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A Comprehensive Review on the Therapeutic Potential of Pectin

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Abstract:- In our present paper we have given a comprehensive review of the medical uses, chemistry and other application of pectin. Pectin has many relevant therapeutic uses which is needful for obtaining effective herbal formulation. Pectin is chemically polysaccharide obtained from many fruits and vegetables. It occurs naturally as partial methyl ester of a (1→4) linked (+) - polygalacturonate sequences interrupted with rhamnose residues the neutral sugars. Pectin molecules are namely: galactose, rabinose, xylose and fructose. Common types of pectin are high methoxypectin (HM) and low methoxy pectin (LM). HMP is the common type and labelled as "fast –or rapid-set" and "slow-set" .fast-set HM is best for chunky jams and slow set HM work well for clear jellies.it is used pharmacologically for regulation of blood cholesterol level and act as antioxidant, antimicrobial and antidiabetic. We have compiled the pharmaceutical, chemical and pharmacological uses of pectin.

Keywords:- *Pectin, Pharmacology, Pharmaceutical Additive, Natural Stabilizer.*

I. INTRODUCTION

A poly saccharide known as pectin having special qualities that allow it to either bind and remove hazardous chemicals like heavy metals and radionuclide from the body or form a dense gel, it is a vital nutritional component.[1] Pectin provides the three-dimensional structure which results in a jellied product. Fully ripe fruit contain less pectin then partially ripe fruit. Pectin is a naturally occurring compound found in the cell wall of plants for cosmetics and personal hair products.[2]It is used in formulation of body and hand products in makeup foundations, shampoos, hair conditioners, permanent waves, personal cleanliness products, and hair products. The general applications of pectin used as gelling agent, thickening agent, stabilizing agent and emulsifier used as filler in tablet formulations and sweetening agent. Pectin is a plant based hydrocolloid. It mainly added in food products and other applications are development of edible films, plasticizer, and paper substituent forms its unique structure and biochemical properties[3]. Pectin is applied in numerous polymer that vary in neutral sugar content molecular weight and chemical configuration and specific modification pectin molecules can be used for a wide range of purpose. This is mostly due to its easy accessibility, non-toxic, qualities, and low cost of manufacture. Hazardous heavy metals bind with pectin during digestion as a result polygalacturonic acid is created.

Among other chemical characteristics, the amount of galacturonic acid, methoxyl, and acetylation in pectin influences its use[4]. Galactose and arabinose are among the many neutral saccharides that make up the core of the polysaccharide pectin. These neutral saccharides consist of D-galacturonic acid-1,4-linked and L-rhamnose-1,2-linked units. According to Noreen, pectins have a linear anionic backbone with "hairy parts" and "smooth regions" that have non-ionic side chains. Homogalacturonan (HG), rhamnogalacturonan I (RG-I), and substituted galacturonans like rhamnogalacturonan II (RG-II) are included in the structural classification of pectin. [5,6] The article provides descriptions of each of the major pectin kinds. The solution's pH and temperature has an impact on the rate of breakdown. pH-4 is the point at which pectin is most stable. [7,8]

II. SOURCES OF PECTIN

Pectin is chemically polysaccharides obtained from many fruits and vegetables like apple pomance, papaya, orange peel and other citrus fruits. These materials contain high amount pectin substances and can found available as residues from juice production. Pectin is frequently found in plant tissues where it functions as thickening agent on cell walls.[3,9] Although pectin is widely found in most plant tissues, there are only a few sources that can be exploited to produce pectin for sale, this is due to the fact that the degree of esterification and molecular size of pectin determine its ability to form gel. Finding a significant amount of pectin in a particular fruit does not guarantee the fruit will be used as a source of commercial pectin. Pectin's ability to create gel is depended on its molecular size among other criterias, as a result different sources of pectin have varying levels of gelling ability. Sugar beet and leftovers from sunflower seed heads are two further sources of pectin that had been identified. The cell wall's lamella have the largest concentration of pectin, which gradually decreases as one passes through the primary wall and approaches the plasma

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membrane. The majority of commercial pectins come from apple pomance or citrus peel, both of which are by-products of manufacturing facilities.[9] When it comes to their physical characteristics, apple pectins are typically deeper in colour while citrus pectins are typically light cream or tan.

III. CHEMICAL STRUCTURE

Pectin is a complex polysaccharide with a primary structure composed mainly of repeating units of galacturonic acid. Its chemical structure can vary depending on factors such as its source and extraction method. However, here is a simplified representation of the basic structure of pectin as given in figure 1.

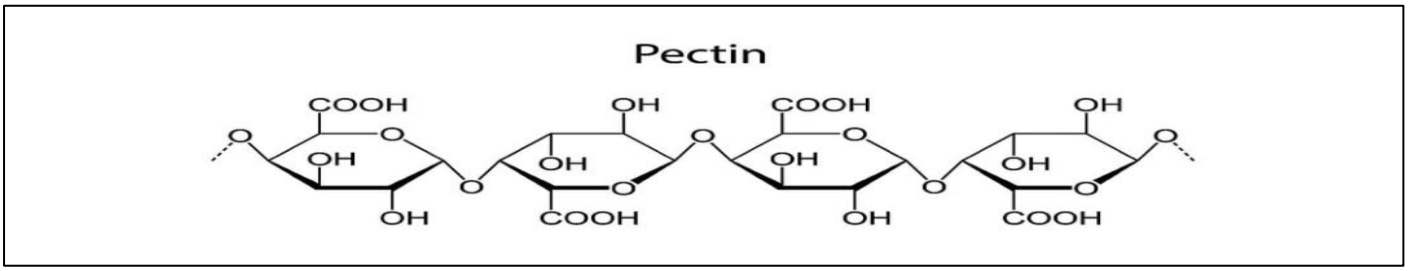

Fig 1: Structure of Pectin

Pectin has a chain-like structure made up of a few hundred to around a thousand saccharide units as linear carbohydrate. Its composition changes depending on the source and the circumstances. Certain factors such the molecular weight or the amount of certain subunits, will vary from molecule to molecule in each sample source of pectin. Because pectin can alter when plant material is processed, stored, and isolated from other plants, figuring out its structure is incredibly challenging. [10]

IV. GENERAL PROPERTIES OF PECTIN

Pectin dissolve well in clear water. When dry powdered pectin is mixed with water, it quickly becomes hydrated and forms clumps. The chemical properties are: At neutral pH, pectin are poly anions, and low pH, they almost have no charge[7,8]. This are polysaccharide enriched galacturonic acid and galacturonic acid and methyl esters unit.[5,6] Combined with proteins and polysaccharide pectin form skeletal tissues of plants this are physically strong and chemically stable .The biochemical properties of pectin such as non-toxicity, emulsion behaviour, diverse chemical composition, biocompatible and high stability.[3] Pectin is structurally a hetero polysaccharide present in the primary cell wall of terrestrial plants.it is also used in filling medicines sweets as stabilizer in fruit juice and milk drinks. The medicinal properties of pectin are high cholesterol high triglycerides and prevent colon cancer and prostate cancer. It is an important polysaccharide with applications in food, pharmaceuticals, and a number of other industries. It is having therapeutic properties such as immunoregulatory, antibacterial, anti-inflammatory, anti-tumour, and antioxidant activities. Pectin has the ability to form a gel when combined with sugar and acid under specific. Pectin acts as a thickening agent in food products, providing viscosity and texture. It helps give jams and jellies their characteristic consistency.[3], due to its high water-binding capacity, which contributes to its ability to form gels and thicken liquids. This property is essential for maintaining the structural integrity of food products.

Pectin is a soluble fibre, meaning it can dissolve in water. It adds bulk to stools and can help regulate digestion and promote bowel regularity when consumed as part of a balanced diet. [11]

V. GEL FORMATION OF PECTIN

Pectin capacity to produce gels is what makes it's so useful. Gels are formed by HM- pectin, acid, and sugar. This can be seen as the pectin molecule becoming partially dehydrated to the point that it is in between completely dissolved and participated. There are certain restrictions because of the unique structure of pectin. Unlike LM- pectin, HM- pectin lacks enough acid groups to gel or precipitate when combined with calcium ions, though in some cases, other ions like copper or aluminium can produce precipitation. Hydrogen interaction in between the hydroxyl groups of nearby molecules and the free carboxyl groups on the pectin molecules is what causes gel formation.[12] Pectin contains spectinic acid as major components, are water soluble and are able to form gels. A neutral or slightly acidic dispersion of pectin molecules contains partly ionized salts containing the majority of the unesterified carboxyl groups. Ionized once provide the molecule a negative charge that, when combined with the hydroxyl groups, makes it attractive layers of water. Repulsive forces between these groups, due to their negative charge, it prevent from the formation of pectin. The carboxyl ions are predominantly unionized carboxylic acid groups when acid is introduced. Both the attraction and repulsion forces between pectin molecules and water molecules are lowered by this reduction in the quantity of negative charges. Sugar competes with the pectin for water, thus reducing its hydration. These circumstances lessen pectin's capacity to remain disturbed. A gel is created when the less hydrated pectin that was previously unstable disperses and cools, forming a continuous network that holds the aqueous solution. The degree of esterification also influences the rate at which gel formation occurs. Setting happens faster when the DE of is higher. Moreover, compared to slow-set pectins (i.e., pectin with a DE of 58-65%), rapid set pectin (i.e., pectin with a DE of above 72%) get at lower

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soluble solids and greater levels. Divalent cautions are necessary for the correct gel formation of LM- pectins. The well- known "egg- box" hypothesis is the primary foundation for the LM- pectin gelation process. The process involves the formation of junction zones by the ordered, side-by side associations of galacturonans. The same is explained diagrammatically in Figure 2.

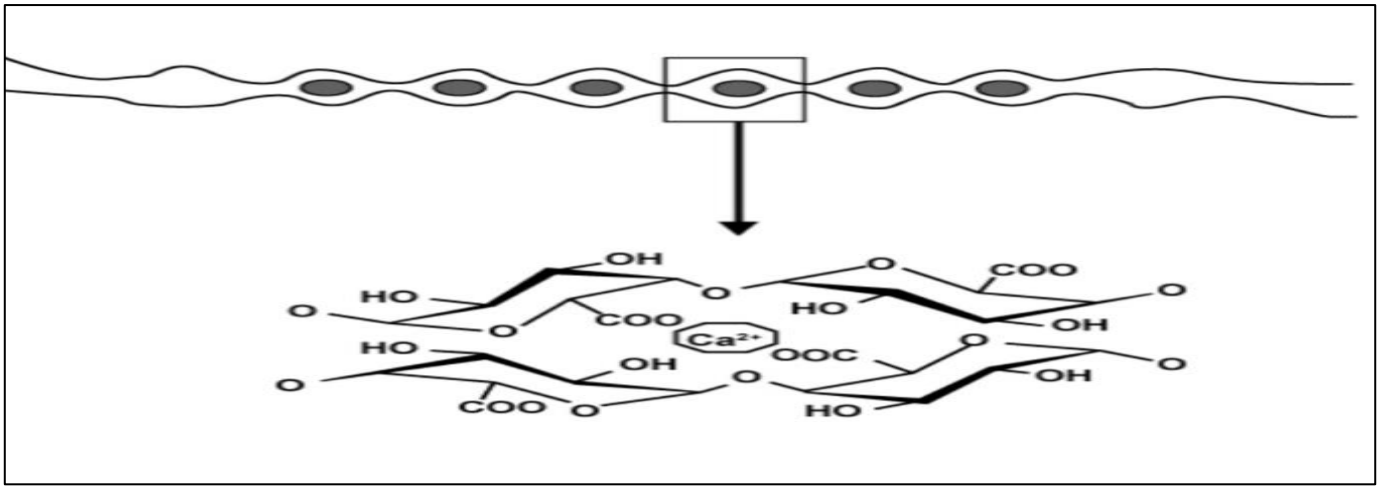

Fig 2: The "Egg-Box" Hypothesis for the LM- Pectin Gelation Process

Cross-linked pectin molecules produce a net-like structure that is known as the gel structure. Strong ionic interactions between the carboxyls create cross-linkages that are less elastic and more brittle than hydrogen bonds, which form that cross-linkage in ordinary pectin.[12] For a given quantity of calcium, the likelihood of cross-link formation increases with pectins with lower DM. The likelihood that a salt bridge will form rises with the number of reactive carboxyl groups that can form one. Moreover, de-esterified molecules are more straight than esterified once due to greater quantity of charged groups, which increases the likelihood that they will form calcium linkages. As the DE increases, less LM –pectin is needed to make this type of gel. The DE has a significant impact on the ionic bonded gels strengths. Because they enhance the solubility of LM-pectin in the presence of calcium, monovalent ions like sodium, which can also react with free carboxyl groups, can have an impact on gel formation. While sugar is not necessary for the LM – pectins to form gels, its addition in tiny amounts (10-20%) te3ndes to reduce give these gels the desired hardness. When some sugar is present, the amount of calcium required to form gel is reduced. High concentrations of sugar (60% or higher) interfere with gel formation because the dehydration of the sugar favours hydrogen bonding and decreases cross-linking by divalent ion forces.[13]

VI. USES OF PECTIN

A. *Pharmaceutical uses of Pectin:*

➢ *Drug Delivery Systems*

Since its discovery more than 200 years ago, the polymer pectin has been used in a variety of ways. Despite this, its primary use has been in the food business, where it has been applied as a thickening, stabilizing, emulsifying, gelling, and more recently, as a substance for food packaging that forms edible films on fruits and vegetables, among other things. Pectin's ability to form gels is what makes it so valuable as an excipient; it has been used in tablet formulations as a controlled-release matrix, as a binding agent and as a carrier for drug delivery to the gastrointestinal tract via matrix tablets. Additionally, gel beads have employed it as a sustained release medication delivery device.[14,15] Pectin is used as a viscosifier in beverages and soft drinks, and high-ester pectin may be used as a mouth-feel improver. This use has been widely developed for juice drinks with a reduced juice content or sugar-free soft drinks. Low-concentration pectin solutions can be considered Newtonian and show a low viscosity. Pectin has been used as a drug delivery vehicle within the deliveries of colon- specific drugs and hydrogels generally consist of crosslinked, hydrophilic polymer chains that form three dimensional networks.[16] Gels with sugar and acid are produced by high methoxyl pectin. High methoxyl pectin lacks enough acid groups to gel or precipitate with calcium ions, in contrast to low methoxyl pectin, despite Under some circumstances, precipitation is caused by other ions like copper or aluminum.[16,17] The rate at which gel forms is dependent on the degree of esterification (DE). occurs.[17] A faster setting results from a higher DE. Compared to rapid-set pectins (DE > 72%), slow-set pectins (with DE 58–65%) gel at lower soluble solids and higher levels. Divalent cations, typically calcium, are necessary for low methoxylpectins to properly form gels.

➢ *Bioadhesive System*

Mucoadhesive compositions, like patches, are made possible by pectin's capacity to absorb water, expand, and establish bioadhesive connections with biological tissue.[18] Pectin has also been reported to be helpful as a demulcent in throat lozenges, where it shields irritating areas in painful mouth and sore throat and provides momentary relief for mild discomfort.[19] Pectin's antihemorrhagic properties have also been applied to the healing of wounds as medicinal adhesives.[20]

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➢ *Dispersion System*

Pectin's hydrophobic acetyl groups and protein can function as anchors on the surface of oil particles, reducing surface tension and demonstrating pectin's potential for emulsification and foam stabilization.[21] It has also been used as a viscosity enhancer in lipid digests.[22] It has an emulsifier in oil: water emulsions .[22,24] Due to its high water-binding capacity, which minimizes the interaction between food and intestinal enzymes and prolongs the half-life of gastric emptying, pectin is used by weight-watchers as a means of controlling energy intake. This allows for a significant decrease in the amount and frequency of meals.[25] Moreover, systemic anti-inflammatory effects are a result of its interaction with polyphenolic chemicals. [26]

B. Pharmacological uses of Pectin

- Gastrointestinal Health: Pectin is used to relieve diarrhea by adding bulk to stools and slowing down intestinal transit time. It's also used to alleviate symptoms of irritable bowel syndrome (IBS) by regulating bowel movements.
- Cholesterol Reduction: Pectin can help lower cholesterol levels by binding to bile acids and preventing their reabsorption in the intestines, which leads to increased excretion of cholesterol.
- Blood Sugar Regulation: Due to its ability to slow down digestion and absorption of carbohydrates, pectin can help regulate blood sugar levels, making it beneficial for individuals with diabetes.
- Management Weight: Pectin's ability to promote satiety and regulate bowel movements can aid in weight management by reducing appetite and promoting a feeling of fullness.
- Wound Healing: Pectin-based dressings are used in wound care to promote healing and provide a moist environment conducive to tissue repair.
- Drug Delivery: Pectin can be used as a matrix for controlled drug delivery systems, enabling the sustained release of medications in the body.
- Radioprotection: Some studies suggest that pectin may have radioprotective properties, potentially reducing the harmful effects of radiation exposure. [27]

C. Ayurvedic uses of Pectin

In Ayurveda, pectin is not directly mentioned as a herbal remedy, but the fruits rich in pectin, such as apples, are often used in Ayurvedic practice. Here are some Ayurvedic applications and benefits associated with fruits high in pectin:

- Digestive Health: Fruits like apples, which are rich in pectin, are considered beneficial for digestive health in Ayurveda. They are believed to pacify aggravated Pittadosha and support healthy digestion.
- Detoxification: Pectin-rich fruits are thought to help in detoxification by binding to toxins and aiding their elimination from the body, thus supporting overall detox processes.
- Balancing Doshas: Ayurveda emphasizes the importance of balancing the three doshas (Vata, Pitta, and Kapha) for optimal health. Pectin-rich fruits are often recommended for balancing Pittadosha due to their cooling and soothing properties.
- Weight Management: Ayurveda considers obesity as an imbalance in the body, often related to impaired digestion and metabolism. Pectin-rich fruits may help in weight management by improving digestion, regulating bowel movements, and promoting a feeling of satiety.
- Heart Health: Fruits containing pectin, when consumed as part of a balanced diet, may contribute to heart health by helping to lower cholesterol levels and supporting healthy blood pressure.
- Skin Health: Ayurveda suggests that certain fruits rich in pectin, when consumed regularly, may help maintain healthy skin by promoting detoxification and providing essential nutrients.
- Immune Support: Pectin-rich fruits are considered to have immune-boosting properties in Ayurveda. They are believed to support the body's natural defense mechanisms and promote overall wellness.

While Ayurveda does not specifically isolate pectin as a medicinal substance, it recognizes the therapeutic properties of fruits rich in pectin and incorporates them into dietary recommendations and herbal formulations for various health benefits.

VII. APPLICATIONS OF PECTIN

A. Pharmaceutical Application of Pectin:

➢ *Gelling Agent*

Pectin is mostly employed as a gelling agent, although it can also be stabilized, thickened, and a water binder. Pectin is divided into two primary categories based on esterification. The low methoxy pectin, which is frequently used for jam, and the high methoxy pectin, which has an esterification degree greater than 50% and is primarily utilized for its thickening and gelling. Used in Several formulations like hair gel for smoothening effect.

➢ *Emulsifying Agent*

Pectin is a possible emulsifier based on polysaccharides however the stability of stabilized emissions. Emulsifier aid in formulating the stable emulsion by minimizing the interfacial tension between two immisible liquids and solubilizers help in dissolving or increasing the drug solubility in the formulation. Emulsifying agent is mainly used to prevent the breaking of emulsion. Natural emulsifier derived from plant or animal source common examples are beeswax cetylalchol. stearic acid.

➢ *Encapsulating Agent*

Pectin provide health advantage in addition to being useful for controlling texture and delivering food precisely to certain parts of digestive tract. Pectin can be utilized in the process of nano encapsulation. which create nano-capsules by forming hydrogel, liposomes, nanocomplexes and spray

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drying emulsion, among other technique. Pectin is a natural biomaterial now used as an matrix polymer for encapsulation. Pectin efficiently enhances the stability and bioavailability and also increase shelf life of encapsulated bioactive substances.

➢ *Stabilizing Agent*

Pectin used as an stabilizer in fruit juices and provide mouth feeling usually lost in cases where juice or sugar content occur at reduced level. Pectin increases the viscosity of continuous phases and prevent the upward movement of oil droplets. Citrus pectin are able to reduce the interfacial tension between an oil phase and water phase.

➢ *Metal Binding Agent*

Pectin contain functional group such as hydroxyl, methoxyl and amide. These functional group used to bind heavy metals, especially hydroxyl groups.[28]

B. Pharmacological Application of Pectin:

➢ *Anti-Cancer*

The protein galectin-3, which is involved in the development of colorectal cancer, is highly binding to pectin. Pectin has the ability to stop the expression of specific enzymes that encourage the invasion of breast cancer cells and trigger their death.

Pectin has the ability to suppress the expression of specific enzymes that encourage the invasion and metastasis of breast cancer. By triggering the intrinsic apoptosis pathway, pectin has also been demonstrated to cause apoptosis in breast cancer cells. Pectin has also been demonstrated to use the intrinsic apoptosis pathway to cause prostate cancer cells to undergo apoptosis. It has also been demonstrated that pectin uses the intrinsic apoptotic pathway to cause lung cancer cells to undergo apoptosis. Moreover, pectin has the ability to suppress the production of specific enzymes that encourage lung cancer cell invasion and metastasis.[30]

➢ *Anti Inflammatory:*

Pectin's ability to influence immune function and lower the production of proinflammatory cytokines is principally responsible for its anti-inflammatory effects. By preventing the synthesis and release of these cytokines, pectin can lessen inflammation. Glycemic management and lipid profile metrics were also enhanced by pectin supplementation.

Being a prebiotic fiber, pectin has the ability to encourage the development and activity of good bacteria in the stomach. Short-chain fatty acids, which are produced by these bacteria, have anti-inflammatory properties. When it comes to diabetes, pectin has strong anti-inflammatory qualities. Its capacity to alter immune response, lower cytokine production, and modify gut microbiota can aid in lowering inflammation and averting problems from diabetes.

➢ *Anti Diabetic:*

Appropriate biomolecules, such as pectin, which has shown to be a promising antidiabetic agent, should be consumed in conjunction with treatment and management of these complications. These include those related to glucose metabolism, improved insulin sensitivity, slowed glucose adsorption, reduced lipid levels, improved gut health, and other related complications. The evidence to date indicates that pectin may be a helpful therapeutic agent for people with diabetes, but more research is necessary to fully understand the mechanism by which it may help treat the condition. Additionally, pectin may be advantageous for lipid metabolism, which plays a significant role in the onset of diabetes and cardiovascular disease. It has been demonstrated that pectin lowers total cholesterol and lowers the risk of heart disease. The capacity to attach to bile acids in the gut, which encourages their excretion and decreases their reabsorption, is probably the cause of this.[31]

VIII. CONCLUSION

Pectin is a naturally occurring biopolymer that is employed in the pharmaceutical business, health promotion, and therapy due to its unique chemistry and gel- forming properties. It has also shown promise in the synthesis and formulation of pharmaceuticals as a carrier of a wide range of biologically active substances, both for sustained release applications and for delivering medications to the colon for systemic or local action. Dosage forms with a range of morphology and properties can be created by choosing the right kind of pectin, gelation conditions, additional excipients, and coating agents. Future research and development on pectin delivery systems should yield a number of fascinating and inventive uses. The pharmaceutical and chemical features obtained from apple pectin have been studied. The technological factors during the extraction of the pulp of apple from different varieties of apples and studied the yield of pectin. Chemical analysis of pectin content and output was carried. Fractional composition of pectin was analysed. The pectin obtained from the apple pectin in the presence of various acid agents. The development of novel combination medications that are safe, effective, high-quality, and reasonably prised appears to be promising application for apple pectin. Potential application of pectin include the management of pulmonary dermatological endocrine and heavy metal poisoning.

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