



Tamarind Seed Polysaccharide: A Versatile Pharmaceutical Excipient and its Modification

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ABSTRACT

Patient compliance and safety is of prime importance in case of any drug delivery system. As safety is concern, natural polymers are always better than synthetic and semisynthetic polymers. The reason behind this fact is that all natural polymers are either biodegradable or biocompatible. Unlike synthetic polymers, they are nontoxic, noncarcinogenic and most admirably ecofriendly. Tamarind Seed Polysaccharide (TSP) is one of such natural polymer which is obtained from seeds of *Tamarindus indica*. Isolation and characterization of TSP involves simple techniques resulting in lucrative yield in its production. In order to improve the physicochemical properties like heat stability TSP is modified either by physical or chemical method. High drug holding capacity, high swelling index, high thermal stability and improved shelf life are some valuable properties of modified TSP. Due to these remarkable properties TSP has wide range of application from food industry to pharma industry.

Keywords: Tamarind Seed Polysaccharide, Physical Modification, Chemical Modification, Application etc.

INTRODUCTION

Over the last two decades, mucoadhesion has become of interest for its potential to optimize localized drug delivery, by retaining a dosage form at the site of action (e.g. within gastrointestinal tract) or systemic delivery, by retaining a formulation in intimate contact with the absorption site (e.g. the buccal cavity).

Various studies have been conducted on buccal delivery of drugs using mucoadhesive polymers including mainly polysaccharides.¹ Polysaccharides are relatively complex carbohydrates. They provide good mechanical properties for applications as fibers, films, adhesives, rheology modifiers, hydrogels, emulsifiers, and drug delivery agents. For instance, some polysaccharides have proven to enhance the contact between drug and human mucosa due to their high mucoadhesive properties.² Polysaccharides, such as cellulose ethers,³ xanthan gum,⁴ scleroglucan,⁵ locust bean gum,⁶ and gaur gum,⁷ are some of the natural polysaccharide which have been evaluated in the hydrophilic matrix for drug delivery system.

Although tamarind seed polysaccharide (TSP) is used as an ingredient in food material but as novel drug delivery system in pharmaceuticals formulations, it has not been extensively evaluated till date.

TSP is a galactoxyloglucan isolated from seed kernel of *Tamarindus indica*. It possesses properties like high viscosity, broad pH tolerance and adhesivity.⁸ This led to its application as stabilizer, thickener, gelling agent, and binder in food and pharmaceutical industries.

In addition to these, other important properties of TSP have been identified recently. They include non-carcinogenicity,⁹ mucoadhesivity, biocompatibility,¹⁰ high

drug holding capacity,¹¹ and high thermal stability.¹² This led to its application as excipient in the hydrophilic drug delivery system.

Tamarind Seed Polysaccharide

History

Tamarind, commonly known as *Imli*, is a rich source of tamarind gum or tamarind kernel powder which came into commercial production in 1943 as a replacement for starch in cotton sizing in Indian textile market.¹³

Method of isolation and extraction of TSP was first devised in laboratory by Rao⁸ improved by Srivastav,¹⁴ and further modified by Nandi¹⁵ on a laboratory scale.

Thereafter, a number of methods were given as a modified parent method that is best suited for the commercial or laboratory scale by a number of workers.

TSP has the ability to form gels in the presence of sugar or alcohol and can be used to form pectin like gels in jams, jellies and other preserves.¹⁶ TSP is found to be free from carcinogenicity in mice.

Origin

Tamarind is amongst most common and commercially important large evergreen tree that is grown abundantly in the dry tracks of Central and South Indian states, and also in other South East Asian countries.¹⁷

Following parts of fruit of *Tamarindus indica* L. Family - Leguminosae are commercially very important:

1. Pulpy portion of the fruit mainly used as acidulate in Indian recipes.
2. Tamarind gum is obtained from the kernel of the seeds powder.



Tamarind products are widely used in Asia and also used in some part of Africa. In Asian countries, especially India, tamarind is mainly cultivated and used as an acidulant, gelling, and acidifying agent.¹⁸ Tamarind gum along with xanthan gum hydroxypropyl cellulose is used for nasal mucoadhesion studies in powder formulation.¹⁹ Tamarind gum is also used for as a bioadhesive tablet.

Chemical Structure

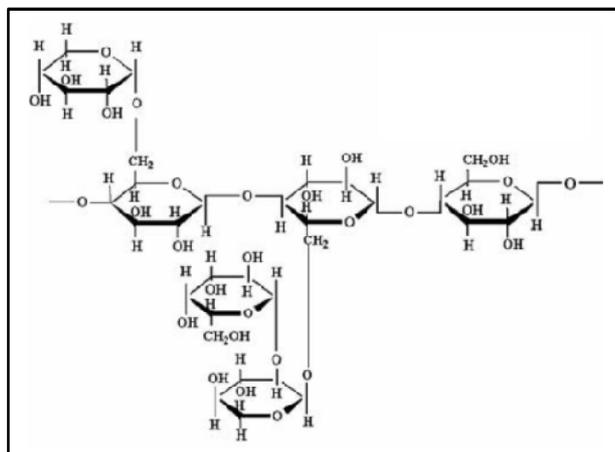


Figure 1: Chemical Structure of Tamarind Seed Polysaccharide

Chemically, tamarind kernel powder is a highly branched carbohydrate polymer. TSP is a polymer with an average molecular weight of 52350 Daltons and a monomer of mainly three sugars-glucose, galactose and xylose in a molar ratio of 3:2:1.²⁰ A polymer consists of cellulose-type spine which carries xylose and galactoxylose substituents. About 80% of glucose residues are substituted by xylose residues (1-6 linked), which themselves are partially substituted by 1-2 galactose residues. The exact sequential distribution of branches is not known.²¹ TSP is a branched polysaccharide with a main chain of α -D-1-glucopyranosyl units, with a side chain consisting of single D-xylopyranosyl unit attached to every 2nd, 3rd and 4th D glucopyranosyl unit through 1-6 linkage (Fig. 1).¹³ Native TSP is shown to exhibit a strong tendency to self-aggregation when dispersed in aqueous solvents. The aggregates consist of lateral assemblies of single polysaccharide strands, showing a behavior that could be well described by the wormlike chain²² or the Kuhn's model. Static light scattering data on these particles show that their stiffness is determined by the number of aggregated strands. High degree of substitution of glucan chain produces a stiff extended conformation for tamarind polysaccharide molecule, with large volume occupancy in a solution.¹⁶

Composition of Tamarind

The composition of tamarind kernel powder, the source of gum resembles cereals with 12.7-15.4% of protein, 3-7.5% of oil, 7-8.4% of crude fiber, 61-72.2% carbohydrates, and 2.45-3.3% of ash. All of this was measured on dry weight basis.¹³ Tamarind seeds are good source of minerals, carbohydrates, proteins, vitamins,

fatty acids, amino acids etc. and are shown in following tables.

Table 1: Mean Composition of Tamarind Fruit⁴²⁻⁴³

Constituents	Amount (Per 100 gm)
Ash	2.6-3.9 gm
Calcium	34-94 mg
Carbohydrates	41.1-61.4 gm
Fat	0.6 gm
Fibre	2.9 gm
Iron	0.2-0.9 mg
Niacin	1 gm
Phosphorous	34-78 mg
Protein	2-3 gm
Riboflavin	0.1 mg
Thiamine	0.33 mg
Vitamin C	44 mg
Water	17.8-35.8 gm

Table 2: Mineral Content of Tamarind Pulp, Seed, Kernel and Testa⁴⁴⁻⁴⁷

Mineral mg/100 gm	Pulp	Seed	Kernel	Testa
Calcium	81-466	9.3-786	120	100
Copper	0.8-1.2	1.6-19	~	~
Iron	1.3-10.9	6.5	80	80
Magnesium	25-72	17.5-118.3	180	120
Manganese	~	0.9	~	~
Nickel	0.5	~	~	~
Phosphorous	86-190	68.4-165	~	~
Potassium	62-570	272.8-610	1020	240
Sodium	3-76.7	19.2-28.8	210	240
Zinc	0.8-1.1	2.8	100	120

Table 3: Composition of Tamarind Seed, Kernel and Testa (%)⁴⁶⁻⁴⁹

Constituents	Whole Seed	Seed Kernel	Testa
Calories/100 gm	340.3	~	~
Carbohydrates	50-57	65.1-72.2	~
Crude Fibre	7.4-8.8	2.5-8.2	21.6
Fat/Oil	4.5-16.2	3.9-16.2	~
Moisture	9.4-11.3	11.4-22.7	11
Nitrogen free extract	59	~	~
Protein	13.3-26.9	15-20.9	~
Reducing Sugar	7.4	~	~
Starch	33.1	~	~
Tannin	~	~	20.2
Total Ash	1.6-4.2	2.4-4.2	7.4
Total Sugar	11.3-25.3	~	~
Yield of TKP	50-60	~	~

Table.4: Fatty Acid Composition of Tamarind Seed Oil⁵⁰

Fatty Acids	Percentage
Arachidic Acid	2.0-4.0
Behenic Acid	3.0-5.0
Lignoceric Acid	3.0-8.0
Linoleic Acid	36-49
Oleic Acid	15-27
Palmitic Acid	14-20
Stearic Acid	6.0-7.0
Sterols % of Total Sterols	
Beta Sitosterol	66.0-72.0
Campesterol	16.0-19.0
Stigmasterol	11.0-14.0

Method of Extraction

Method 1

200 g of tamarind seeds are soaked in double distilled water and boiled for 5 h to remove the outer dark layer. When the outer dark layer is removed, to the inner white portion sufficient amount of double distilled water was added and boiled with constant stirring to prepare the slurry. Now cool the resultant solution in refrigerator so that most of the undissolved portion settles down. The supernatant liquid can be separated out by simple decantation or best by centrifugation at 500 rpm for 20 min. After this, the solution is concentrated on a water bath at 60°C to reduce the volume to one-third of the initial volume. Now cool the solution and pour into 3 volumes of acetone by continuous stirring. Precipitates obtained were washed with acetone and drying in vacuum at 50-60°C.²³

Method 2

Tamarind seeds were collected and dried in sunlight. The kernels are then crushed to fine powder. 20 g of fine kernel powder was added to 200 ml of cold distilled water to prepare slurry. The slurry obtained is then poured into 800 ml of boiling distilled water and are boiled for 20 min on a water bath; a clear solution was obtained which was kept overnight. The thin clear solution was then centrifuged at 5000 rpm for 20 min to separate all the foreign matter. Supernatant liquid was separated and poured into excess of absolute alcohol with continuous stirring. Precipitates were obtained which were collected by a suitable method and washed with 200 ml of absolute ethanol and dried at 50°C for 10 h. Store the polymer obtained in a desiccator.^{11,24}

Method 3

This method is patented in United States by Jones. It involves the separation of tamarind kernel powder on the basis of their size distribution. Tamarind kernel powder was defatted by using C-6 or C-8 aromatic hydrocarbons or C-1 or C-2 or above halogenated lower hydrocarbons or C-1 or C-5 mono or dihydroxy alcohols, e.g. ethylene dichloride, heptanes, or toluene. (For defatting, Crude

TKSP is suspended in suitable solvent to extract fat that is mechanically recovered by filtration or centrifugation and dried.) After drying, HiSil or other siliceous materials like CabOSil improve the flow properties of powder. The powder is further grounded by using Hammer mill or Pin mill that will reduce the size of the powder below 100 mm. The powder is further air classified by using suitable air classifier (The Walther type 150 laboratory air classifier, The Alpine Mikroplex model 400, MPVI Air Classifier). Three fractions of the powder were obtained after air classifications:²⁵

1. 10-20% of fine fraction rich in protein.
2. 60-80% of moderately fine fraction rich in polysaccharides.
3. 10-20% of the coarser fraction rich in mechanical properties.

Modification

Physical Modification

Freeze Thaw Method

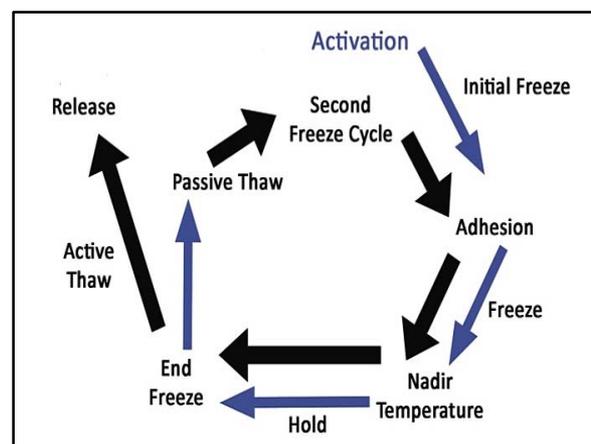


Figure 2: Freeze Thaw Cycle

The freeze thaw cycle shall follow the profile shown in fig.2 and shall be controlled using thermocouples in the area of the test sample to insure complete freezing and thawing of water around the test sample. The cycle time is a function of the volume of water and the time it takes the water to freeze and thaw. Different size handhelds will accommodate different volumes of water that will determine the freeze thaw cycle. The samples under test shall be subjected to the required 6 freeze thaw cycles.²⁶ Effect of freeze thaw modification was observed that improved drug holding capacity of TSP by six times than simple TSP and sustained drug release of Ranolazine.²⁷

Microwave Technique

Accurately weighted 1gm of pure TSP and deionized water (1ml) were mixed until the TSP was hydrated. That mixer was poured in a lidless glass petridish and entire mass was exposed to a microwave at 350W for various time intervals (1,3,5 and 10) min. Dried material (Modified TSP) was collected, passed through a sieve 100# and stored in a desiccator for further study.²⁸

Chemical Modification

Carboxymethylation

Carboxymethylation of tamarind kernel powder was carried out with monochloroacetic acid in the presence of alkali as a catalyst under heterogeneous conditions. The optimum DS (0.649) was obtained by using [TKP], 0.050 mol; [NaOH], 0.158 mol; [MCA], 0.090 mol; methanol-water ratio, 4:1; temperature 70 °C; and duration 60 min. The paste quality and microbial resistance of CM-TKP was much better than that of native gum. The viscosity of CM-TKP in 2% solutions was higher compared to native gum. Rheological studies showed the non-Newtonian pseudoplastic nature of CM-TKP solutions.²⁹

Degalactosylation

The aggregation of xyloglucan is the major factor responsible for gel formation and the conformation was practically unaffected by the enzymatic treatment. The stripping rate constant of the lateral galactose on the xyloglucan ($1.3 \times 10^{-6} \text{ s}^{-1}$ determined by TDSLs), *fp* (0.78) and a constant *Lp* (of 4 nm before and after enzymatic hydrolysis) confirm the proposition. There was an increase in aggregation during degalactosylation, especially during later stages, resulting in a microgel at dilute concentrations. *Lp* was determined using viscosimetric techniques in order to avoid the influence of aggregates. A value of approximately 4 nm was obtained, both before and after enzymatic hydrolysis. The results confirm that aggregation is the principal phenomenon responsible for gelling of degalactosylated xyloglucan and that the conformation is practically unaffected during the enzymatic treatment.³⁰

Calcium Pectination

In this investigation, novel mucoadhesive beads containing metformin HCl made of LM pectin-TSP polymer-blend was developed through ionotropic gelation technique and optimized. The optimized calcium pectinate-TSP mucoadhesive beads containing metformin HCl displayed high drug encapsulation, good mucoadhesivity with the biological membrane, suitable controlled in vitro drug release pattern and also significant hypoglycemic activity in alloxan induced diabetic rats over prolonged period after oral administration.

The results of this investigation suggested that the optimized calcium pectinate-TSP mucoadhesive beads containing metformin HCl swelled slowly in the stomach and accordingly adhered to the stomach mucosa allowing more drug to be absorbed minimizing the diffusion barriers to increase the absorption period by prolonging the gastric residence time. Then, these beads were subsequently moved to the upper part of the intestine, where they swelled more and released drug through the polymeric gel layer, formed at the matrix-periphery. Thus, these newly developed calcium pectinate-TSP mucoadhesive beads containing metformin HCl could

possibly be lucrative in terms of prolonged systemic absorption of metformin HCl maintaining tight blood glucose level and advanced patient compliance.³¹

Grafting using ethyl acrylate

The copolymer was prepared via free radical polymerization, with EA as the synthetic monomer and TKP as the natural polymer in a mass concentration of 70:30 (P7:3). Synthesis was conducted in solution with azobisisobutyronitrile (AIBN) as the initiator. Before polymerization, nitrogen was bubbled through the reaction mixture to remove any dissolved oxygen. Ethyl acrylate was successfully grafted onto tamarind kernelpowder via free radical polymerization, as confirmed by the shift signals observed with FTIR and NMR1H. The mechanical proper-ties of this new copolymer lie between those of the two parent polymers, though its tensile strain increased, compared to that of the pure tamarind kernel powder films. The mechanical proper-ties of this new copolymer are adequate for disposable products. The incubation experiments revealed that P7:3 surface shows anerosion in the samples incubated and NIR displayed a reduction of signals showing that the copolymer developed can be degraded by a soil bacterium, *Alicyclophillus* sp. BQ1, suggesting that it may be biodegradable under environmental conditions. Therefore, the use of these materials would prevent environmental damage. The new copolymer is a water-based moldable material, which is important for reducing solvent use and energy consumption during processing. For these reasons, it can be considered an environmentally friendly copolymer.³²

Grafting using methyl methacrylate

Xyloglucan, a water-soluble food grade polysaccharide, was reported as a substrate for graft copolymerization of methyl methacrylate (MMA). Grafting PMMA (polymethyl methacrylate) with xyloglucan (XG) makes a new material with improved thermal stability and shelf life without affecting its hydrophilicity. XG was isolated from tamarind seed mucilage by aqueous extraction. Grafting of MMA was initiated by ceric ion in aqueous medium under N₂ atmosphere and the progress of the reaction was monitored gravimetrically by varying different reaction parameters. Grafting of MMA onto XG was confirmed by FTIR spectroscopy, NMR spectroscopy, differential scanning calorimetric (DSC) studies, thermal gravimetric analysis (TGA) studies and scanning electron micrographs (SEMs). This material might find potential to be used in drug delivery systems. Grafting of PMMA with xyloglucan, a natural polysaccharide, offer a new polymeric material with properties that can be exploited by pharmaceutical industry.

Grafting of PMMA on XG makes a material with improved thermal stability and shelf life. Grafting introduces more reactive sites on XG without affecting its hydrophilicity and without making any change in the molecular mobility of its chelating groups. Grafting has been done

successfully by using CAN/HNO₃ redox initiator system. The optimum monomer and initiator concentrations were 0.02 M and 1.5×10^{-3} M, respectively. The maximum percent grafting (84.7%) was achieved at 30°C after 2 hrs. Grafting was studied by IR and NMR spectroscopy, scanning electron microscopy and differential scanning calorimetric analysis. This material might find potential to be used in drug delivery systems.³³

Allylation

Allyl functionalities can successfully be introduced to tamarind xyloglucan, by combining oxidation using galactose oxidase with an indium mediated allylation reaction the galactose units can selectively be derivatized by allyl halides. Reaction was carried out by using water as the only solvent, thus the polysaccharide was functionalized in a one-pot reaction. Reactivity with xyloglucan polysaccharides was observed that xyloglucan reacted completely with allyl bromide.³⁴

Thiolation

The objective of present study was to enhance bioadhesive potential of xyloglucan by thiolation. Thiolation of xyloglucan was achieved with esterification with thioglycolic acid. Thiolated xyloglucan was characterized by NMR, DSC, and XRD analysis. Thiolated xyloglucan was determined to possess 4 mmol of thiol groups/g of polymer by Ellman's method. Comparative evaluation of mucoadhesive property of ondansetron containing in situ gel system of xyloglucan and thiolated xyloglucan using sheep nasal mucosa revealed higher *ex vivo* bioadhesion time of thiolated xyloglucan as compared to xyloglucan. Improved mucoadhesive property of thiolated xyloglucan over the xyloglucan can be attributed to the formation of disulfide bond between mucus and thiolated xyloglucan. *Ex vivo* permeation study conducted using sheep nasal showed improved drug permeation in formulation based on thiolated xyloglucan. In conclusion, thiolation of xyloglucan improves its bioadhesion and drug permeation without affecting the resultant gel properties.³⁵

Sulphonation

Sulphated tamarind seed polysaccharide derivatives have been prepared by swelling the polysaccharide in dimethylformamide (DMF) and treating with sulphur trioxide-pyridine complex in DMF at 50°C. The method detailed below was chosen following experimentation to optimise exposure of the polysaccharide chains to the sulphating reagent and to minimise chain degradation: it was reasoned that this should lead to high molecular weight products with a reasonably regular distribution of sulphate groups along the chains. Tamarind seed polysaccharide (0.5 g) is dissolved in distilled water (80 ml) and precipitated in a gelatinous state by addition of ethanol (100 ml) under stirring. The precipitate is collected on a G3 glass filter under gentle suction, and washed on the filter with ethanol and then thoroughly with DMF. The product is added to 50 ml DMF and stirred

overnight at room temperature. The finely dispersed suspension is cooled to 2°C and 1.7 g of SO₃-pyridine complex (Merck-Schuchard) in 15 ml DMF is added. The mixture is stirred vigorously for 24 h at 50°C and then dialysed against 5% sodium hydrogen carbonate for 48 h and then against distilled water, exhaustively. After careful neutralization with dilute sodium hydroxide, the products are recovered by lyophilisation in overall yields of c. 85%. Products were analyzed by potentiometric titration as described above and elsewhere in order to determine the degree of sulphation, and by IR and NMR spectroscopy.³⁶

Alkylamination

Oxidation of galactosyl hydroxymethyl groups to formyl groups with galactose oxidase/catalase as described above for carboxylate derivatives, a reductive amination reaction can be used to introduce alkylamine substituents on C-6 of galactose residues. Ethylamino-, octylamino- and nonylamino- derivatives were prepared by addition of a tenfold molar excess of the appropriate alkylamine to the product of galactose oxidase/catalase reaction as described above. An equimolar amount of sodium cyanoborohydride with respect to the aldehyde groups was then added and the mixture kept at room temperature for 96 h. Reaction was carried out in phosphate buffer at pH 6.5 to limit direct reduction of the aldehyde. As the formation of the Schiffs base is probably the rate determining step in the reductive amination procedure, it may be advantageous to allow the amine to react with the aldehyde for 1-2 h prior to adding the reducing agent. Following reaction, products were dialysed exhaustively against distilled water and lyophilised. Yields were 80%. Products were analysed by H NMR spectroscopy to determine the extent of reaction as described below. The interracial properties of native polysaccharide and alkylamine derivatives were assessed both by surface and interfacial tension measurements and from foaming and emulsifying activity. Surface tension and interfacial tension (decane/water) were obtained using a DuNouy ring apparatus (Kruss). Emulsification activity was assessed by mixing aqueous solutions (6 ml) with sunflower oil (4 ml) and homogenising for 1 min at room temperature using an Ultra-Turrax (Janke Kunkel) at full speed. One ml of the resulting mixture was diluted 1:250 and the absorbance at 500 nm used as a measure of emulsification. After standing for 30min, 1 ml was withdrawn from the bottom of the remaining mixture, diluted 1:250 and the absorbance at 500 nm used to assess the stability of the emulsion.³⁷

Crosslinking with Epichlorohydrin

TSP can be cross-linked with epichlorohydrin and it can be confirmed by FTIR. The cross-linked TSP exhibits superior wicking and swelling action and hence can be used as a superfunctional disintegrant. Cross-linked TSP was found to be more effective in retarding the drug release compared to TSP without cross-linking.³⁸



Application

TSP is a remarkable candidate for pharmaceutical use, e.g. as a carrier for variety of drugs for controlled release applications. Many methods have been used to manufacture the TSP-based delivery systems which makes it an exciting and favorable excipient for the pharmaceutical industry for the present and upcoming applications.

Binder in Solid Dosage Form

Evaluations of tamarind seed polyose as a binder for solid dosage forms was taken up for the weight granulation as well as direct compression methods. The results specified that tamarind seed polyose could be used as binder for weight granulation and direct compression tableting methods.³⁸

In Controlled Release of Spheroids

TSP was used as release modifier for the preparation of Diclofenac sodium spheroids using the extrusion spheronization technique with microcrystalline cellulose as a spheronization enhancer. It was found that release was sustained over a period of 7.5 h.³⁹

In Ocular Drug Delivery

Administration of vicosified preparations produced antibiotic concentrations both in aqueous humor and cornea that were significantly higher than those achieved with the drugs alone. The increased drug absorption and the prolonged drug elimination phase obtained with vicosified formulations indicate the usefulness of the TSP as an ophthalmic delivery system for topical administration of antibiotics. Eye drops from TSP are used to treat dry eye syndrome. TSP was used for ocular delivery of 0.3% rifloxacin in the treatment of experimental *Pseudomonas aeruginosa* and *Staphylococcus aureus keratitis* in rabbits. The polysaccharide significantly increases the intraocular penetration of rifloxacin in both infected and uninfected eyes. Polysaccharide allows sustained reduction of *Staphylococcus aureus* n cornea to be achieved even when the time interval between drug administrations was extended. The results suggested that TSP prolongs the precorneal residence time of antibiotic and enhances the drug accumulation in the cornea, probably by reducing the washout of topically administered drugs.⁴⁰

In Ophthalmic Drug Delivery

TSP is used for production of gelled ophthalmic solutions having a pseudoplastic rheological behavior and mucoadhesive properties. The solution is used as artificial tear and as a vehicle for sustained release ophthalmic drugs. The concentrations of TSP preferably working in ophthalmic preparations for use as artificial tears, i.e. products for replacing and stabilizing the natural tear fluid, particularly indicated for the treatment of dry eye syndrome are comprised between 0.7% and 1.5% by weight. The concentrations of tamarind polysaccharides

compromised between 1 to 4 % by weight is preferably employed in the production of vehicles (i.e. delivery system) for ophthalmic drugs for prolonging the prevalence time of medicaments at their site of actions.⁴¹

In Sustained Drug Delivery

It is used as potential polysaccharide having high drug holding capacity for sustained release of verapamil hydrochloride. The release pattern was found to be comparable with matrices of other polysaccharide polymers such as ethyl cellulose, hydroxyethyl cellulose, and hydroxypropylmethyl cellulose, as well as the commercially available sustained release tablets. Sustained release behaviors of both water-soluble (acetaminophen, caffeine, theophylline and salicylic acid) and water-insoluble (Indomethacin) drugs on TSP was examined. Studies showed that TSP could be used for controlled release of both water-soluble and water-insoluble drugs. Zero-order release can be achieved taking sparingly soluble drugs such as indomethacin from TSP. The rate of release can be controlled by using suitable diluents such as lactose and microcrystalline cellulose. For water-soluble drugs, the release amount can also be controlled by partially cross-linking the matrix. The extent of release can be varied by controlling the degree of cross-linking. The mechanism of release due to effect of diluents was found to be anomalous and was due to cross-linking.³⁸

CONCLUSION

When question of patient safety arises about new formulation approval, bio-materials like TSP are easily favored by Regulatory authorities. TSP is being widely used as an excipient in hydrophilic drug delivery system because of its remarkable properties like noncarcinogenic, biocompatibility, mucoadhesivity etc. It also plays the role of stabilizer, thickener, binder, release retardant, modifier, suspending agent, viscosity enhancer, emulsifying agent, as a carrier for novel drug delivery systems in oral, buccal, colon, ocular systems, nanofabrication, wound dressing. TSP is also becoming an important part of food, cosmetics, confectionery and bakery.

Various studies and experiments have been carried out to prove its multi-functional potentiality, from which it can be concluded that TSP can be a promising natural polysaccharide having enormous applications.

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