Its composition is composed of roughly 40–60% boswellic acid, 13–17% resin acids, 20–30% polysaccharides, and 5-9% oil. Research has been done on olibanum gum's ability to bind and form a sustained release matrix [36]. Microcapsules coated with olibanum resin were created using the solvent-evaporation method of emulsification. Drug release from the resin-coated microcapsules was found to be sluggish over the course of 24 hours and to be dependent on the microcapsules' size, wall thickness, and core-to-coat ratio [37].

21. **Terminalia gum:** The tree *Terminalia randii* (family Combretaceae) has an incised trunk from which Terminalia gum exudates are obtained. Hemorrhoids, wounds, diarrhea, and dysentery are all treated with extracts from the bark and stem of Terminalia randii. Terminalia randii gum exudates have been tested as binding agents. The findings demonstrated that while friability decreased, crushing strength and crushing strength friability ratio increased as polymer concentration increased[38] .

22. **Cordia Mucilage :** The raw fruits of *Cordia obliqua* (family Boraginaceae) are used to make Cordia

mucilage. In addition to being an effective lung disease treatment, cordia mucilage can be used as an expectorant and to treat gonorrhea with raw gum. Research was done on the binding and emulsifying qualities of cordia mucilage[39] .

23. **Ocimum mucilage:** The seeds of *Ocimum americanum*, also known as *Ocimum canum* (family Lamiaceae), are used to make occimum mucilage. Xylose, arabinose, rhamnose, and galacturonic acids are found in mucilage. It was discovered that the mucilage had disintegrating properties. When ocimum mucilage was used to prepare tablet formulations, the disintegration time was shorter than when starch was used as a disintegrant[40].

24. **Konjac Glucomannan:** *Amorphophallus konjac* (family Araceae) tubers are used to extract konjac glucomannan. D-glucose and D-mannose are present in konjac glucomannan in the ratio 1:1.6[41]. Research on the gelling properties of konjac glucomannan was conducted [42].

25. **Salvia hispanica:** *Salvia hispanica*, an herbaceous plant in the Lamiaceae family, is the source of chia seeds. This edible seed possesses exceptional medicinal properties and nutritional worth because of its high content of protein (15–25%), fat (30–33%), dietary fiber (18–30%), and mucilage. It is a great source of antioxidants, omega-3 fatty acids, and a number of polyphenolic compounds, including myricetin, caffeic acid, quercetin, chlorogenic acid, and kaempferol.[10] Chia seeds' mucilage network is made up of polysaccharides called ß-D-xylopyranosyl, a-D-glucopyranosyl, and 4-O-methyl-a-D-glucopyranosyluronic acid, which are located in the outer layers of the seed coat. The polysaccharides exude, absorb water, and unravel to their full length when water is added. The mucilage of chia seeds, or Salvia hispanica gels, is suitable for use in drug delivery as pharmaceutical excipients[43].

26. **Potato starch:** Potato starch is thought to be a versatile pharmaceutical auxiliary. In solid dosage forms, it is used as a disintegrating agent and filler/diluent. Additionally, it is used in the wet-granulation process to create starch paste, or mucilage, as a binder in solid dosage formulations. Therefore, it is evident that the amylose-to-amylopectin ratio, crystallinity, and gelatinization properties of potato starch are essential attributes that significantly impact the formulation properties, swelling properties, and compaction behavior (plastic-elastic deformation) of potato starch. These pharmaceutical characteristics, such as tablet strength, disintegration, and drug dissolution, have a significant impact on the final product's properties[44].

27. **Jackfruit seed starch:** To investigate the possibility of creating FDTs, an attempt was made to separate the starch from the powdered jackfruit seed (JFSP) and use it as a superdisintegrant. The mulberry family (Moraceae) includes the jackfruit (*Artocarpus heterophyllus*), a tree species that grows widely in Bangladesh, India, and other parts of Southeast Asia. This nonleguminous plant also produces large, edible seeds. A thin brown spermoderm encircling a single seed covers the fleshy white cotyledon, and the spermoderm is surrounded by a white aril. The cotyledons of jackfruit are relatively high in protein and starch[45].

CONCLUSION

Faster drug dissolution and increased bioavailability are characteristics of natural superdisintegrants, which contribute to more effective therapy and better patient compliance. As a result, using natural superdisintegrants as disintegrants in tablet formulations can be done successfully. The overviews of the different kinds of superdisintegrants that are currently on the market were covered in the article. The development of fast-dissolving tablet formulations has made it feasible to formulate these tablets with a variety of superdisintegrants in smaller amounts.

Roughly one-third of patients require the medication to start working right away. Superdisintegrants, which are used in fast-dissolving tablets, combine the benefits of convenient and easy dosing, faster medication release, safe and efficient drug delivery, improved patient compliance, and increased therapeutic benefits.

Source of Support: The author(s) received no financial support for the research, authorship, and/or publication of this article

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

1. Pandey P, Dahiya M. Oral Disintegrating Tablets: A Review. Int J Pharma Res Rev. 2016;5(1):50-62.
2. Sarang K, Shivprasad MB, Parvej HS, Poul BN. Use of Natural Superdisintegrant in Mouth Dissolving Tablet. 2013 Mar 20.
3. Ratanaparkhi M, Mohanta GP, Upadhyay L. Review on Fast Dissolving Tablets. J Pharm Res. 2009;2(1):5-12.
4. Allen LV, Wang B. Method of Making Rapid Dissolving Tablet. US Patent No.5, 298-261. 1997.
5. Camarco W, Ray D, Druffner A. Selecting Superdisintegrant for Orally Disintegrating Tablet Formulation. Pharm Technol. 2006;1(1):1-4.
6. Gandhi L, Akhtar MS. Comparative Study on Effect of Natural and Synthetic Superdisintegrants in the Formulation of Orodispersible Tablets. J Drug Deliv Ther. 2019;9(2):507-13.
7. Verma J, Prajapati SK, Irchhiaya R. An Overview on Superdisintegrants: A Review. Eur J Pharm Med Res. 2017;4(09):252-60.
8. Malviya R, Srivastava P, Bansal M, Sharma PK. Preparation and Evaluation of Disintegrating Properties of Cucurbita Maxima Pulp Powder. Int J Pharm Sci. 2010;2(1):395-9.
9. Madhulika GS, Ramya Kuber B. A Review on Natural and Synthetic Polymers Employed in the Formulation of Oral Disintegrating Tablets. J Drug Deliv Ther. 2019;9(2-5):652-8.

10. Karate CK, Pande VV, Bhalake RD, Asane GS, Thorat SS. Inclusion of Novel Natural Super Disintegrant in Fast Dissolving Tablet Formulation Using 32 Factorial Design. Der Pharm Lett. 2015;7(5):348-59.
11. Hirose K, Endo K, Hasegawa K. A Convenient Synthesis of Lepidimoide from Okra Mucilage and Its Growth-Promoting Activity in Hypocotyls. Carbohydr Res. 2004;339(1):9-19.
12. Kumar R, Patil MB, Patil SR, Paschapur MS. Evaluation of Abelmoschus Esculentus Mucilage as Suspending Agent in Paracetamol Suspension. Int J Pharmtech Res. 2009;1(3):658-65.
13. Ashton WA, Jefferies M, Morley RG, Pass G, Phillips GO, Power DMJ. Physical Properties and Applications of Aqueous Solutions of Albizia Zygia Gum. J Sci Food Agric. 1975;26:697-704.
14. US National Academy of Sciences. Tropical Legumes. Washington, D.C., USA: National Academy of Sciences; 1979.
15. Odeku OA, Fell JT. In-Vitro Evaluation of Khaya and Albizia Gums as Compression Coatings for Drug Targeting to the Colon. J Pharm Pharmacol. 2005;57(2):163-8.
16. Deveswaran R, Abraham S, Bharath S, Basavaraj BV, Furtado S, Madhavan V. Design and Characterization of Diclofenac Sodium Tablets Containing Tamarind Seed Polysaccharide as Release Retardant. Int J PharmTech Res. 2009;1(2):191-5.
17. Mishra MU, Khandare JN. Evaluation of Tamarind Seed Polysaccharide as a Biodegradable Carrier for Colon Specific Drug Delivery. Int J Pharm Sci. 2011;2(1):395-9.
18. Üner M, Altinkurt T. Evaluation of Honey Locust (Gleditsia Triacanthos Linn.) Gum as Sustaining Material in Tablet Dosage Forms. Il Farmaco. 2004;59(7):567-73.
19. Food Standards Australia New Zealand. Final Assessment Report: Application A546 Tara Gum as a Food Additive. 2006.
20. Shin HJ, Ki MH, Yoon B, An SW. Gastricretentive Controlled Release Mono Matrix Tablet. WO/2006/088305. Chong Kun Dang Pharmaceutical; 2006.
21. Zeng H, Moroni A, Baichwal AR, Goliber PA, Ketsela S, McNamara DP. Controlled-Release Emulsion Compositions. Penwest Pharmaceuticals. 2007.
22. Morkhade DM, Fulzele SV, Satturwar PM, Joshi SB. Gum Copal and Gum Damar: Novel Matrix Forming Materials for Sustained Drug Delivery. Indian J Pharm Sci. 2006;68(1):53–58.
23. Morkhade DM, Joshi SB. Evaluation of Gum Damar as a Novel Microencapsulating Material for Ibuprofen and Diltiazem Hydrochloride. Indian J Pharm Sci. 2007;69(2):263–268.
24. Umekar MJ, Yeole PG. Characterization and Evaluation of Natural Copal Gum-Resin as Film Forming Material. Int J Green Pharm. 2008;2(1):37–42.
25. Venkaiah K, Shah JJ. Distribution, Development and Structure of Gum Ducts in *Lannea coromandelica* (Houtt.) Merril. Ann Bot. 1984;54(2):175–186.
26. Nayak BS, Nayak UK, Patro KB, Rout PK. Preparation and In Vitro Evaluation of Lamivudine Entrapped Moi Microspheres for Oral Administration. Res J Pharm Technol. 2008;1(4):437–441.
27. Ngwuluka NC, Idiakhoa BA, Nep EI, Ogaji I, Okafor IS. Formulation and Evaluation of Paracetamol Tablets Manufactured Using the Dried Fruit of Phoenix Dactylifera Linn as an Excipient. Res Pharm Biotechnol. 2010;2(3):25–32.
28. Nayak BS, Nayak UK, Patro KB, Rout PK. Design and Evaluation of Controlled Release Bhara Gum Microcapsules of Famotidine for Oral Use. Res J Pharm Technol. 2008;1(4):433–436.
29. Singh K, Kumar A, Langyan N, Ahuja M. Evaluation of Mimosa Pudica Seed Mucilage as Sustained-Release Excipient. AAPS PharmSciTech. 2009;10(4):1121–1127.
30. Kothawade SN, Shinde PB, Agrawal MR, Aragade PD. Preliminary Evaluation of Dendropthoe Falcata Mucilage as Tablet Binder. Int J Pharmtech Res. 2010;2(2):1474–1476.
31. Rao KM, Gnanaprakash K, Badarinath AV. Preparation and Evaluation of Flurbiprofen Gel; Mucilage of Cocculus Hirsutus Leaf Powder as Gel Base. Int J Pharmtech Res. 2010;2(2):1578–1583.
32. Peter FK, Alistair MS, Shirley CC. Molecular Structures of Gum Exudates from Hakea Species. Phytochemistry. 1993;34(3):709–713. DOI: 10.1016/0031-9422(93)85344-Q.
33. Alur HH, Pather SI, Mitra AK, Johnston TP. Evaluation of the Gum from Hakea Gibbosa as a Sustained-Release and Mucoadhesive Component in Buccal Tablets. Pharm Dev Technol. 1999;4(3):347–358. DOI: 10.1081/Pdt-100101370.
34. Okafor IS, Chukwu A, Duala K. Some Physicochemical Properties of Grewia Gum. Niger J Polym Sci Technol. 2001;2(1):161–167.
35. Martins E, Christiana I, Olobayo K. Effect of Grewia Gum on the Mechanical Properties of Paracetamol Tablet Formulations. Afr J Pharm Pharmacol. 2008;2:1–6.
36. Muzib YI, Kurri PS. Formulation and Evaluation of Gum Olibanum-Based Sustained Release Matrix Tablets of Ambroxol Hydrochloride. Int J Pharm Pharm Sci. 2011;3(2):195–199.
37. Chowdary KPR, Mohapatra P, Krishna MNM. Evaluation of Olibanum Resin as Microencapsulating Agent for Controlled Drug Delivery. Rasāyan J Chem. 2008;1(1):99–104.
38. Bamiro OA, Sinha VR, Kumar R, Odeku OA. Characterization and Evaluation of Terminalia Randii Gum as a Binder in Carvedilol Tablet Formulation. Acta Pharm Sci. 2010;52(3):254–262.
39. Dinda SC, Mukharjee B. Gum Cordia—A New Tablet Binder and Emulsifier. Acta Pharm Sci. 2009;51(2):189–198.
40. Sheth NS, Shah NV, Shah NC. Extraction of Mucilage from Ocimum Americanum Linn and Its Role as Disintegrant in Tablets Formulation. J Global Pharma Technol. 2010;2(12):26–31. Davé V, McCarthy SP. Review of Konjac Glucomannan. J Environ Polym Degrad. 1997;5(4):237–241.
41. Alvarez-Manceñido F, Landin M, Lacik I, Martínez-Pacheco R. Konjac Glucomannan and Konjac Glucomannan/Xanthan Gum Mixtures as Excipients for Controlled Drug Delivery Systems. Diffusion of Small Drugs. Int J Pharm. 2008;349(1-2):11–18.
42. Ullah R, Nadeem M, Khalique A, Imran M, Mehmood S, Javid A, Hussain J. Nutritional and Therapeutic Perspectives of Chia (*Salvia hispanica* L.): A Review. J Food Sci Technol. 2016;53:1750–1758.
43. Swarbrick J, Boylan JC. Encyclopedia of Pharmaceutical Technology. Vol. 2. New York: Marcel Dekker; 2002. pp. 223–248, 2574–258.
44. Suryadevara V, Lankapalli SR, Danda LH, Pendyala V, Katta V. Studies on Jackfruit Seed Starch as a Novel Natural Superdisintegrant for the Design and Evaluation of Irbesartan Fast Dissolving Tablets. Integr Med Res. 2017;6(3):280–291.