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Natural Polymers used in Novel Drug Delivery System (NDDS)

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Abstract: Numerous innovative drug delivery systems have been invented as a result of developments in polymer science. It might be highly beneficial to consider both bulk and surface properties when designing polymers for various drug delivery systems. Natural polymers for pharmaceutical applications is good prices, availability, low toxicity, ability to undergo chemical modifications, potential for biodegradation, and, with a few notable exceptions, biocompatibility. This review mainly focused on describing different natural polymers used in the process of developing new drug delivery systems.

Keywords: Natural Polymer, Novel Drug Delivery System,

INTRODUCTION:

Novel drug delivery system (NDDS):

It is the new approach that combines innovative development, formulation, new technologies, novel methodologies for delivering pharmaceutical compound in the body, improve drug potencycontroldrugreleasewithprolongedpharmacologicaleffect,sometypes arementionedbelow.[3]
Liposomes, Niosome, Transdermal DDS, Antibody targeted system, Ionophorectic system, Controlled released DDS, Sustained release DDS, Delayed release DDS, Hydrodynamic activated DDS, Vapour pressure activated DDS, Mechanically activated DDS, Sonophoresis activated DDS, Iontophorosis DDS, Hydration activated DDS, Magnetically activated DDS, Feedback regulated DDS, Site targeted DDS, etc.

Polymers are substances whose monomers are condensed into massive numbers of repeating units and have high molar weights. Polymers can form particles of solid dosage form and also can change the

flow property of liquid dosage form. The foundation of pharmaceutical drug delivery is polymers. Polymers have been used as an important tool to control the drug release rate from the formulation.[1] Polymers is both naturally occurring and synthetic. Natural polymers include latex, carbohydrate, proteins, and cellulose. Usually united by covalent chemical bonds, a polymer is a big molecule (macromolecule) made up of repeated structural units or chains. Many important natural materials are organic polymers including cellulose ,lignin, rubber,proteinsandnucleicacids.[2]

Herbal Polymers:[4]

Biodegradable: Naturally occurring polymers produced by all living organisms. They show no adverse effects on the environment or human being.

Biocompatible and non-toxic: Either non-toxic or biocompatible, nearly most of these plant components are carbohydrates and are made up of mono saccharine units that keeps repeating.

Economic: They cost less to produce and are more affordable than synthetic materials.

Safe and devoid of side effects : They are from a natural source and hence, safe and without side effects.

Easy availability : In many countries, they are produced due to their application in many industries.

Classification of Natural Polymers:[5]

Plant origin- Cellulose, Hemicellulose, Glucomannan, Agar, Starch, Pectin, Inulin, Rosin, Guar gum, Locust bean Gum, Gum Acacia, Karaya gum, Gum Tragacanth, Aloe Vera gel.

Animal origin-Chitin, Alginates, Carageenans, Psyllium, Xanthun gum.

Microbe's origin-Alginate, Cellulose.

CHITOSAN:

Biological Source:

Chitin is naturally located in the exoskeleton of shellfish such as crabs and shrimps, and in the cell membranes of fungi, yeasts, and other microorganisms.[6]

Chemical Constituents:

Chitin Biopolymer is primarily composed of glucosamine and N-acetyl glucosamine residues with a 1, 4-β-linkage. Chitosan has a net positive charge due to the presence of primary amines (-NH2),which is essential for its biologicalfunction.[7]

Extraction:

The production of chitosan starts with the selection of a suitable source for chitin extraction. Chitin can be extracted from either the animal sources such as shellfish or non-animal sources such as fungi. Chitin is extracted from natural sources via De-mineralization and De-proteination. To createchitosan, concentrated alkalis(such as sodium hydroxide) are introduced to the purified chitin. The process is known as De-acetylation and it affects the characteristics of chitosan, which include the extent of positive charge (proportion of amine groups in polymer) and molecularweight.[7]

Physicochemical characteristics:

The degree of acetylation, temperature, PH, and polymer crystallinity are some of the variables that affect how soluble chitosan is. Chitin can be homogeneously deacetylated (alkali treated) to produce polymers soluble in aqueous acetic acid solutions with DD as low as 28%, although heterogeneous deacetylation never obtains this value (alkali treatment, high temperatures). Also, the samples are water soluble with a DDof49%.[9]

Applications:

Chitosan and its components (N-trimethyl chitosan, mono-N-carboxy methyl chitosan) are safe and effective absorption enhancers to improve mucosal, nasal, per oral drug delivery of hydrophilic macromolecules such as peptide and protein drugs and heparins. Chitosan nanoparticles and microparticles are also suitable for controlled drugrelease.[5]

CELLULOSE:

Biological Source:

Cellulose is an important structural component of the primary cell wall comprising of mycetes, several types of algae, and green plants. Certain types of bacteria secrete it to create biofilms.[10]Cellulose is among the most prevalent organic compounds. The molecule can form long, straight chains as it is a polymer consisting of unbranched glucose residues connected bybeta-1,4 linkages.[11]

Chemical Constituents of Cellulose:

This biopolymer is a polysaccharide composed of a linear chain of β-1,4 linked d-glucose units with a degree of polymerization ranged from several hundreds to over ten thousands, which is the mostabundantorganicpolymerontheearth.[12,13]

Extraction of Cellulose:

Nano-fibrillated cellulose extracted from waste citrus sinensis peels were transformed with silver nanoparticles utilising a chemical process comprising alkali and acid hydrolysis and extract of citrus sinensis skins as a reducing agent were engineeredforheavymetalsorption.[14]

The spiny margins and midribs of the leaves were removed, after which the leaves were chopped into approximately 12 cm × 3 cm pieces and partially dried in the sun. After that, the leaves were submerged in still water for three days, with frequent water changes. After about 15 minutes of boiling, the leaves were then washed several times in fresh water. After drying in the sun, the leaves were pulverised in a mill. The leaves were first treated with 4% NaOH at 125°C for 2hours,and then bleached with 1.7 w/v% NaClO2atpH 4.5 and 125°Cfor 4 hours. The ratio of the leaves to liquor was 5:100 (g/mL). Each step was repeated several times, and the leaves werewashedwithdistilledwateraftereachtreatment.[15]

Applications of Cellulose:

Microcrystalline cellulose is mainly used in the pharmaceutical industry as a diluent/binder in tablets for both the direct compression and granulation processes. In medication formulations, carboxylated methyl cellulose is used as a binder for pharmaceuticals, a film-coating agent for drugs, an ointment base, etc. Wound dressings use fibres made of cellulose acetate.[5]

CARRAGEENAN:

Biological Source of Carrageenan:

Carrageenans are a family of natural linear sulfated polysaccharides that are extracted from rededible seaweeds. Chondrus crispus (Irish moss), a dark red parsley-like plant that grows adhering to the rocks, is the most well-known and still the most significant red seaweed utilised for producing the hydrophilic colloids to manufacture carrageenan.[16] E. cottonii and E. spinosum which together account for roughly three-quarters of global production, are the most frequently used sources.[16]

Chemical Constituents of Carrageenan:

All carrageenan's are high-molecular-weight polysaccharides, and the disaccharide repeating unit of carrageenan's is mainly composed of alternating 3-linked b-D-galactopyranose (G-units)and 4-linked a-D-galactopyranose (D units) or 4-linked 3,6-anhydro-a-D-galactopyranose (DA-units).[16]

ApplicationofCarrageenan:

Carrageenan has been studied as an excipient in the pharmaceutical industry for use as a polymermatrix in oral extended-release tablets, a novel extrusion assist for the manufacturing of pellets,and as a carrier/stabilizer in micro/nanoparticle systems, among other applications. Carrageenanhas also been employed as a gelling agent and viscosity enhancer for controlled medicationrelease and prolonged retention due to its unique properties, such as the high negative charge andgelling.[53]

ALGINATE.

Biological Source of Alginate:

Alginates are the natural colloidal polysaccharide group, which are water soluble, biodegradable, non toxic, and non-irritant in nature. These are mainly extracted from different species of brown marine algae. Some Pseudomonas sp. And Azotobacter sp. also produce bacterial alginates.[17]

Chemical Constituents of Alginate:

Alginates are natural polymers consisting of linear copolymers of β-(1–4) linked d-mannuronicacid and β-(1–4)-linked l-guluronic acid units, which exist widely in brown seaweeds such as species of ascophyllum, durvillaea, ecklonia, laminaria, lessonia, macrocystis, sargassum, andturbinaria.[18,19]

Extraction of Alginate:

The seaweed is chopped up and mixed in a hot alkali solution—typically sodium carbonate—to extract the alginate. The alginate turns into sodium alginate over the course of about two hours, creating a very thick slurry. The portion of the sea weed that does not dissolve, primarily cellulose, is also included in this slurry. The solution needs to be cleansed of this insoluble residue. The mixture needs to be greatly diluted with water because it is too thick (viscous) to be filtered. A filter press is used to press the diluted solution through a filter cloth. The undissolved residue, however, comes in extremely small particles that can easily clog the filter cloth. Therefore, a filter aid, such as diatomaceous earth, must be applied before filtration begins; this keeps the majority of the tiny particles away from the surface of the filter fabric and helps with filtering. Filter assistance, however, can add significantly to costs due to its high cost. Some processors pressurise the extract while it is diluted with water (the extract and diluting water are combined in an in-line mixer into which air is pressed),reducing the amount of filter aid required. The leftover flakes are adhered to by tiny air bubbles. For several hours, the diluted extract stands as the air rises to the top, carrying the residue particles with it. The solution is extracted from the bottom and pumped to the filter as the foamy mixture of air and residue is removed from the top. The alginate is then precipitated from the filtered solution as eithercalciumalginateoralginicacid.[20]

Physico chemical Properties:

Soluble in alkaline solutions Insoluble but swells in water, Almost insoluble inorganic solvents or very little soluble in ethanol.[8]

Applications of Alginate:

Tablets of mesalazine formed of alginate are utilized for intestinal medication administration. Alginatenis is also used as encapsulating materials for the muco salt issue of controlled medication delivery. Additionally, Mucoadhesive medication delivery systems are made usingit.[5]

PECTIN.

Biological Source of Pectin:

Pectin is a carbohydrate and is present in the cell wall as the calcium salt or methyl ester in the middle lamina. These are obtained from the inner portion of the rind of citrus fruits like lemon, orange, etc. and vegetative matter like sunflower, mangoes, papaya and guavas etc.[21]

Chemical Constituents of Pectin:

Pectins are polygalacturonic acids in their chemical components, yet some of their carboxyl groups are also found as methyl esters. Aldobionicpectic acid breaks down into galacturanic acid, arabinose, galactose, and methyl pectose upon hydrolysis. Pectic acid's methoxy ester is pectin. It is hydrolyzed by the pectase of diluted caustic soda, resulting in pectic acid and methyl alcohol, which are the building blocks of cellulose and pectin. Water cannot dissolve it. Pectin and cellulose are produced by the alkaline hydrolysis of pectose.[22]

Extraction of Pectin:

On an industrial scale, acid extraction and alcoholic precipitation are generally used to extract pectin on a commercial basis. Acid extraction of pectin is based on the fact that hydrolysis of proto pectin occurs at higher temperatures. The microwave-assisted extraction was found to be better than ultrasound-assisted extraction as the highest pectin yield was recorded with 17.97%yield at 360 W for 3 min, whereas 17.30% was achieved when using HCl as the solvent in ultrasound-assisted extraction at75 °C for45 min. Electromagnetic induction was used for pectin extraction from citrange albedo, and extracted protopectin was further compared with that obtained by the conventional heating method. When the pectin solution is concentrated (2-4%),precipitating agents like alcohol are typically used; when the solution is diluted (0.3-0.5%),aluminum salt is typically used. Commercial pectin extraction methods use organic solvents, while salts of poly valent metals are alsooccasionallyemployed.[23]

Application of Pectin:

Pectin is an important polysaccharide use for pharmaceutical purpose e.g. as a carrier of a variety of drugs delivery system. It is also a promising excipient for the pharmaceutical industry for present and future applications.[54]

AGAR

Synonym: Agar-agar, Japanese Isinglass, Vegetable gelatin.[24]

Biological Source of Agar:

The dried gelatinous substance known as agar is derived from Gelidium amansii Lamouroux, Gelidium cartilagineum Gall, Gelidium pristoides TurnKiitz, Family: Gelidiaceae, Rhodophyceae (redAlgae).[24,25]

Chemical Constituents of Agar:

Composition of Agarose and agaropectin are the main ingredients in agar. The repeating monomeric unit of agarobiose is the basis for the linear polymer known as agarose. The disaccharide agarobiose, on the other hand, is composed of D-galactose and 3, 6-anhydro-L-galactopyranose.Agaropectinisa hetero generous mixture of smaller acidic molecules.[5]

Extraction of Agar:[26]

At initially, the conventional method of making natural agar was employed, and it remained mostly unchanged until 1939, when American Agar 29 & Co. (USA) started creating agar in factories using freezing tanks similar to those used to produce ice bars. After World War II, Japan used the same strategy, as did new buildings built in Spain, Portugal, and Morocco. The extract from seaweeds,which typically contains between 1and 1.2% agar throughout the procedure, is significantly concentrated to 10 to 12% agar after thawing and filtering, which is an increase of roughly ten times. Gelling type of polysaccharides can easily be separated from non-gelling types by freezing followed by thawing or pressing. Some non-gelling polysaccharides have been identified as having an agar.

In contrast to other extraction techniques, this method enhances agar output in a shorter length oftime and

works better with firm seaweed. It is typical to apply a gauge compulsion of 1-2 kg/cm2for 2-4 hours. In comparison, pressurised cooking extraction produced more agar than standardacid-cookingextractionunderclimaticconditionswhenemployedtoderivehardAfricanGelidiaceaesppcartilagineum.

Physicochemical properties of Agar:

Molecular Masses:

They typically have molecular weights greater than 52 150,000 Daltons and a low sulphate concentration of less than 0.15 percent. Agaropectine refers to the remaining portions. They have molecular mass of less than twenty thousand Daltons, generally about 14,000 Daltons. Sulphates have a significantly greater concentration, ranging between 5 to 8 percentages in fewcases. This level is much less compared to carrageenan's, with 24 to 53 per cent sulfation even furcellaran, which is the minimum sulphated Carrageenan at around per centsulfation.[26]

Applications of Agar:

Agar is used as a laxative, emulsifying agent, surgical lubricant, tablet disintegrate, gelling agentin suppositories, and suspension agent. The creation of jellies, confectionery goods, tissue cultureresearch,andmicrobiologyinvestigationarefurtherusesforit.[5]

CELLULOSE ACETATE PHTHALATE.

Cellulose acetate phthalate (CAP) is a widely employed enteric coating polymer. A commonpolymer phthalate used in the manufacture of pharmaceuticals, such as the enteric coating oftablets or capsules and for controlled release formulations, is cellulose acetate phthalate (CAP), also known as cellacefate(INN)[27]

Biological Source of Cellulose acetate phthalate:

Cellulose acetate phthalateis derived from plant-based raw materials and is used in a wide range of applications across the globe. The chemical compound is used as a matrix binder for tablets and capsules or as an enteric film coating material.[28]Cellulose is an important structural component of the primary cell wall of green plants, many forms of algae and the oomycetes. Some species of bacteria secrete ittoformbiofilms.[10]

Chemical constituent of Cellulose acetate phthalate:

A cellulose derivative is cellulose acetate phthalate. The most prevalent organic polymer on earth is cellulose, a polysaccharide made up of a linear chain of 1,4-linked d-glucose units with a degree of polymerization ranging from few hundreds to over ten thousand. It is an organic polysaccharide consisting of a linear chain of several hundred to over ten thousand β (1→4)linked D-glucose units having the formula(C6H10O5)n.[5]

Preparation of Cellulose acetate phthalate:

A highly substituted form of cellulose acetate (CA) is reacted with phthalic anhydride in thepresenceofanorganicsolventandabasiccatalysttoproducecelluloseacetatephthalate,which is the most commonly used form of the compound. Acetic acid, acetone, or pyridines are the most often utilised

organic solvents as reaction media for the phthaloylation of cellulose acetate. Anhydrous sodium acetate, amines, and the organic solvent itself are used as the fundamental catalysts when using acetic acid, acetone, or pyridine as the reaction medium, respectively.[27] the application of an environmentally acceptable process to extract cellulose acetate (CA) from bagasse and cajuput(Melaleucaleuc adendron)5twigs.

Cajuput twigs (CT) and sugarcane bagasse (SB) were first prehydrolyzed, pulped with soda(NaOH), and then bleached with elemental chlorine-free (ECF) to extract the cellulose. Later, iodine (I) was utilized as a catalyst to acetylate the extracted cellulose. [30]

Physicochemical Properties of Cellulose acetate phthalate:

Freely soluble in water. Soluble in diethylene glycol and dioxan. Essentially water insoluble, ethanol, toluene etc.[8]

Application of Cellulose acetate phthalate:

Cellulose acetate phthalate (CAP) is used as an enteric film coating material, or as a matrix binder for tablets and capsules. 1 - 8 such coatings resist prolonged contact with the strongly acidic gastric fluid, but dissolve in the mildly acidic or neutral intestinal environment.

Cellulose acetate phthalate is commonly applied to solid-dosage forms either by coating from organic or aqueous solvent systems or by direct compression. Concentrations generally used are0.5-9.0% of the core weight. The addition of plasticizers improves the water resistance of this coating material, and formulations using such plasticizers are more effective than when cellulose acetate phthalate is used alone.

Celluloseacetatephthalateiscompatiblewithmanyplasticizers,includingacetylatedmonoglyceride;butylphthaly butylglycolate;dibutyltartrate;diethylphthalate;dimethylphthalate; ethyl phthalyl ethyl glycolate; glycerin; propylene glycol; triacetin; triacetin citrate; and tripropionin. It is also used in combination with other coating agents such as ethyl cellulose, indrugcontrolled-releasepreparations.[52]

HYDROXY PROPYL METHYL CELLULOSE (HPMC)

Biological Source of HPMC:

One or more of the three hydroxyl groups located in the cellulose ring have been substituted byhydroxyl groups in the cellulose ethers group, which contains hydroxypropyl methylcellulose(HPMC).[34]

Chemical constituent of HPMC:

Hydroxy propyl methyl cellulose is derivative of cellulose. The most frequent organic polymer on earth is cellulose, a polysaccharide made up of a linear chain of 1,4-linkedd-glucoseunitswith a degree of polymerization varying from several hundreds to over ten thousands.[13]

Extraction of HPMC:

Extraction The coarse bamboo powder was dried in an oven at 106 °C for 6 h. Furthermore, it was ground to a fine powder and sieved with 80 mesh sieve. The fine bamboo powder was washed repeatedly with water, then dried at 60°C for24 h in an oven. About 300g of fine bamboo powder was macerated with 3 l of n-hexane: ethanol (2:1) for 24h and stirred every 8h. The pulp was filtered and dried at room temperature.[35]

Physicochemical Properties of HPMC:

It swells in water forming an opalescent viscous in colloidal solution. Practically not soluble in warm water, acetone, ethanol, etherandtoluene.[8]

Application:

It has been extensively studied for its use as a viscolizing agent (thickening agent), coating polymer, bioadhesive, in solid dispersion to improve solubility, binder in the process of granulation, and in modified release formulations. The manufacturing of capsule shells, which replaces the animal-derived gelatin in traditional two-piece capsules, is another important application.[55]

As film coating materials, the products with low viscosity and high concentration can be used as the aqueous film coating solution, while those with high viscosity can be used as organic solvent solution. It can be used as the binder of tablets, the thickener for eye drops, and as topical preparations such as the protective colloid for gels or ointments, as well as the stabilizer of emulsions and suspensions. It can also act as the adhesive of plastic bandage. In recent years, Hydroxy Propyl Methyl Cellulose has been used as the matrix, adhesives, frame materials, the porogen, and the film forming material or coating material. Furthermore, it has been widely used in the development of new formulations such as the sustained-release mucosa adhesive, controlled- release pellets, microcapsules, a variety of matrix sustained-release tablets, controlled-release tablets, Multilayer sustained-release tablets, a variety of coating sustained-release formulations, suppositories,ophthalmicpreparationsandsustained-releasesuppositories.[57]

XANTHAN GUM.

Biological Source of Xanthan Gum:

Xanthan gum is a high molecular weight extra cellular polysaccharide produced by the fermentation of the gram-negative bacterium Xanthomonas campestris.[5]

Chemical Constituents of Xanthan Gum:

The primary structure of naturally produced cellulose derivative contains a cellulose backbone (-D-glucose residues) and a tri saccharide side chain of D-mannose - D gluronic acid-D-mannose attached with the central chain of alternate glucose residues.[5]

Xanthan Gum Production &Extraction:

The primary laboratory and commercial fermentation medium – as has been known for over fifty years for X. campestris growth and xanthan production is a phosphate-buffered (pH ≃ 7) broth containing D-glucose (30 g l-1) (or sucrose, starch, hydrolysed starch), NH4CI, MgSO4 At a temperature of almost 28°C, the fermentation process 6 takes place aerobically with trace saltsand5gofl-1caesin(or soybean) hydrolysate.

While pyruvic, succinic, or other organic acids are available, xanthan production is further boosted. The xanthan made in this manner is remarkably similar to the xanthan made by the microorganisms that live on a cabbage in nature. The oxygen in take from the broth is regulated in the commercial process to a rate of 1 m mol 1-1 min-1. In this manner, the bacterium is converted into a very effective mini-enzyme factory that

produces polymeric xanthan from >70%ofthesubstrate (D-gluco seor equivalent substrates).

After the microbe had finished its job, it is undignifiedly removed by centrifugation, and the xanthan is then precipitated using methanol or 2-propanol at a 50% weight concentration. After drying, the xanthan slurry is ground for use. Fig. 10.2 shows the production flow chart for xanthan. The first company to make xanthan effectively was Kelco Ltd. (now MSD-Kelco), and with the help of additional suppliers, the worldwide annual production is presently over 10,000tonnes.[38]

Xanthan Gum's physico chemical characteristics:

Soluble in water. Practically insoluble in organicsolvents.[8]

Applications of Xanthan Gum:

Xanthan gum is widely used in oral and topical formulations, cosmetics, and in food industry asa suspending and stabilizing agent. It has also been used to prepare sustained release matrixtablets.[5]

PSYLLIUM.

Biological Source of Psyllium:

Psyllium mucilage is obtained from the seed coat of Plantago ovata by milling the outer layer of the seeds.[5] Psyllium ororispaghula is the common term given to a number of Plantago genera whose seeds are employed in the production of mucilage.[39]

Chemical Constituents of Psyllium:

Plantago have major therapeutic role due to presence of flavonoids, alkaloids, phenol and phenolic derivatives and terpinoids compounds. They also contain iridoidglycosides, fatty acids and polysaccharides. The major treatment effect of plantago 21's main ingredient is vitamin C. It contains 4 polysaccharides and 2 to 6.5% mucilage. 6.5% tannin, anvrtyn, emulsions, and the glycoside aucubin are all ingredients. They have pectins, heterozeid, colouring agents, and diastase. Salicylic acid as well as other carboxylic acids makes up more than 1% of them. They have zinc and potassium as minerals. They include saponin and silicic acid. In addition to plantenolic acid, the seeds of this plant also contain glotinic substances.Adenine,choline,succinicacid,andaeocoeine.[41]

Extraction of Psyllium:

Samples were prepared in equivalent ratio of psyllium: water (pH being adjusted when necessary with hydrochloric acid and/or 0.1 M sodium hydroxide). Subsequently, it was placed in an ultrasonic bath for a fixed time under constant stirring at 500 rpm. After that, the gel was filtered twice: once using an organza fabric to remove smaller particles and once with a cotton cloth to remove bigger particles. The gel was transferred to silicone trays and carried to a forced air circulation oven at 50 °C for 24 hours until the mixture was completely dried. The separated mucilage was then weighed on analytical scale and this data used for the calculation of extraction yield. Emulsion stability analysis was performed for each sample obtained. All assays wereperformedintriplicate.[42]

Applications of Psyllium:

It quality management systems for binding tablets. A novel sustained release, swellable, and bioadhesive gastro retentive drug delivery system for ofloxacin was created using psyllium husk in combination with various excipients, such as hydroxyl propyl methyl cellulose.[5]

GELATIN.

Collagen is physically and chemically degraded to generate gelatin, a high molecular weight polypeptide. Gelatin includes 19 amino acids and is a protein as well. It dissolves in water. Additional proteins from animal origins include elastin,albumin,andfibrin.[5]

Biological Source of Gelatin:

By drying an aqueous extract derived from the bones, skins, and tendons of various domesticanimals, gelatin is a protein derivative. Among the key sources are: Sheep, Ovis aries, and Bostaurus aremembers of the Bovidaefamily.[43]

Chemical Constituent of Gelatin:

The protein glutin, which makes up gelatin, hydrolyzes to release a variety of amino acids the percentages of glycine (25.5%), alanine (8.7%), valine (2.5%), and other amino acids are about. Leucine, isoleucine, cysteine, cysteine, methionine, and tyrosine make up the majority of the amino acids in human blood. Lysine (4.1%), arginine (8.1%), aspartic acid (6.6%), glutamic acid(11.4%), and (0.8%) Histidine Gelatin is an incomplete protein because it lacks tryptophan. The gelatinizing ingredient chondrin, which provides gelatin its sticky properties, the glutin'spresence.[43]

Preparation of Gelatin:[43]

The process known as "liming" is initially applied to the raw material. The skins and tendons are steeped in a diluted milk of lime during this process for fifteen to twenty, and occasionally for fortydays. This process involves dissolving fleshy material, removing connective tissue chondro proteins, and saponifying fatty material. The animal skin is then given a last, thorough wash under running water. When working with bones, the material is appropriately crushed and defatted in compact iron cylinders by application of organic solvents like benzene. Treatment with hydrochloric acid removes the bone's mineral and inorganic components.[43]

In open pans with false bottoms that are perforated, the processed material from bones, skins, and tendons is cooked with water. Reduced pressure can also be used to complete this operation. The clear liquid flows off continuously and are evaporated until it has a gelatin content of much more than45%. Transferring the concentrated gelatin extract to shallow metal trays or glass-bottomed trays. It may harden in to a jelly-like semisolid state.

The jelly is put onto trays with a bottom made of perforated wire netting before going through a succession of drying compartments that range from 30 to 60 degrees Celsius and increase intemperatureby10degreeseachtime.The entire drying process takes about a month. Sulphur dioxide is used

to bleach completed products when they have a deeper colour. Bleaching results in gelatin that is light in colour.

Physicochemical properties of Gelatin:

Suitable for hot water. Essentially insoluble in water; yet, when submerged, it expands and softens. Slowly absorbing 5–10 times its own weight, and in the majority of organic solvents.[8]

Applications of Gelatin:

Emulsifiers, foaming agents, colloid stabilizers, biodegradable film-forming compounds, and microencapsulating agents are a few examples of this frequently utilized substances.[5]

GUARGUM

Biological Source of Guar Gum:

Guar gum is also called as cluster bean, Calcutta Lucerne, Cyanosis gum, Guardian, Glucotard, and Guyarem. Guar gum is a powder derived from the endosperm of Cyamopsis tetragonolobus Linn seeds.(Leguminosae).[5]

Chemical constituents of GuarGum:

Guar gum is a naturally occurring polysaccharide made up of the sugars galactose and mannose. It is a galactomannan, a linear polysaccharide made up of D-mannose monomers that have been1–4–diequatorially linked together, some of which have single D-galactoseside chains attached. Guar gum's backbone is made up of 1, 4-linked D-mannopyranoses, to which each alternate mannose and D-galactoseis typicallylinked1–6.[46]

Production of Guar Gum:

Here are the important steps to produce Guar-Gum Powder: To start with the guar pods are dried in sun light. They are then manually separated from seeds.

A byproduct called Churi and Korma is well-known for being used as cow fodder. The industry continues to process these seeds in order to extract gum. Gum is extracted mechanically through roasting, differential attrition, serving, and polishing. After the seed has been extracted, it is broken apart and the germ and endosperm are separated. Endosperm from each seed is divided into two halves, which are also known as "husked Guar Splits." After being separated from the endosperm, the husk, which is a fine fibrous material, is polished; this produces the refined guar splits. This is given additional treatment in order to be turned into powder. There are many different processing methods that can be used for this.[46]

Physicochemical Properties of Guar Gum:

When stirred with 50 parts of water, a thick jelly is formed which, with further addition of 150partsofwater,yields a thick transparent suspension; practically insoluble in ethanol(95%).[8]

Applications of Guar Gum:

Several modifications of guar gum are used for drug delivery system. Carboxy methyl guar film is used for the formulation of transdermal therapeutic system.

Guar gum is particularly useful for colon delivery because it can be degraded by specific enzymes in this region of the gastrointestinal tract. The gum protects the drug while in the stomach and small intestine environment and delivers the drug to the colon where it undergoes as simulation by specific microorganisms or degraded by the enzymes excreted by these microorganisms.[5]

STARCH

Biological Source of Starch:

The primary carbohydrate reserve found in green plants is starch, which is primarily found in seeds and subterranean organs. Granules of starch are present in the world (starch grains). Maize(Zea mays), rice (Oryzasativa), wheat (Triticum aestivum), and potato are among the starches that are approved for use in pharmaceuticals (Solanum tuberosum).[47]

Chemical Constituents Starch:

A carbohydrate known as starch or amylum is made up of many glucose units bound together byglycosidic linkages. It is made up of two polymers: amylopectin, a highly branched polymermade up of both 1 ,4- and 1,6-linked D-glucose monomers, and amylose, a nonbranching helicalpolymermadeupofD-glucosemonomers.[47]

Production Starch:

Starch from potatoes, maize and cassava was extracted separately using standard procedure.Potato and cassava starches were extracted using sodium metabisulphite solution. Maize starchwas extracted by steeping the maize with sulphur dioxide followed by determination and glutenseparation.[48]

Physico chemical properties Starch:

Practically insoluble in cold water and in ethanol(95%).[8]

Applications of Starch:

Thermoplastic starch is used in packaging, containers,mulchfilms,textilesizingagents,adhesives.[5]

LATEX

Biological Source of Latex:

A naturally occurring plant polymer known as latex is secreted by cells called laticifers. Latex is milky fluid secreted by ducts of lactiferous tissue. it is emulsion like sticky material that exudes from various plant parts after having small tissue injury. [49]

Chemical constituent of Latex:

The molecular formula of latex is C3H3N (carbon, hydrogen and nitrogen). It consist so many constituents such as glycolipid, alkaloid, acid, laticifer protein, acid phosphatase *Euphorbia characias*latex.[49]

Extraction of Latex:

For the first time, a natural rubber was recognized and described in the latex of the perennial Mediterranean shrub Euphorbia characias. The natural rubber was extracted using four distinct techniques, including

acetone, acetic acid, tri chloro acetic acid, and Triton® X-100, followed by cyclohexane/ethanol treatments. The rubber concentration of E. characias latex was found to be14%(w/v), which is low compared to that of Heveabrasiliensis (30–35%)but comparable to other rubber-producing plants. The characteristics of the cis-1,4-polyisoprene typical of natural rubber were disclosed by (1) H NMR, (13) C NMR, and FTIR study on characias rubber, which had a molecular weight of 93,000 and a M(w) /M(n) of 2.9. These findings contributed new understanding of latex components and will ultimately technique developed of the latex composition of E.characia.[51]

Application of Latex:

Heveabrasiliensisproducesnaturalrubberlatex(NRL),whichhasdemonstratedintriguingbiological features such as enhancing tissue development, cell adhesion, wound healing, and angiogenesis. It's employed in the biosynthesis of nanoparticles, sensors, prosthetics, and medication delivery devices (for drugs, plant extracts, and nanoparticles). To improve its wound healing abilities, Casearíasyl vestris Swartz extract was added. This extract's pharmacological action includes anti-inflammatory, analgesic, antiseptic, antiulcer, and anticancer activities because of its casearins and phenols. Results indicated that the chemicals released over a longerperiod of time (35 days), and the Korsmeyer-Peppas model's super case II release mechanism explains how this happened.[58]

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