IJPSR (2021), Volume 12, Issue 12 **(Review Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 20 October 2020; received in revised form, 03 June 2021; accepted, 13 June 2021; published 01 December 2021

NATURAL GELLING AGENTS POLYMER IN PHARMACEUTICAL PREPARATION

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Keywords:

Natural Polymer, Natural Gums, Cellulose derivatives, Starch derivatives, Chitin derivatives

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ABSTRACT: Pharmaceutical preparation mostly contains active ingredients and excipients. The function of excipients to improve the physicochemical properties of pharmaceutical manufacturing products. In pharmaceutical preparation, polymer plays a key role act as excipients in any dosage formulation development. Polymers are derived from the source of natural and synthetic. The polymer should have basic properties such as stable, biocompatible, non-toxic, economical, biodegradable, and hydrophilic and influence the release of the drug. For designing any pharmaceutical dosage form, the selection of polymer play a key role because due to polymer diversity. Natural polymers help in the improvement and control of the pharmacokinetics of the drug. In recent times, pharmaceutical manufacturing companies use a natural polymer to resolve the problem of side effects and drug release in sustained release formulation. The polymers which isolate naturally are mostly polysaccharides. Here in this review discussion of natural polymer source, solubility, chemical nature, and pharmaceutical application for novel drug formulation.

INTRODUCTION: Herbal polymers consist of a large macromolecular structure of repeating units. According to the chemical structural orientation of polymer, subunits are connected by covalent bonding. Whether the polymer nature is natural or synthetic. By comparison survey, we can analyze that natural polymer availability and utilization in pharmaceutical preparation are very common due to availability, biodegradability, economically and non-toxicity [1]. Chemical structural modification can occur in the natural polymer. These polymers, which are original in a natural way, have many potential-oriented tasks. For example, the quantity of compound isolated is very small and has a complex structure in mixtures.

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.12(12).6139-50

This article can be accessed online on www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.12(12).6139-50

This is due to the different habitation of the plant and seasonal conditions. That is an effect on the isolation and purification methods of the natural polymer are slow and high-cost value. The other important point is the intellectual right of ownership [2]. Utilization of the natural polymer in pharmaceutical preparation manufacturing such as Gelling films, microsphere beads, solid monolithic matrix system, nanoparticles, implants, tablets, injection, emulsion, suspension, Cosmetic products. In these Pharmaceutical formulations, the natural polymer is used as binding, coating, suspending, emulsifying, gelling, sustained-release, or modified release and viscosity-enhancing [3].

Recent research showed that natural polymer is used in the preparation of novel drug delivery; these polymers have identical properties that depend upon the nature of the polymer. From the literature survey, it has been identified that polymer used to increase solubility stability and support as mechanical for the preparation of sustain drug release [4].

At that time it is a need to elaborate on the properties of the polymer. According to the role of polymer, we categorized the polymer 1) Isolation (by natural, semi-synthetic and synthetic), 2) Structural Orientation of polymer (Straight, cross-linked, branched, and polymer network.3) Polymer type (polymer addition and polymer condensation). 4) Arrangement of molecule strength (thermo-plastic/Fiber/Thermosetting/elastic) 5) Long-chain polymer(Governed by free radical) 6) Breaking down(bio &non-biodegradable) [5].

The polymer which has the property to soluble in water mostly used in the paper industry/paint industry/food industry/ biomedical industry &pharmaceutical industry [6, 7].

Natural Polymer Ideal Characteristics:

Categorizations of Natural Polymers: The natural polymer used in pharmaceutical product preparation due to the following factors.

1) Bioavailability & Stability: Natural origin polymer pharmaceutical products are stable for a longer duration of time especially when they are in solid dosage form and good bioavailability when it is to be taken.

2) Easily Available: In most parts of the world, the natural polymer is present and utilization for the preparation of different pharmaceutical products such as suspension, emulsion, capsule, table, *etc.*

3) Biodegradable: Natural polymer pharma-ceutical products commonly not show adverse effects.

4) Non-Toxic and Biocompatible: Natural material isolated from a plant or animal chemically has the structure of multiple units of mono-saccharide due to this they did not produce toxicity.

5) No Side Effect: Mostly, a natural polymer used in a pharmaceutical product is safe and has no side effects.

6) Economical: Natural Polymer materials are economical as compared to synthetic polymer material [8].

7**) Flexible & Portable:** Natural polymer pharma-ceutical products are ease for consumer handling, transportation, and storage condition especially oral dissolving films.

8) Effective Dosage Product: The drugs which enter directly into the systemic circulation, such as Buccal dissolving films. We can enhance the oral bioavailability of drugs that undergo the first-pass effect by using natural polymers [9].

9) Binder: Natural polymer used in pharmaceutical products to enhance the disintegration and dissolution of pharmaceutical products. Such as directly compressed tablets [10].

10) Bioadhesive Nature: Natural polymer use in bioadhesive delivery of the drug. (mucoadhesion means adhesion interaction of mucosal surface and polymer which act as soft tissue such as epithelial cells [11].

1) Plant Origin Gelling Polymer. The natural polymer originates from plants, which belong to different families. Most of the natural polymer nature is a carbohydrate, and the molecular weight is higher [12]. The natural polymer mainly consists of a single unit of sugar (monosaccharide units having bonding glycosidic in nature). The solubility of the natural polymer mainly in water /absorb water and after it swells up to make a thick solution or behave like a gelling agent. Natural polymer used in pharmaceutical preparation includes suspension, emulsion, tablet, capsule, injection, sustained release dosage form, film-forming, fast dissolving oral films, and tablets. Selection of the natural polymer in pharmaceutical dosage form for stable, effective, and delay drug release from the formulation. It depends upon the chemical nature and behavior of the natural polymer.

1) Agar-Agar or Agar: Agar derived from gelidium amansii, grailaria, and pterocladia which are the species of red algae. Chemical structure of the agar is composed of agarose and agaropectin. It can be utilized commonly at pH (5-11). For sterilization, autoclave the agar at 121 ^{o}C temperature, 15lb pressure for 15 min.

Agar is mainly used in pharmaceutical products for emulsifying agents, tablet disintegrants, suspending agents. It is used mostly as a surgical lubricant and culture of the microorganism [13].

2) Aloe Vera Gel: Aloe gel is isolated from the plant leaf (tissue of parenchyma). Physical nature of aloe gel-like mucilaginous. Extraction from aloe Vera gel treated with acetone and precipitate and converted directly compressed in the matrix system. In Pharmaceutical preparation, it is used in the formulation of delay release matrix tablets [14].

3) Cellulose & Its Derivatives: A French scientist in 1838 isolates cellulose from a plant and elucidates its chemical structure, which has a D-glucose unit liked by beta (1-4) linkage. The plant cell wall polysaccharide in nature, which contain pectin, cellulose and hemicelluloses. It is not soluble in water. By research, cellulose changes into cellulose ether. This is soluble in water. After the conversation of cellulose ether, many derivative prepared, which are and biocompatible in nature such as Hydroxylpropylmethylcellulose, Sodium carboxymethylcellulose, Hydroxyethylcellulose, and Hydroxypropyl cellulose with respect to type, molecular weight, and particle size [10]. This cellulose ether is used in the preparation of, thickening agent, film coating, binder, controlled release formulation, granulation, direct compression, mucoadhesive delivery system, and in the monolithic matrix system.

4) Carrageenans: Carrageenans extracted from carrageen seaweed and red algae. Chemically it sulfated polysaccharides and has three types. Gamma type produces viscosity but does not produce gel, but Iota type is elastic and produces a gel. It is used in tablet excipients, hydrogel beads, and controlled release tablet formulation. It can be cross-linked with calcium, potassium and alginate. It is also used in novel product formulation of sustain release products [15].

5) Natural Gums: The gums like (Guar gum, Locust bean Gum, Gum Acacia, Cassia Roxburghii, Ferula gummosis, Karaya gum, Gum Tragacanth, Gum Damar, Bhara Gum, Fenugreek gum, Grewia gum, Gum Arabic, Mango Gum& Tamarind gum) extracted from the plant stem, branches, seeds, and fruit. Gums have the ability to swell in water. The chemical nature of these gums is polysaccharides. These gums are used widely in pharmaceutical preparations such as emulsion, suspension, matrix tablets, novel sustain release matrix-forming material, thickening, Stabilizer, gel-forming agents, and also used in the food and cosmetic products [16, 17].

6) Glucomannan: Glucomannan extracted from the plant (bulbs, roots, softwood, and tubers). Chemically it is carbohydrates and a very large amount present in nature. It contains β(1,4) monomers linkage of D-mannose and D-glucose and has a property of hydrocolloids poly-saccharides and swelling. It produces weak gel but utilized in sustain release and matrix tablet formulation by a combination of a different natural polymer, which enhances the strength of the polymer [3].

7) Hemicellulose: The chemical nature of hemicelluloses like a heteropolymer. For example, Arabinoxylan, isolated from the psyllium husk seed coat of the plant *Plantago ovata*. The physical nature of the hemicelluloses amorphous, because it has a small chain of saccharides units and has branches with little strength.

It can extract from the plant's outer cell wall by treatment of a strongly basic solution. It contains a linkage of (β-1,4- DXylan). It is used in pharmaceutical preparation such as controlled release formulation, binding, film-forming, and cross-linked hydrogels formation [18].

8) Inulin: Inulin is isolated from the plant such as garlic and onion roots and contains a mixture of polymer and oligomers. It contains (β-2,1)linkage and not digest in the upper GIT and digest in the large intestine by microflora. It is used in the preparation of biodegradable films by a combination of other polymers, which are not disintegrating in the stomach and small intestine but swelling in the large intestine. It is also used in the formulation of the hydrogel [19].

9) Pectin: Isolation of pectin from citrus and apple and contain D-galacturonic acid chain with alpha (1-4) linkage. It's solubility in water and has properties like viscous and gelatin-like.

It is used as a binder in a directly compressed tablet along with other cellulose ether polymer and in sustains release formulation by gel beads. By emulsification technique use for microsphere, gelling, and matrix formation [20].

10) Rosin: Rosin isolates mostly from conifer plants. It contains terpene(abietic and pimaric acids), which are volatile liquid in nature. It is produced by heating to take fresh resin. It is widely used in pharmaceutical products such as film-forming, coating, matrix material, micro-encapsulation, controlled release formulation, plasticizers, and highly effective for nanoparticles formulation and drug delivery systems [21].

11) Starch and It's Derivative: Starch isolates from the plant (maize, potato, and sorghum) parts of the root, fruit, and seeds. It formed paste which uses in tablet granulation. It acts as a thinking, swelling, film-forming, and thickening agent and easily available at a cheaper price. Nature and chemical composition change in different regions. Substitute source of starch from wheat, barley, and rice .it can be used as a binder; disintegrants, diluents, gelling, and matrix agents in sustain release of the drug. Maltodextrin is not a sweat polymer. It is manufactured from starch by partial hydrolysis and found as a creamy-white hygroscopic spray-dried powder. Chemically starch consists of two units of homopolymers of D-glucose, amylase liner (1, 4)-glucan, and branched structure. It is biodegradable, biocompatible, non-toxic, and thermoplastic in nature. It also uses in scaffolds of bone tissue engineering [22].

12) Sodium Alginate & Alginic Acid: Alginate and alginic acid which is a hydrophilic colloid in nature extracted from seaweeds. It is a mixture of polychronic acid. It is used in pharmaceutical preparations such as thickening, suspending, gel producing, stabilizing, coating, biopolymer film, binder, and stabilization of the emulsion. It also promotes the Bifidobacterium species in the colon [23].

2) Animal Origin Gelling Polymer:

1) Chitin and Chitosan: Chitin isolates from invertebrates such as arthropods, mollusks, and annelids. Chemically contain polysaccharide (Amino an acetyl group). It is used in the formulation of gel beads for sustain release formulation of oral administration. The chitosan derivatives are effective in enhancing the mucosal drug delivery of hydrophilic macromolecules (protein drugs and heparins) transport and vaccine delivery [24].

2) Pullulan: Pullulan isolates from an extracellular microbial polysaccharide, it produces naturally from yeast (Fungus Like). Chemically it contains alpha-glucan one and depending upon the condition of fermentation by the microorganism. The (1-4) & (1-6) linkage between polysaccharides molecules change the structure and increase the solubility.

It is adhesive in nature and formed very strong films of high tensile strength. It is biodegradable, non-toxic, and edible property. It is stable at 5 PH. In the solution of water, its viscosity is low as compared to other polysaccharides. The film of Pullulan vaporized water molecules rapidly. It is mostly mixed with gelatin, polyvinyl alcohol, and amylase [25].

3) Albumin: Albumin synthesized in the liver and abundantly present in plasma protein (Human serum). The half-life of the serum albumen of humans is 19 days. It was solubilizing the long-chain fatty acids and take a necessary part of lipid metabolism. It binds with drugs (Penicillin, indole compound, benzodiazepine, and sulfonamide) [26].

Its nature is acidic, solubility in protein & 40% ethanol. It is stable at pH (4-9). It is non-toxic, biodegradables, and used in drug targeting for pharmacokinetic of peptide or the drug of protein in nature.

It is well taken up by cancer cells and consider ideal for the preparation of nanoparticles and delivery by injection due to solubility in water. It is also very good for gene delivery.

4) Xanthan Gum: Xanthan gum is taken from G(-) gram-negative bacteria by the method of fermentation. Chemically it is extracellular polysaccharides. It is used with other natural polymers for the preparation of sustain release formulation and direct compression of the tablet. It also uses in biotechnological, cosmetic, target, and novel drug delivery pharmaceutical preparation [27].

5) Dextran: Dextran took from gram (+) Positive bacteria by the method of fermentation. It contains alpha-D-(1-6) glucose-linked glucan with a side chain (1-3) linked with units of dextran biopolymer. It is very quick in water and formed a clear solution. It is used in the formation of hydrogels implants formation by cross-linking and

microsphere for scaffolds. Due to expensive, low yield value, toxicity, and without specificity of the affected area and very limited in the clinical use of these enzymes [28].

6) Gelatin: Gelatin isolated from animal collagen (bone, animal skin &fish skin) by partial alkaline hydrolysis. Chemically, purified protein fractions consist of amino acids with amide linkage to form linear polymers (coiled linear polypeptide chain.

Its solubility in water above 40-degree temperature and formed viscous solution. It is used in film-forming and can dissolve rapidly and act as a good carrier [29].

TABLE 1: NATURAL GELLING AGENT POLYMER FOR PHARMACEUTICAL PREPARATION

Polymer Name	Source/Solubility	Chemical Nature	Pharmaceutical Application	Reference
Agar	*Gelidium amansii*/ Grailaria) / Pterocladia / Gelling in water./ Not melt below 85 °C	Agarose /Agaropectin./ Agarobiose (D-galactose /3,6 Anhydro-L-Galactopyranose.)	Gelling agent / Suspending agent/ Emulsifying agent/Gelling Suppositories/Surgical Lubricant/Tablet Disintegrants/ Bacterial Culture/ Laxative	17
Albumin (Human serum albumin)	Synthesized in the liver/Soluble in water/ Soluble in 40% Ethanol.	Plasma Protein/(*Human serum* albumin consists of 585 amino acids/ Protein is composed of three homologous domains (I,II,III))	Drug delivery (Peptide or Protein-based drug)/ Injection/ Nanoparticles Preparation/ Gene Delivery	30
Aloe Gel	Leaves of Aloe Vera/ Swelling in water	Polysaccharides gel/(Pectin/ Cellulose/Hemicelluloses/ Glucomannan/ Acemannan)	Direct Compressible Matrix Tablets/ Sustained Release	3, 32, 33
Bhara Gum	Bark of *Terminalia bellerica* (Combretaceae)	ß-sitosterol/gallic acid/ellagic acid/ ethyl gallate/ galloyl glucose/ chebulaginic acid	Controlled release microcapsules/ controlled release Drug Oral	34
Carrageenans	*Chondrus crispus*, Eucheuma Cottonii/Eucheuma Spinosum Species/ Red Seaweed/	Repeating Galactose units and 3,6-Anhydrogalactose (3,6-AG)/ Sulfated and Non-sulfated- Joined alternating α (1-)-and β (1-4)-Glycosidic Linkages	Hard and Soft gel Capsule/ Antacid Gels/ Topical Bases/ Suppository Bases/ Contraceptive Gels/ Hand Lotions / shampoos/ Emulsion/ Dressings/ Controlled-Release Tablets	35, 28, 36
Cassia Roxburghii	Ceylon Senna/ Red Cassia Seed/50% Endosperm /water Soluble Gum	Alkaloids/ Sterols/ Anthraquinones/Glycosides/Tannins/ Flavonoids	Binding Properties/tablet	37
Chitosan Derivatives (Chitin and Chitosan)	Shrimp/Lobster/Crab/ Deacetylation of Chitin/Fungi-Yeast/Water or Organic Solvents	Cationic Polysaccharide (Amino and Acetyl Groups)/ Glucosamine and N-Acetyl Glucosamine	Gene delivery/Oral Absorption Enhancer/Mucoadhesive/Controlled Released drug/Mucosal drug/vaccine delivery/ Ophthalmic Vehicle/Hydrogel.	38, 39, 40, 41
Dextran	Fermentation/ Soluble in Water - Stable Solutions/ Insoluble in Alcohols.	α-D-1,6-glucose-linked Glucan	Hydrogel Implants / Microspheres	42, 43
Fenugreek gum	Trigonella *Foenum graecum*/L. Seed Mucilage	Galactomannan (galactose/mannose)	Suspending Agent/suspension.	44
Ferula gummosa	*Ferula gummosa* Boiss. (Apiaceae)/ Perennial Plant	resin galbanum(β-pinene and α-pinene)	binding agent/tablets	6
Gelatin	Animal Collagen	Mixture Of Purified	Film Forming/Dissolve Rapidly	45

	(Thermal Denaturation of Collagen)/Animal Skin/Bones/Fish Dkins / Soluble in water at above 40ºC	Protein Fractions (Proline/Hydroxyproline/ Glycine-polypeptide chain)		
Gellan Gum	Secreted by Microbe Sphingomonas elodea /Ion-Sensitive Polymer/Linear Anionic.	Heteropolysaccharide/Glucose/ Glucoronic Acid/Rhamnose	Thickening Agent/ Gelling Agent/ Stabilizing Agent	40, 46
Glucomannan	Softwoods/Roots/ Tubers/ Plant Bulb /Hydro colloidal Polysaccharide/ Solubility and Swelling in Water	β-1,4 Linked Dmannose / D-glucose Monomers.	Controlled Release Drug Delivery/ Matrix Tablets/Sustain Hydrocortisone Release/ Controlled Release of DNA/ Hydrogel Systems	47
Grewia gum	extracted from the inner stem bark of *Grewia mollis*	Amorphous polysaccharide gum (glucose/ Rhamnose/galactose/arabinose / xylose as neutral sugars	suspending agent	48
Guar gum	Endosperm of Guar Plant (Cyamopsis Tetragonoloba)/	Polysaccharide (Galactose/Mannose)	Binder/ Disintegrants in Tablet/ Stabilizers/Emulsifier/Thickening/Suspending agent in Liquid Formulations/ Oral Extended Release Drug Delivery/ Three-Layer Matrix Tablets	49, 50
Gum Acacia	Stem/Branches Acacia wild/ Acacia Senegal	D-galactose/L-arabinose/ L-Rhamnose/ D-glucuronic acid.	Oral /Topical Pharmaceutical Formulations/Suspending/Emulsifying agent/Pastilles/Lozenges/ Tablet Binder	51
Gum Arabic	Stem/Branches Arabica wild.	D-galactose/L-arabinose/L-Rhamnose/D-glucuronic acid	Matrix Microencapsulating/ Osmotic Suspending/Expanding Agent/Monolithic Osmotic Tablet system/Sustained Release Pellets.	16
Gum Damar	*Shorea wiesneri*.	40% Alpha-Resin (Resin that Dissolves in Alcohol)/ 22% -13 Beta Resins/23% Dammarol Acid /2.5% Water	Matrix tablets/Sustained Drug Delivery	52
Hemicellulose	Heteropolymer (Matrix Polysaccharides)/ Arabinoxylan/ Resistant to Hydrolysis/Solubility /Swelling in Water	(Xyloglucans/ Xylans /Mannans)/ β-1,4-Linked Dglycans/Xyloglucans	Film Forming Agent	53
Hyaluronic acid	Joint liquid of Mammalians/ Soluble in Water	Polyanionic Polysaccharide/ Glucuronic Acid/N-Acetyl glucosamine	Injections (Intra-Articular)/Eye Gel/Prolonged Drug Release/ Artificial Insemination	54, 55
Hydroxyethyl Cellulose	Soluble in Hot or Cold water	Cellulose Ethers	Film Forming/ Binders/Coating agents/Emulsifying/Stabilizing Agents/ For Tablet	56, 57
Hydroxypropyl Cellulose	Non-ionic water-Soluble/Thermoplastic Polymer/ softening in 100–150 ºC	Cellulose Ethers/(NMT 0.6% of Silica-Hypromellose)	Buccal delivery /film forming/ Binders/Coating Agents/ Emulsifying/Stabilizing Agents/ Tablet Disintegrants/ Mucoadhesive Delivery Systems	58

Hydroxypropyl Methyl Cellulose.	Water-soluble-colloidal solution)	Cellulose Ethers/ (O- methylated and O-(2-hydroxypropylated) cellulose)	Thickening Agent/Prolong Drug Release /Film Forming /Cosmetics/ Binders/Coating agents in Tablet/ Emulsifying for Emulsion/Stabilizing, Agents/Tablet Disintegrants/Stabilizing Agent	59, 60, 61
Inulin	Bulbs of Dehlia/ *Inula helenium*/ Roots of Dendelion/*Taraxacum officinale*/Burdock Root/*Saussurea lappa*/ Chicory roots, *Cichonium intybus*	Polysaccharide/Mixture of Oligomers (gluco-fructans) /Polymers/ Derivatised with Methacrylic Anhydride/Succinic Anhydride	Film Former/ Methylated Inulin Hydrogels	62
Karaya Gum	*Sterculia urens*/Swell in Water	Acetylated Polymer of Galactose, Rhamnose/Glucuronic Acid	Release-Controlling Agents/Directly Compressed Matrices/ Buccal Delivery	63, 64
Locust Bean Gum	Seeds of Leguminous Plant *Ceratonia siliqua* Linn/ Brown Pods/Beans of Locust Bean Tree Endosperm	Galactomannan Polymer (1,4-Linked Dmannopyranosyl)	Matrix Tablets/ Controlled-Release Tablets	65, 66
Lycoat NG 73	Pea Starch/Disperse in Cold Water	Hydroxypropyl Starch.	Orodispersible Films /Film-Forming Polymer	67
Maltodextrin	Starch by Partial Hydrolysis/Water Soluble	D-Glucose Units (α (1→4) Glycosidic Bond)	Film Forming Agent/Mouth Dissolving Film	68
Mango Gum	superdisintegrants swell when they interact with water		Orally disintegrating tablets	69, 70
Modified Starch	Enzymatic Degradation of Potato Starch/Swelling in Water	Pregelatinized Starch (linear amylase/ highly branched amylopectin)	Directly Compressible Controlled-Release Matrix Systems/ Tablet Preparation	71
Native Starch	Swelling in Water	Starch Acetate (Acetyl Esterification)	Swelling /Rapid Fast Release of Drugs/Controlled Release Direct Compressible Matrix Systems/ Peptide Drugs Orally/Microcapsules.	72, 73
Pectin	Fruit /Vegetables /Citrus Peel/Apple Pomades/ Citrus Simon/Citrus Aurantium/ Polysaccharides/ Soluble in Water	D-galacturonic Acid/Anionic Polysaccharide β-1, 4-linked D-galacturonic Acid	Tablets (Directly Compressed/Sustain Release Drug /Gel Beads/Injections/Oral Films/ Film Coating of Colon- Drug Delivery Systems/ Transdermal Patches	74, 75, 76
Polymerized Rosin	Pines/Conifers/Liquid Resin (Liquid Terpene)	Gum Rosin by Polymerization. (Monomeric Resin Acids)	Non-Crystallizing/Film Forming Properties /Enteric Coating /Delayed Release of Drugs	77
Psyllium	Seed Coat of Plantago Ovata -outer layer of the seeds/Swelling in water	N,N'-Methylenebisacrylamide	Tablet Binding/ Hydrogels/Cross-Linked Hydrogels /Controlled Release of the Active Ingredient	78, 79, 80
Pullulan	Fungal Exopolysaccharide (*Aureobasidium pullulan*)/ Microbial (*Tremella mesenterica*)/Water Soluble(Hot and Cold	Linear Polysaccharide (α–1, 6-Linked Maltotriose)	Film-forming./ Blending with sodium alginate or CMC enhance the properties of the film/ Pullulan–HPMC films improved thermal-mechanical properties	81, 82

	Water)			
Rosin	Pines/Conifers/ Pinus Soxburghui/Pinus Longifolium /Pinus Toed	Abietic / Pimaric Acids.	Film-Forming/ Microencapsulation/Coating Properties/ Matrix Materials Tablets/Sustained Controlled Release/Nanoparticles	83, 84, 85
Sodium Alginate	Brown Seaweeds /*Laminaria hyperborea*, *Ascophyllum nodosum* /*Macrocystis pyrifera*. (Phaeophyceae Laminaria)/ Hydrophilic /Anionic	Sodium Salt of Alginic Acid/ D-Mannuronic acid/ L-guluronic acid/β-D-Mannuronic acid/α-L-guluronic acid linked in α- or β-1,4 glycosidic bonds/β-D-Mannuronic acid or α-L-guluronic acid in Homopolymers.	Biopolymer Film/Colloidal Preparation/Thickening/Stabilizing/Suspending/Gel producing/Emulsion Stabilizing/ Tablet binders/Tablet Disintegrants/Thickening Agent	86, 87, 88, 89
Sodium Carboxymethyl Cellulose.	Water-soluble/ Non-Ionic Cellulose Ether	Cellulose by treatment with alkali / Mono-chloro-acetic acid/ Sodium Salt	Emulsion/Cosmetic (binding/thickening/ stabilizing agent)/ Microspheres and Drug Encapsulation/Controlled Release Hydrophilic Matrix Systems/preparation of microspheres using glutaraldehyde a cross-linker	90, 91, 92
Starch or Starch-Based Derivatives	Green plants/ Seeds / Rice/ Wheat/ Potato	Two Homopolymers of D-glucose/ (Amylose (α-1, 4 linked D-glucose monomers) /Amylopectin- both α-1,4 and α-1,6 linked D-glucose monomers)	Formulation of Capsules/ Tablet Binder Diluents/Disintegrants / Subcutaneous Implants/ Sustained Release (Matrix Systems)/Microspheres hydrogels / Modified starch oral film	93, 94, 95, 96
Tamarind gum	Polysaccharides	Mucoadhesive Polymers	Buccal Delivery of Drugs	97, 98
Tragacanth gum	*Astragalus gummifer*/ Dissolves in water Colloidal solution (sol)/ Bassorin swells to form a thick gel	Tragacanthic acid/Arabinogalactan/ D-galacturonic acid/D-xylose/L-fructose/ D-galactose	1- and 3-layer Matrices/Release Prolongation/Emulsifier/ Thickening agent/Suspending Agent	99, 100, 101
Xanthan Gum	Gram-Negative Bacterium Xanthomonas Campestris/Soluble in both hot and cold water	Two D-glucopyranosyl units/ Two D-mannopyranosyl units/ One D-glucopyranosyluronic unit	Cosmetic products/Paste/Cream/Eye gel/Emulsion/Suspension/Hydro Collides	102, 103

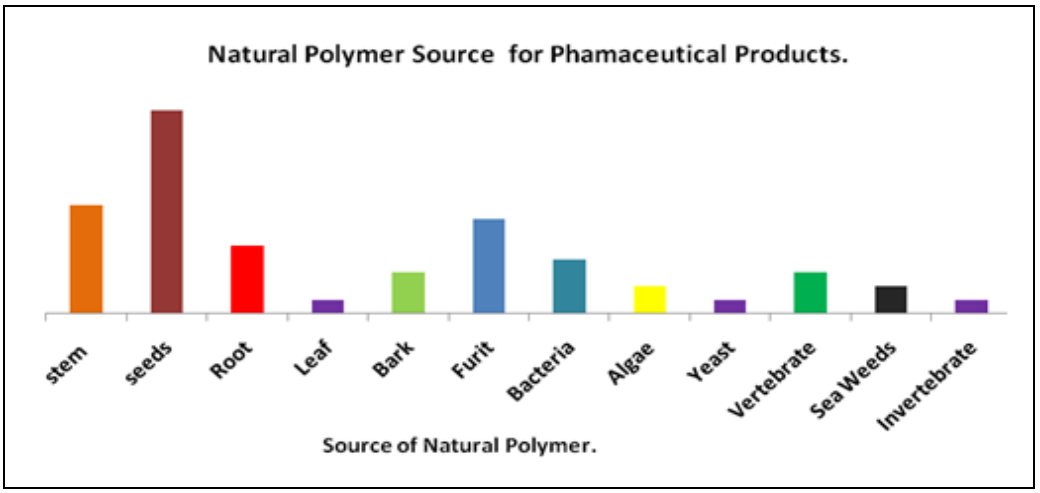

FIG. 1: SOURCE OF NATURAL PRODUCT FOR PHARMACEUTICAL PRODUCTS

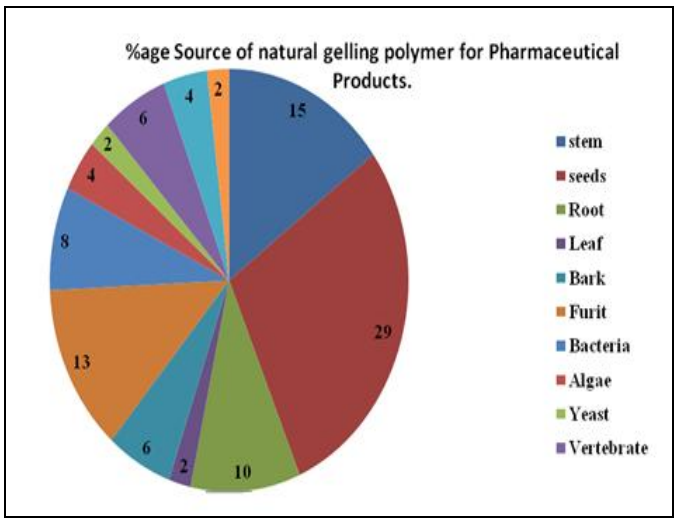

FIG. 2: (%AGE) SOURCE OF NATURAL POLYMER FOR PHARMACEUTICAL PRODUCTS

CONCLUSION: In drug delivery, polymer plays a key role. For pharmaceutical product preparation, polymer selection is vital because of the nature of polymer incompatibility with drugs, the pattern of degradation, and the level of toxicity. The final analysis of this review depicts that natural polymer plays an effective role in pharmaceutical dosage formulation. Natural polymer improves the bioavailability and resident time of the drug at the site of action. It also helps in the improvement of novel natural polymer utilization in drug delivery systems.

Future Prospective of Natural Polymers: Polymer of natural in nature improves the drug molecules' time by bioadhesion. It is used in novel formulation development to enhance the drug release pattern; this characteristic of natural polymer enhances the administration of the drug in the specific treatment and its effectiveness along with patient compliance. Natural polymer utilized for the improvement in the delivery of the drug by a different route of administration. In the delivery of the macromolecules therapeutics, vaccine and gene natural polymer has good potential. A few studies practically conduct on recent generation natural polymer for novel delivery of the drug. Few research articles focus on the structural changes of natural polymer to enhance release or sustain of the drug in the biological system. In the future natural polymer plays a vital role in the development of biotechnological products and gene therapy [104, 105].

ACKNOWLEDGEMENT: We would like to thank our colleague's college of pharmacy, Jouf University, for suggestions and valuable guidance while writing this paper.

CONFLICTS OF INTEREST: The authors declare no conflict of interest.

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How to cite this article:
Ahmad MM and Bukhari SNA: Natural gelling agents polymer in pharmaceutical preparation. Int J Pharm Sci & Res 2021; 12(12): 6139-50. doi: 10.13040/IJPSR.0975-8232.12(12).6139-50.