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Review Article

OVERVIEW OF PECTIN AS AN EXCIPIENT AND ITS USE IN THE PHARMACEUTICAL DOSAGE FORM

IYAN SOPYAN[1,2*], DOLIH GOZALI[1], INSAN SUNAN K. S.[1], RIZKA KHOIRUNNISA GUNTINA[1]

[1]Department of Pharmacutics and Technology Pharmacy, Faculty of Pharmacy, Universitas Padjadjaran, Bandung, Indonesia, [2]Dosage Form Development Research Center, Faculty of Pharmacy, Universitas Padjadjaan, Bandung, Indonesia
Email: i.sopyan@unpad.ac.id

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ABSTRACT

Pectin is a polysaccharide that is abundant in nature and has promising uses in the pharmaceutical field. Pectin is resistant to digestive enzymes but pectin gel can swell in aqueous media and small amounts of compounds can be released into the gastrointestinal tract. This problem can be solved by developing pectin composites obtained from the incorporation of pectin polymers with other polymers. This article discusses the interaction of pectin with other polymers in various drug delivery systems. The method used in review articles is to review nationally and internationally published scientific journals obtained from Google, Google Scholar, Pubmed and Science Direct. From several related studies, delivery systems that have been developed and reported in the form of films, hydrogels, particulate systems and tablets. Other polymers such as Alginatee, protein, chitosan, gelatin and starch are known to improve the properties of pectin so that pectin composites can be used as controlled drug delivery. Thus, the development of other drug delivery systems with pectin composites becomes an opportunity and challenge in the future.

Keywords: Pectin, Composit pectin, Drugs delivery system, Dosage form

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INTRODUCTION

Pectin is a type of structural fiber located in the primary cell wall and intracellular layer of plant cells, especially in fruits, such as oranges, lemons, apples and so on [1]. Over the years, pectin has been widely used in the food and beverage industry as a gel-forming ingredient, thickening material, stabilizing material and emulsifier [2], pectin also has uses in the pharmaceutical field for the protection and controlled release of active substances, due to its excellent biocomamylumbility properties, pH sensitivity, biodegradability, and non-toxicity. In addition, pectin is also resistant to protease and amylase enzymes that are active in the digestive tract and is easily fermented intestinal microflora thus making it suitable for drug delivery to the large intestine [3]. Pectin also has uses in the pharmaceutical field for the protection and controlled release of active substances due to its excellent biocomamylumbility properties, pH sensitivity, biodegradability, and non-toxicity. In addition, pectin is also resistant to protease and amylase enzymes that are active in the digestive tract and is easily fermented intestinal microflora, thus making it suitable for drug delivery to the large intestine [4].

Pectin composites are the combination of pectin polymers with other polymers to produce new materials with better functional properties. In terms of drug delivery, polymer composites can be used as protective matrices, promote the controlled release, and increase the bioavailability and stability of the loaded drug. Various biopolymers of great importance in the pharmaceutical industry include Alginatees, proteins, chitosan, gelatin and starch. Alginatee and protein play a role in the drug delivery system [5, 6]. Chitosan is widely used for biomedical applications such as tissue engineering, drug delivery systems, and increasing drug bioavailability [7, 8]. Gelatin is a very interesting raw material because of its gelling ability for the manufacture of hydrogels so that it can be used as a biodegradable material in the medical and pharmaceutical fields [9]. While amylum polymers have been widely used for drug delivery because they can increase drug solubility and stability, reduce drug toxicity and side effects, as well as excellent biocomamylumbability and storage stability [10]. The purpose of this review article is to understand the interaction between pectin mixtures with different polymers, which will generate commercial interest in the development of formulations with better stability or more desirable textures and can reduce the use of more expensive synthetic biopolymers so that they can be replaced by one that is cheaper and safer [11].

METHODS

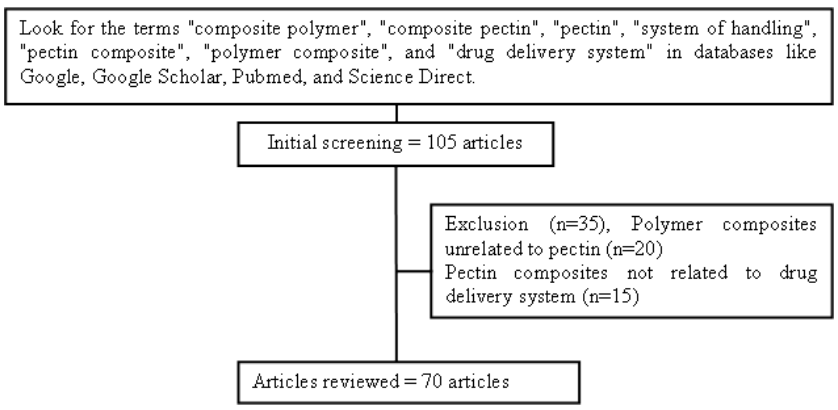

Fig. 1: Flowchart of review article preparation

Literature searches obtained from scientific journals published nationally and internationally, journal searches are carried out online through search engines such as Google, Google Scholar, Pubmed and Science Direct with keywords using English in the form of "polymer composites", "composites". pectin", "pectin", "drug delivery system", "pectin", "pectin composite", "polymer composite", and "drug delivery system". The literature that will be used is then screened for journals with inclusion criteria, namely the time of publication in the range of 2011-2021. Based on the search results using the keywords as mentioned, the article search results chart is obtained as attached in fig. 1.

RESULTS AND DISCUSSION

Chemical structure

Pectin is a cell wall polysaccharide that is very important in higher plants. Located in the middle and primary lamellae of the dicot plant cell wall. Pectin plays a role in plant growth and development [12]. The structure of pectin is difficult to determine because its composition varies depending on the plant source and extraction conditions [13]. Pectin can also change due to different plant varieties and maturity levels as well as various technological procedures on pectin quality [14]. Currently, it is stated that pectin is a heterogeneous polysaccharide with three basic structural domains, namely Homogalacturonan with two branches of Rhamnogalacturonan expressed as RG-I and RG-II, based on the findings of the study. Fig. 2 demonstrates this.

Homogalacturonan is a D-galacturonic acid-based single polymer that can be esterified or methylated. Rhamnogalacturonan I is a molecule made up of galactose and arabinose side chains that are generated by repeating the disaccharide rhamnose-galacturonic acid. Rhamnogalacturonan II, on the other hand, is a homogalacturonan chain with a more complicated side chain [12].

Source of pectin

Pectin can be found in almost all types of plants as shown in table 1, especially in the citrus family, such as oranges, lemons, grapefruit, and apples. Pectin is also found in cashew pomace about 10-25% with different extraction conditions [15]. In addition, the pectin found in lemon, tangerine, and orange peel were 14.36; 12.82 and 14.08% [16]. The pectin content in banana peels with different types is 15.89-24.08% and apple pomace peels are 10.91% [17].

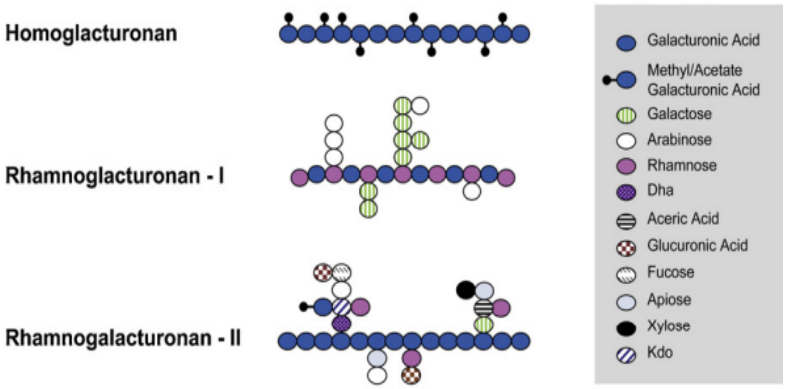

Fig. 2: Pectin struktur [12]

Table 1: Source of pectin

Source of pectin	Percentage amount of pectin	Esterification degree (%)	Refferences
Cashew pomace	10-25	28-46	[15]
Lemon	14.36	84.54	[16]
Tangerine	12.82	78.88	[16]
Orange peel	14.08	84.68	[16]
Banana peel	15.89-24.08	63.15-72.03	[17]
Pomace apple peel	10.91	58.44	[17]
Sugar beet pulp	5.5-17,2	42-71	[18]
Potato pulp	14.34	37.45	[19]
Jackfruit waste	8.94-14.14	Not shown	[20]
Tomato waste	15.1-21.1 and 31-35.7	84.5-89% and 76.9-87.9%	[21]

Sugar beet pulp, which can yield pectin in the range of 5.5-17.2 percent and has been shown to rise with reducing pH, has been increasingly popular in recent years as an alternate source of pectin synthesis. Solution for extraction [18]. Yang *et al.*, (2018) examined potato pulp with different acids to see which one produced the most pectin, 14.34 percent [19]. Various extraction procedures and solvent types can be used to recover pectin from jackfruit waste at 8.94-14.14 percent dry weight, albeit the resulting solubility is lower than commercial pectin [20]. Grassino *et al.* (2016) used tomato waste to manufacture pectin for their study. The results showed that tomato waste contained 15.1-21.1 percentage pectin with conventional extraction methods and 31-35. Seven percent with ultrasonic extraction methods [21] using different extraction methods, namely conventional and ultrasonic extraction methods.

Classification of pectin

Pectin is split into two types based on the degree of esterification (DE), namely pectin with high methoxyl content (HM) and pectin with low methoxyl content (LM) (LM). On pectin with a high methoxyl content, the degree of esterification (DE) is greater than 50%. When opposed to low methoxyl pectin, high methoxyl pectin (HM) requires certain circumstances to form a gel, such as a pH of 3-6, the presence of soluble materials such as sucrose, and a higher temperature (LM) [22]. Sucrose's role in gel formation is to improve viscosity and speed up the gelation process [23]. High methoxyl pectin (HM) is soluble in hot water and thermally reversible in general [24].

Content (LM) is less than 50%. Pectin with a low methoxyl content (LM) is chemically more stable to moisture and heat than pectin with a high methoxyl concentration (HM). Low methoxyl pectin (LM) can form a gel in the presence of a specific quantity of calcium or divalent cations, and this gelling process can be easily reversed by adding monovalent ions such as sodium (Na+) or potassium (K+). By altering the calcium to pectin delivery ratio, the texture of the low methoxyl pectin gel can be adjusted. A high pectin content combined with a low calcium amount produces an elastic gel, whereas a high calcium content combined with a low pectin content produces a gel that

crumbles easily, potentially with syneresis [25]. Although sugar is not necessary for gelling at low methoxyl pectins, tiny amounts of sugar tend to diminish syneresis and improve the desired strength of these gels, and the quantity of calcium required to create a gel is lowered in the presence of sugar. High sugar concentrations, on the other hand, obstruct gel formation because dehydration of sugar increases hydrogen bonding and inhibits divalent ionic force cross-linking [26].

Pectin composite

Pectin composites are made up of pectin polymers combined with other polymers to create novel materials with improved functional qualities. As shown in table 2, polymer composites can be employed as protective matrices, promote controlled release, and improve the bioavailability and stability of the loaded drug.

Table 2: Pectin composites in drug delivery system

Composite	Mixture rasio	Function of compisite	API	Preparation	Methods	Refferences
Alginate-pectin	100:0, 80:20, 70:30, 60:30	Diluent	Folic acid	Microcapsul	Extrusion	[27]
Alginate-pectin	100:0%, 75:25%, 50:50%, 25:75% dan 0-100%	Film agent	-	Edible film	Solvent casting	[28]
Pectin-Alginate	1:1	Film agent	-	Film	Solvent casting	[29]
Pectin-Alginate	4:1%	Diluent	Cisplatin	Microsfer	Elektrospray dan polyelectrolite multilayer coating	[30]
Alginate-pectin	80:20	Diluent	Polifenol and β-karoten	Mcrocapsul	Ionic gelation	[31]
Pectin-chitosan	0.5%, 1%, 2%	Diluent	Mesalamin, kurkumin dan progesteron	Hydrogel	cross-linking	[32]
Pectin-chitosan	2:1, 3:1, 4:1, 5:1 (coating). 1.2:1, 2:1 (blending).	Diluent	Bovine Serum Albumin (BSA), albumin dari putih telur	Nanoparticle	Coating and blending	[33]
Pectin-chitosan	5:5%	Film agent	Dextromethorphan Hbr	Orally dissolving film (ODF)	Solvent casting	[34]
Pectin-chitosan	3:1%, 3:2%, 5:1%, 5:2%	Diluent	Hesperidin	Hidrogel	factorial Design	[35]
Pectin-chitosan	1:4	Matric	Lydokain HCl	Hydrogel	cross-linking	[36]
Chitosan-pectin	1.5%:2%	Coatig agent	5-fluorourasil	Microgel	cross-linking	[37]
Chitosan-pectin	60:40	Coating agent	Mesalamin	Coating tablet	spray drying	[38]
Chitosan-pectin	1:5	Diluent	Teophylin	Coating tablet enteric	Wet granulation	[39]
Chitosan-pectin	1:1	Diluent	Tenofovir	Vaginal tablet	Direct compresion	[40]
Chitosan-pectin	1:2, 2:3, 1:1, 3:2, 2:1 dan 3:1	Diluent	-	Nanoparticle	Ionic gelation	[41]
Pectin-protein	1:1	Coating agent	Curcumin	Nanoparticle	Freeze drying	[42]
Pectin-protein	5:5%	Diluent	Acetaminophen	Microcapsule	Compleks coarsevation	[43]
Pectin-protein	1:3, 1:4	Coatinh agent	-	Nanoparticle	Nano spray drying	[44]
Gelatin-pectin	1:1	Matrices	Lycopene	Microcapsule	Compleks coarsevation	[45]
Pectin-gelatin	70:30	Matrices	Ciprofloxaxin HCl	*wound dressing*	Cross-linking	[46]
Pectin-amylum	1:4,1:1,4:1	Matrices	Nimesulide	Tablet	Cross-linking	[47]
Pectin-amylum	2:0, 1.5:0.5, 1:1, 0.5:1.5	Diluent	Lactobacillus plantarum	Hydrogel	External gelation	[48]
Amylum-pectin	2:1, 1:1, 1:2	Matrices	Ascrbic acid	Microparticle	Spray drying	[49]
Amylum-pectin	4:1, 1:1, 1:4	Diluent	Sodium-diklofenak	Microparticle	Cross-linking	[50]
Amylum-pectin	1:1, 1:4	Film agent	-	Film	Solvent casting	[4]

Pectin-alginate

One of the gel mixes that has been widely employed in numerous researches is the pectin-Alginate system. The ratio of pectin to Alginate, the degree of pectin esterification, and the amount of mannuronic acid and guluronic acid in Alginate all influence the structural features of these two gel combinations. The structure of an alginate gel with a high mannuronic acid content and pectin with a high degree of esterification is vulnerable to release. Alginate with a high guluronic acid content, on the other hand, can generate stiff gels that are less prone to swelling and erosion, resulting in a slower release and greater encapsulation efficiency. A weaker structure is produced by pectin with a higher esterification level [51].

Pectin-alginate biocomposites of diverse compositions can be transporters of microcapsules throughout the gastrointestinal and intestinal tracts, according to Kiaei Pour *et al.* (2020), whereas an Alginate hydrogel covered in pectin in a 70:30 ratio provides adequate folic acid protection. Alginate hydrogel without pectin was compared to Alginate hydrogel with pectin [27] under artificial gastric and intestinal conditions. The pectin-Alginate mixture has been shown to perform well as a protective gel matrix under acidic circumstances [51].

The combination of pectin and alginate is also utilized in the manufacturing of composite films; the mixing of polysaccharides can produce a homogeneous and clear film free of pores and cracks. As the pectin concentration rises, so does the thickness of the composite film. This has to do with the colloidal properties of the substance and the interactions between the constituents. Films with a higher Alginate content have a lower thickness [28]. In another study, Seixas *et al.* (2013) employed biofilms made of alginate and pectin to develop uniform and transparent composite films with superior physical properties that might be used as pharmaceutical medicine coatings [29].

In recent years, numerous incidents have been documented. Using an electric spray approach, *Hsu et al.* (2013) created and assessed pectinate/Alginate microspheres coated with Eudragit S100 polymer for cisplatin distribution in the colon, obtaining

microspheres with homogenous size and pH-independent under simulated gastric conditions [30]. Other researchers have tested the microencapsulation of Taraxacum officinale L. polyphenols and carotenoids in a binary mixture of pectin and alginate, which allows for a longer release profile of these chemicals in artificial gastrointestinal fluids [31].

Pectin-chitosan

Pectin and chitosan are polysaccharides that can create complexes that have biodegradability, amylum biocompatibility, and are non-toxic. These biopolymers are polyelectrolytes chemically, therefore they can form polyelectrolyte complexes [52]. Because chitosan is a weak base and pectin is a weak acid, electrostatic interaction between the positively charged amino group (NH+3) in chitosan and the negatively charged carboxyl group (-COO) in pectin can occur in solution [53]. The pH, charge density, concentration of both polymers, and the ionic state of the medium all play a role in the stability of this pectin-chitosan complex. Temperature, the concentration of particular molecules, and environmental variables all play a role in the gel mixture's stability [54, 55]. These polyelectrolyte complexes have a variety of applications in the pharmaceutical industry, including drug delivery [32] and targeted drug delivery to the large intestine [33]. The fact that both polymers can keep the drug from being released in the upper gastrointestinal tract and deliver it to the large intestine tickles interest in this system for controlled drug release [56].

Pectin-protein

Depending on the nature of the biopolymer, concentration, and solution conditions, the interaction between proteins and polysaccharides as two biopolymers can be classified into two circumstances: mutual repulsion and mutual attraction (such as pH, ionic strength, temperature). The protein-polysaccharide mixture exists in two stages as a result of the interaction: associative phase separation and segregative phase separation. When proteins and polysaccharides have opposite charges, they can form a soluble phase (single-phase system) or an insoluble precipitate (two-phase system) (two-phase system). Mutually repelling biopolymers are those in which proteins and polysaccharides have comparable charges. Under these conditions, the two biopolymers can coexist in a single phase at low concentrations, but phase separation occurs at larger concentrations [57].

Non-covalent interactions such as electrostatic, hydrophobic, hydrogen, and van der Waals forces can be formed between proteins and polysaccharides, resulting in very stable structures [58]. Chang, C., *et al.* used pectin as a coating material to make sodium caseinate/zein nanoparticles more physicochemically stable (2017). The pectin coating improved curcumin encapsulation in sodium caseinate/zein nanoparticles while also allowing for regulated release in the gastrointestinal tract, according to the researchers. Pectin can thus be employed to deliver medications [42].

Various physicochemical factors can affect the formation and stability of complexes such as pH, ionic strength, pectin to protein ratio, pectin and protein charge, and molecular weight so that the dominant interaction is associated with ionic bonds and charge density is very decisive in complex formation. Parameters such as decreasing pectin charge density through partial esterification of carboxyl groups, increasing ionic strength, or decreasing pH can reduce the interaction ability between these biopolymers [59].

The molecular interactions between these two biological macromolecules have been intensively studied in recent years as a technique of generating complex biopolymers employed in the pharmaceutical sector, such as nanoparticles [44] microparticles [43], and hydrogel [35].

Pectin-gelatin

Gelatin is one of the most studied dietary biopolymers. The interactions between gelatin and pectin have been provided by a number of researchers. High calcium generates a loose and brittle gel structure by raising the melting temperature, viscosity, and hardness of the gel, according to Huang, S *et al.* (2020). This demonstrates that the ratio of pectin to gelatin impacts the cohesiveness and friability of the biopolymer-biopolymer interaction [60] According to many research, particle form, size, and size distribution affect the rheological properties of hydrogel particles [61–63].

Gupta et al., (2014) discovered that elements such as reaction duration, reaction temperature, reaction pH, and composition had a direct impact on the interactions between these polymers in their study analyzing crosslinking techniques for the synthesis of hydrogel gelatin and pectin [64, 65]. In the pharmaceutical industry, gelatin/pectin interactions have been studied in composites for regulated drug delivery [66], microencapsulation of bioactive chemicals like lycopene [45], and composites for wound healing [46].

Pectin-amylum

The rheological, physical, and chemical properties of these mixtures have all been thoroughly explored. Gakowska *et al.* (2013) looked at the pasting, rheological, and textural properties of a paste and gel prepared from high methoxyl pectin, sucrose, and cross-linked potato starch (Acetated Diamylum Phosphate and Acetylated Diamylum Adipate). The effect of starch concentration on the pasting temperature parameters of the amylum-pectin-sucrose system is dependent on the amount of starch supplied and the kind of starch-modified. Elastic properties were identified by increasing the starch concentration in the amylum-pectin-sucrose system. The textural parameter increases as the amylum concentration increases [67], making the blended solution stiffer than the amylum gel alone during extrusion.

Ma *et al.* studied the effect of pectin content on the paste and rheological properties of maize starch (2019). Increasing pectin concentration modifies the viscosity of the composite system, implying that pectin can increase paste stability and reduce short-term retrogradation [68], according to one study. Other researchers experimented with different pectin and amylum combinations using sodium trimetaphosphate as a crosslinker. Cross-linkers have a substantial impact on the rheological and physicochemical properties of the gel, according to the findings, and cross-linking between these polysaccharides can occur in mixed polymer systems [69].

The use of polymers for regulated drug distribution has also been studied [47] in the pharmaceutical usage for amylum/pectin combinations. Using an amylum-pectin mixture as well as a spray drying technique, Liu (2014) developed a composite material for ascorbic acid delivery. The amylum/pectin ratio affects encapsulation efficiency and release profile, and also the microparticle size distribution; the smaller the particle size, the faster the drug release rate as the surface area to volume ratio rises [49]. Diclofenac drug release in the matrices amylum and pectin has also been examined by other researchers [50].

Pectin application in formulation development

Film forming agent

Rezvanian *et al.* (2017) developed a hydrogel composite film from sodium alginate and simvastatin-loaded pectin, which they combined with CaCl2 to use as a wound dressing in their study. Cross-linking improves the dressing's mechanical profile as well as its wound-absorption capability. The hydrogel film's physical integrity is maintained during use. According to the thermal analysis, the crosslinking process improved the thermal stability of the hydrogel sheet. The crosslinked film produced a delayed and sustained release of simvastatin, and *in vitro* cytotoxicity tests revealed that the hydrogel film was non-toxic [70].

According to Seixas *et al.*, (2013), biofilms formed with a blend of pectin and alginate have better properties than films made with pure polymers. The resulting composite film is transparent and homogeneous. The film characteristics of the crosslinking agent contribute to a decrease in solubility and permeability to water vapor, as well as an increase in the material's resistance [29].

Another study created a film with a mixture of pectin-chitosan matrices using the plasticizers eugenol and oleic acid, as well as dextromethorphan Hbr (DHF) as a model drug. When DHF-eugenol was compared against DHF-oleic acid at different concentrations,

the results revealed that DHF-eugenol had better film characteristics. When oleic acid is used as a plasticizer in a composition for fast-dissolving films, the films can have excellent mechanical properties and meet the criteria [34].

In other studies, retrograded amylum dispersions and pectin were employed to make films for drug delivery in the large intestine. Film manufactured with a solvent casting process from retrograded amylum dispersion and pectin in various proportions and polymer concentrations, with or without plasticizer. *In vitro* investigations show that films with the same number of polymers are more resistant to gastrointestinal issues. In acidic conditions, the presence and type of plasticizer did not affect the dissolving capabilities. Enzymatic digestion was less vulnerable to plasticizer-containing films, which was impacted by the substantial amount of retrograded amylum [4].

Hydrogel agent

Model medicines mesalamine, curcumin, and progesterone were delivered using a thermoreversible hydrogel made with physically crosslinked pectin-chitosan. Lower pectin ratios result in slower drug release rates *in vitro*, owing to the smaller mesh size resulting from greater interactions between polyelectrolytes [32]. Fahrurroji *et al.* (2017) developed a hesperidin hydrogel employing chitosan-pectin mixed matrices, with 5 percent pectin achieving the maximum entrapment effectiveness (96.65 percent) and mucoadhesiveness. *In vitro* tests revealed that hydrogel matrices could modulate the release of hesperidin, with the formula with the highest concentration of pectin releasing 56 percent of the drug in conditions containing 2 percent rat cecum. This demonstrates that chitosan-pectin polymer combinations can be employed as matrices in regulated medication delivery to the target organ, the large intestine [35].

Other researchers have developed *Lactobacillus Plantarum* probiotic bacterial cells encapsulated in pectin-amylum hydrogel by the extrusion method. The results showed that the encapsulated cells were resistant to adverse conditions of the simulated gastrointestinal tract and bile salt solutions compared to free ones. This makes pectin-amylum hydrogel attractive to be used as an ideal drug carrier in the future [48].

Long *et al.* (2019) created a 3D printed chitosan-pectin hydrogel for wound treatment using lidocaine hydrochloride. The *in vitro* release profile shows a burst release after 1 hour, followed by a constant and regulated release over 4 h under physiological conditions. Wound healing can be accelerated by releasing bioactive molecules from wound dressings, which can aid to maintain a healing environment that promotes tissue regeneration [36].

Particulate system agent

Considering acetaminophen as a pharmaceutical model, Baracat *et al.* (2012) developed a pectin-casein microcapsule preparation with complex conservation for regulated drug release. *In vitro* studies revealed that acetaminophen release from microcapsules was sluggish, and that the drug release mechanism was controlled by first-order diffusion kinetics. This polymer system appears to be appropriate for continuous acetaminophen release throughout the gastrointestinal tract [43], because acetaminophen release in gastric fluid is higher than in intestinal fluid.

Other researchers have used the aqueous spontaneous ionic gelation approach to create chitosan-pectin nanoparticles. The particles were stable in the pH range of 3.5-6.0 *in vitro*, but they lost stability after 14 d of storage in an aqueous medium. This is owing to the particle's high positive surface charge, the inherent nature of the polysaccharides utilized, and the polyelectrolyte's harmless dissociation. For the development of chitosan-pectin nanoparticles for chronic wound healing [41], this system has become an intriguing subject.

Islan *et al.*, (2012). described the encapsulating of ciprofloxacin in Alginate-pectin HM microspheres with controlled release in the gastrointestinal system Under acidic conditions, ionotropic gelation with calcium as a crosslinker formed alginate-pectin HM microspheres containing ciprofloxacin. *In vitro* tests show that the Alginate-pectin HM system developed for the study improves ciprofloxacin oral delivery conditions, not only by lowering drug release in stomach settings but also by releasing a significant amount of ciprofloxacin in the intestine [71].

Another study used superhydrophobic substrate polystyrene to produce 5-fluorouracil into a pectin-coated chitosan microgel for oral delivery. *In vitro* experiments revealed that most of the medication was released after one hour, except for when utilizing a very acidic dissolving medium (1 percent HCl), where pectin coating extended the control of 5-fluorouracil release in an acidic medium for over four hours. The drug was delivered in a controlled manner by the 5-fluorouracil encapsulated pectin-coated chitosan microgel. This suggests that the microgels produced can be used for mucosal and topical treatment, as well as that the pectin-coated microgels can be used to deliver anticancer drugs to colon cancer cells [37].

Tableting agent

A new excipient for tablet formulation matrices was evaluated: a high amylose pectin-amylum combination. The mixture has the potential to be a viable excipient for swellable tablet matrices used in drug delivery systems [68]. Using tenofovir as a model medicine, Cazorla-Luna *et al.* (2019) created a vaginal tablet preparation with a mixed mucoadhesive polymer chitosan-pectin for the prevention of HIV transmission by controlled release. *In vitro* experiments have shown that combining chitosan and pectin polymers can extend the time it takes for tenofovir to be released by up to 96 h. Furthermore, electrostatic interactions between pectin and chitosan polymers in the artificial vaginal fluid led in the formation of a strong and highly structured gelling system in the medium, capable of maintaining its structure during the swelling process, confirming the investigation [40].

Khurana *et al.*, (2014), described the use of chitosan-pectin as a tablet-coating film to release mesalamine. In this study, the Eudragit coating was also used as a comparison. *In vitro* tests revealed no significant differences in release between chitosan-pectin-coated tablets and eudragit-coated tablets; however, chitosan-pectin-coated tablets had better adhesion strength than eudragit-coated tablets, and the chitosan-pectin mixture produced a smooth, soft texture, and uniformity on a tablet [38, 72]. Other researchers looked into the polyelectrolyte complex (PEC) formed by chitosan (polycation) and pectin (polyanion) and produced enteric-coated tablets to carry PEC to the colon. Ex-vivo investigations utilizing mouse caecal content revealed that the best composition [39], which included 1.1 percent PEC and 3 percent coating, exhibited swelling and release in an alkaline pH process believed to be microbial enzyme-dependent destruction.

CONCLUSION

Pectin is a polysaccharide that can be found in abundance in nature and has therapeutic potential. Due to its ability to survive acidic environments, pectin can be mixed with other polymers to generate pectin composites that can be utilized as controlled drug delivery matrices and precisely target the large intestine. Distribution approaches such as films, hydrogels, particle systems, and tablets have all been created and published. As a result, the results of this study may pave the way for more research into the use of pectin composites in other drug delivery techniques. Through so many properties, pectin is extremely likely to be modified in the future so that it can be employed for a larger range of functions in medication formulations, particularly in targeted drug delivery systems.

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AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

CONFLICT OF INTERESTS

Declared none

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