REVIEW ARTICLE

A Review on Natural Polymer Tamarind Seed Polysaccharide

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ABSTRACT

The developing interest in normal polymers for different applications has brought tTamarind seed polysaccharide (TSP) into the spotlight. Gotten from *Tamarindus indica* seeds, TSP's special properties make it a convincing biopolymer. This complete audit investigates TSP's attributes, extraction techniques, and far reaching applications. Featuring its part in drug delivery, wound healing, and then some, the audit highlights TSP's biocompatibility, mucoadhesive nature, and adaptability. While TSP offers various advantages, challenges like extraction hardships and variable organization exist. Future possibilities in drugs include progressed drug delivery system, biocompatible supplements, and creative oral definitions. The survey likewise underscores the requirement for thorough clinical preliminaries, protected innovation contemplations, and joint effort for TSP's fruitful interpretation into certifiable applications. In general, TSP emerges as a promising biopolymer with significant industry-wide potential.

Keywords: Application, Binder, Sustained and controlled release, Physical and chemical modification, Tamarind seed polysaccharides.

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INTRODUCTION[1-12]

Lately, there has been a blossoming interest in regular polymers as flexible materials with different applications in different fields, going from drugs to food enterprises. Among these, tamarind seed polysaccharide (TSP) has arisen as a promising biopolymer, dazzling scientists' and ventures' consideration. Gotten from the seeds of the *Tamarindus indica* tree, TSP has an interesting mix of primary qualities and physicochemical properties that make it a fascinating subject for investigation. This survey plans to comprehensively assess the present status of information encompassing TSP, digging into its primary complexities, extraction techniques, and the wide range of utilizations it offers. As we navigate the scene of TSP research, we will investigate its rheological way of behaving, bioavailability, biocompatibility, and collaborations with different materials. Also, we will examine the techniques utilized for its segregation and sanitization, revealing insight into the difficulties and progressions in the extraction cycle. The drug domain, specifically, stands to benefit essentially from the intrinsic properties of TSP. From its true capacity as a medication conveyance vehicle to its job in planning controlled discharge frameworks, TSP has shown excellent commitment in upgrading remedial results. In addition, its biocompatibility and mucoadhesive nature permit novel biomedical applications in tissue engineering, wound healing, and other fields. TSP's versatility extends beyond the pharmaceutical sector to the food and cosmetics industries, where its stabilizing, thickening, and emulsifying properties have proven useful. As we explore through the huge collection of writing, this audit tries to unite and basically evaluate the current information, tending to holes in understanding and proposing headings for future examination.

Benefits of Tamarind Seed Polysaccharide

Biocompatibility

TSP shows high biocompatibility, making it reasonable for biomedical applications without causing unfriendly or poisonous responses.

Mucoadhesive properties

The mucoadhesive idea of TSP upgrades its capacity to stick to mucosal surfaces, especially in drug conveyance frameworks, advancing delayed contact and supported discharge.

Natural origin

Gotten from the seeds of the *T. indica* tree, TSP is a characteristic and inexhaustible asset, lining up with the

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developing interest for practical and eco-accommodating materials.

Versatility in formulation

TSP's rheological properties add to its flexibility in plan, considering the improvement of different items like gels, films, and nanoparticles.

Drug delivery potential

As a carrier for drug delivery systems, TSP has proven effective in increasing some drugs' bioavailability and providing controlled release mechanisms.

Stabilizing agent

In the food and corrective ventures, TSP goes about as a balancing out specialist, improving the time span of usability of items and keeping up with their primary trustworthiness.

Thickening and emulsifying properties

TSP's capacity to thicken and emulsify makes it significant in food plans, adding to surface improvement and item dependability.

Disadvantages of Tamarind Seed Polysaccharide

Extraction difficulties

The extraction and filtration of TSP can be a perplexing interaction, frequently requiring specific strategies and gear, which might present difficulties for huge scope creation.

Variable composition

TSP's organization can differ in light of elements, such as the wellspring of the tamarind seeds and extraction strategies, prompting irregularities in its properties and execution.

Limited solubility

TSP's restricted dissolvability in specific solvents might block its application in unambiguous details, requiring enhancement and similarity evaluations.

Production cost

TSP may not be economically viable on a large scale because of the higher extraction, purification, and processing costs compared to synthetic alternatives.

Limited research

While TSP has shown a guarantee, a generally restricted group of examinations is contrasted with some other biopolymers, requiring further investigation to comprehend its true capacity and impediments completely.

Biodegradability concerns

Contingent upon the particular application, the biodegradability of TSP might require cautious thought, particularly in settings where complete biodegradation is a basic necessity.

Regulatory issues

Administrative endorsement for the utilization of TSP in specific applications, particularly in the drug business, may present difficulties due to advancing principles and the requirement for thorough security evaluations.

Future Prospects of Tamarind Seed Polysaccharide in the Pharmaceutical Industry

Advanced drug delivery systems

Examination might zero in on planning modern medication conveyance frameworks utilizing TSP, for example, nanoparticles, micro particles, or hydrogel, to further develop drug strength, bioavailability, and designated discharge.

Biocompatible inserts

Investigating TSP's likely in the improvement of biocompatible inserts for supported drug delivery or tissue recovery could prompt creative answers for different ailments.

Oral drug formulations

TSP's mucoadhesive properties make it appropriate for oral medication definitions. Future examinations could focus on streamlining TSP-based details to improve drug assimilation and delay helpful impacts.

Combination therapies

Combination therapies, in which TSP and drugs work together to increase efficacy and decrease side effects, may emerge from examining TSP's compatibility with various therapeutic agents.

Wound healing and tissue repair

Further investigation into TSP's injury recuperating potential might prompt the improvement of cutting-edge wound dressings or effective plans that advance tissue fix and recovery.

Anti-inflammatory applications

Given TSP's accounted-for calming properties, the future examination could dig into its likelihood in creating drugs for provocative circumstances, giving options in contrast to ordinary medicines.

Ophthalmic drug delivery

Due to its mucoadhesive nature, TSP is suitable for drug delivery in the eye. Future examinations could research its utilization in supported discharge plans for treating visual sicknesses.

Biodegradable microspheres

Improvement of biodegradable microspheres utilizing TSP could offer a flexible stage for controlled drug discharge, especially in situations where supported conveyance is urgent for restorative achievement.

Upgraded dioavailability

Techniques to upgrade the bioavailability of inadequately water-solvent medications through TSP-based definitions could be a key concentration, tending to a typical test in drug improvement.

Clinical trials and translation

To translate TSP-based pharmaceuticals into real-world medical applications, rigorous clinical trials evaluating their safety and efficacy must be conducted beyond laboratory studies.

Intellectual property and commercialization

Commercialization and industry adoption can be driven by encouraging research on TSP derivatives and innovative formulations and securing intellectual property rights.

Collaboration with pharmaceutical companies

Cooperative endeavors between scholarly specialists and drug organizations can speed up the turn of events and commercialization of TSP-based drug items.

As TSP keeps on disclosing its expected in the drug business, progressing research and vital drives will be instrumental in bridling its novel properties to help patient consideration and clinical advancement.

Rationale for Investigating Tamarind Seed Polysaccharide

Sustainable and natural source

TSP is gotten from tamarind seeds, giving a characteristic and practical biopolymer source.

Biocompatibility and security

TSP is suitable for pharmaceutical and medical applications because of its safety and biocompatibility.

Mucoadhesive properties for drug delivery

TSP's mucoadhesive nature improves drug conveyance frameworks, particularly in oral plans.

Flexible rheological characteristics

TSP's rheological flexibility takes into consideration assorted plans, taking special care of different enterprises.

Controlled drug release

TSP works with controlled drug discharge, working on restorative adequacy and patient consistency.

Potential for wound healing and anti-inflammation

TSP shows possible in mitigating applications, such as wound recuperation and tissue fix.

Applications beyond rharmaceuticals

TSP's properties reach out to food, beauty care products, and materials science, offering different applications.

Innovation in drug delivery systems

TSP's true capacity in creative medication conveyance frameworks presents valuable open doors for progressions in drug plan.

History of Tamarind Seed Polysaccharides[13-16]

TSP are obtained from the tamarind tree seeds (*T. indica*). The historical backdrop of tamarind itself goes back hundreds of years, beginning in tropical Africa. Nowadays, tropical regions like Asia, South America, and the Caribbean are home to tamarind trees.

The utilization of tamarind and its results, including tamarind seed polysaccharides, has a long history in customary medication and culinary practices. Tamarind has been used for its culinary properties in different cooking styles, giving an exceptional prepared flavor to dishes. In customary medication, tamarind has been utilized for its alleged diuretic and stomach-related properties.

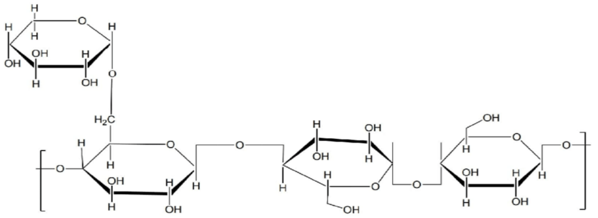

Figure: 1 Tamarind seed polysaccharides

Tamarind seed polysaccharides, removed from the seeds of the tamarind, have stood out lately for their expected applications in different businesses, especially in drugs and food. Here is a brief summary of the various contexts in which tamarind seed polysaccharides have appeared

Traditional medicine

Tamarind seeds have been utilized in conventional medication in certain societies. The seeds were accepted to have restorative properties, including being a gentle diuretic.

Culinary uses

Tamarind itself has been a staple fixing in the culinary practices of numerous nations. From a natural product, Tamarind mash is often utilized in cooking to add flavor to dishes.

Industrial applications

Due to their distinctive properties, tamarind seed polysaccharides' extraction and use in industrial applications attracted attention. Tamarind seed polysaccharides are known for their thickening and gelling abilities, which have prompted their utilization in different businesses like materials, drugs, and food.

Pharmaceuticals

Tamarind seed polysaccharides have been read up for their expected drug applications, including drug conveyance frameworks and as a stabilizer for drug plans.

Food processing

Tamarind seed polysaccharides have tracked down applications in the food business as a thickening specialist, stabilizer, and emulsifying specialist in different food items.

Origin of Tamarind Seed Polysaccharides[17-19]

The tamarind tree (*T. indica*) is local to tropical Africa, and its utilization can be traced back hundreds of years around here. From its place of beginning, tamarind spread to different tropical regions across Asia, South America, and the Caribbean. The seeds that give rise to tamarind seed polysaccharides (TSP) are found within the brown, sticky pulp of the pod-like fruit that the tree produces. TSP's authentic use includes conventional medication and culinary practices in the areas where the tamarind tree is local.

Chemical Structure of Tamarind Seed Polysaccharides

Chemical structure of tamarind is shown in Figure 1.

Table 1: Mean composition of tamarind fruit[42-43]

S.No	*Constituents*	*Amount per gm*
1	Water	Approximately 12.0 g
2	Protein	About 2.8 g
3	Fat	Around 7.0 g
4	Energy	Around 280 calories
5	Carbohydrates	Approximately 68.5 g
	Sugars	About 0.0 g
	Dietary fiber	Around 5.1 g
6	Minerals	
	Calcium	Approximately 68.0 mg
	Iron	Around 2.8 mg
	Magnesium	Approximately 92 mg
	Phosphorus	Around 113 mg
	Potassium	Approximately 668 mg
	Sodium	About 28 mg
	Zinc	Around 0.1 mg
7	Vitamins	
	Vitamin C	Approximately 3.5 mg
	Thiamine [B1]	Around 0.4 mg
	Riboflavin [B2]	Approximately 0.1 mg
	Niacin [B3]	Around 1.4 mg
	Vitamin B6	Approximately 0.1 mg
	Folate	Around 14 µg

Composition of Tamarind Seed Polysaccharides[20-26]

Complex polysaccharide molecules called TSP are derived from the seeds of the tamarind tree (*T. indica*). The synthesis of TSP includes different polysaccharides, which are long chains of sugar particles. The essential constituents of TSP include, Mean Composition of Tamarind Fruit in Table 1.

Galactoxyloglucan

This is the principal part of tamarind seed polysaccharides. Galactoxyloglucan is a heteropolysaccharide comprising of glucose, xylose, and galactose units. The particular proportion and game plan of these sugar units adds to the exceptional properties of TSP, like its thickening and ability to gel.

Xyloglucan

A type of hemicellulose known as xyloglucans is frequently found in the cell walls of plants. In TSP, xyloglucan is important for the galactoxyloglucan structure and adds to the general polysaccharide synthesis.

Mannose and arabinose

TSP's carbohydrate composition may also include arabinose and mannose units, making it more complex.

The mineral substance of tamarind can shift in view of variables like the assortment of tamarind, developing circumstances, and other ecological elements. Furthermore, the mineral content of the pulp, seed, kernel, and testa (seed coat) may vary. A general overview of these components' mineral content in Table 2, fatty acid composition of tamarind seed oil in Table 3. Tamarind seed parts in Figure 2 and tamarind seed and powder in Figure 3.

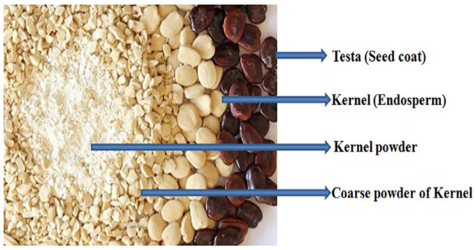

Figure: 2 Tamarind seed Parts

Figure 3: Tamarind seed and powder

Extraction Methods of Tamarind seed Polysaccharides

The extraction of TSP includes a few moves toward confine these mind-boggling polysaccharide particles from the seeds of the tamarind tree. Here is an overall outline of the extraction strategies for tamarind seed polysaccharides:

Cleaning and decortications

Tamarind seeds are gathered, cleaned, and decorticated to eliminate the external seed coat (testa).

Seed powder preparation

The decorticated seeds are ground into a fine powder. This builds the surface region and works with the extraction interaction.

Deproteinization

The seed powder is exposed to a Deproteinization move toward eliminate proteins. This can be accomplished utilizing enzymatic techniques or basic treatment.

Extraction of polysaccharides

The deproteinized seed powder is then exposed to extraction to separate the polysaccharides. Normal extraction strategies include:

Water extraction

TSP can be separated involving water as a dissolvable. The polysaccharides dissolve in the solution when the seed powder is mixed with water.

Soluble extraction

A soluble arrangement, frequently sodium hydroxide, can be utilized to extricate TSP. Soluble circumstances help solubilize the polysaccharides.

Table 2: Mineral content of tamarind pulp, seed, kernel and testa[44-47]

S.NO	*Mineral*	*Tamarind pulp (*mg)	*Tamarind seed (*mg)	*Tamarind kernel (*mg)	*Tamarind seed coat (*mg)
1	Calcium	Approx 35	Around 106	Approx 33	Around 27
2	Iron	Around 2.8	Approx 11.7	Around 11.5	About 6.8
3	Magnesium	Approx 92	About 183	About 140	Approx 52
4	Phosphorus	Around 113	Around 278	Around 150	Around 124
5	Potassium	Approx 628	About 648	About 360	Approx 411
6	Sodium	About 28	Approx 17	Around 2.0	About 27
7	Zinc	Around 0.1	Around 0.8	Approx 0. 9	Around 0.4

Table 3: Fatty acid composition of tamarind seed oil[48-50]

S. No	*Fatty acids*	*Approximate %*
1	Saturated fatty acids	
	Palmitic acid	10–15
	Stearic acid	2–6
2	Monosaturated fatty acids	
	Oleic acid	40–50
3	Polyunsaturated fatty acids	
	Linoleic acid	30–40
	Linolenic acid	0.3–1

Extraction by acid

Acidic circumstances, using acids like hydrochloric corrosive, can likewise be used for TSP extraction. Complex polysaccharides can be broken down into simpler forms with acid hydrolysis.

Precipitation and sanitization

The addition of alcohol or other precipitating agents frequently precipitates the TSP following extraction. The polysaccharides separate from the solution as a result of this. The accelerated TSP is then gathered and further purged through cycles like filtration or centrifugation.

Drying

The refined TSP is dried to eliminate any leftover dampness. This can be accomplished through strategies such as splash drying or freeze drying.

Modification

Physical modification[23-28]

Physical modification of tamarind seed polysaccharides (TSP) includes adjusting the actual attributes of the polysaccharides without changing their substance structure. This adjustment can improve explicit properties or empower new applications. Here are a few normal techniques for physical modification:

- *Machine grinding*

TSP particles can be exposed to mechanical processing cycles to diminish molecule size and increment surface region. This can work on the solvency and scattering of TSP in different applications.

- *Ultrasonication*

Ultrasonication includes the utilization of high-recurrence sound waves to disturb and separate molecule totals. This strategy can bring about more modest and more uniform TSP particles.

- *Micronization*

Micronization includes diminishing the molecule size of TSP to micron or submicron levels. In applications like drug delivery systems, this has the potential to enhance TSP's bioavailability as well as its functional properties.

- *Spray drying*

Shower drying is an interaction where TSP arrangements are atomized into fine beads and quickly dried to shape powder. This can prompt superior steadiness, solvency, and simplicity of taking care of in different applications.

- *Freeze drying*

TSP solutions are frozen and the water is removed by sublimation during freeze-drying, also known as lyophilization. This cycle can bring about a permeable and lightweight construction, which might be invaluable for specific applications.

- *Cross linking*

Cross linking includes the development of covalent connections between various TSP particles. This can work on the security and mechanical strength of TSP, making it more appropriate for specific modern applications.

- *Mixing with different polymers*

TSP can be truly mixed with different polymers to make composite materials with improved properties. This mixing can prompt better mechanical strength, adaptability, or other advantageous attributes.

- *Film arrangement*

Casting and extrusion are two methods by which TSP can be processed into coatings or films. This can bring about materials with exceptional actual properties appropriate for different applications, including food bundling.

Chemical modification[29-37]

Chemical Modification of TSP includes changing the compound construction of the polysaccharide particles to present new practical gatherings or alter existing ones. This can upgrade specific properties or empower explicit applications. Here are a few normal strategies for compound change for TSP:

- *Etherification*

Etherification includes the presentation of ether bunches into the TSP structure. Alkyl or aryl halides are common reagents that modify TSP and alter its solubility and rheological properties.

- *Esterification*

Esterification includes the presentation of ester bunches into the TSP structure. This can be accomplished through responses with acids or corrosive chlorides, prompting changed TSP with various substances and actual properties.

- *Acetylation*

Acetylation includes the expansion of acetyl gatherings to the hydroxyl practical gatherings of TSP. This change can upgrade the water dissolvability and warm solidness of TSP.

- *Carboxymethylation*

Carboxymethylation brings carboxymethyl bunches into TSP, ordinarily utilizing chloroacetic corrosive. Thanks to this modification, TSP may acquire thickening properties and a higher water solubility.

- *Phosphorylation*

Phosphorylation includes the presentation of phosphate bunches into the TSP structure. This change can upgrade the limiting properties of TSP and work on its presentation in specific applications.

- *Graft copolymerization*

Graft copolymerization includes joining polymer chains onto the TSP spine. TSP's compatibility with other materials can be enhanced or new functional groups can be introduced using this approach.

- *Oxidation*

Oxidation brings oxygen-containing useful gatherings into the TSP structure. This can modify the reactivity and similarity of TSP in different applications.

- *Hydrophobic modification*

By attaching hydrophobic groups to TSP, hydrophobic modification can make it more compatible with non-polar substances or more water-resistant.

Applications of Tamarind Seed Polysaccharides[51-53]

Food industry

Thickening specialist, stabilizer, and gelling specialist in sauces, soups, and flavors.

Pharmaceuticals

Utilized in tablet formulations and drug delivery systems.

Cosmetics

Stabilizer in lotions, thickener in creams, and stabilizer in emulsions.

The textile sector

Thickening specialist in printing and measuring specialist for winding around.

Paper industry

Utilized in paper coating for improved printability and smoothness.

Adhesives and binders

Gives restricting and thickening properties.

Water treatment

Goes about as a flocculating specialist.

Oil drilling

Added to penetrating liquids for further developed consistency.

Biomedical applications

Investigated for wound recuperating definitions.

Agriculture

Utilized as a seed covering specialist for upgraded germination.

In sustained drug delivery[38]

- *Gelling ability*

TSP can shape gels, empowering controlled drug discharge.

- *Biocompatibility*

TSP is very much endured by the body.

- *Hydrogel formulation*

TSP adds to hydrogel definitions for sodden medication conveyance.

- *Encapsulation*

TSP epitomizes drugs, guaranteeing assurance and supported discharge.

- *Mucoadhesion*

Because it sticks to mucosal surfaces, TSP extends drug residence.

- *Stability boosting*

TSP adds to medicate security during capacity.

- *Versatility*

Appropriate for different medication conveyance frameworks (oral, nasal, visual, and transdermal).

- *Sustainability*

Being plant-inferred, TSP is regular, maintainable, and biodegradable.

As a binder[38]

TSP are useful binders in tablets and other solid dosage forms. TSP upgrades tablet union during wet granulation, working on mechanical strength and guaranteeing primary honesty. As a characteristic and biodegradable choice, TSP lines up with eco-accommodating definitions. It is suitable for a variety of pharmaceutical applications due to its compatibility with various excipients. Additionally, its gelling properties may contribute to controlled drug release in tablets.

In controlled release[39]

Tamarind seed polysaccharides (TSP) are used in controlled release drug delivery system because of their gelling properties. TSP forms matrices that release drugs gradually and sustainably. Its biocompatibility, mucoadhesive nature, and normal beginning make it appropriate for controlled drug conveyance, offering adaptability and strength improvement.

In ophthalmic drug delivery[40-41]

Tamarind seed polysaccharides (TSP) are promising for ophthalmic drug delivery because of their gel-framing, mucoadhesive properties, upgrading drug maintenance on the visual surface. Biocompatible and economical, TSP upholds controlled drug discharge, working on helpful results in eye care.

CONCLUSION

When evaluating the safety of new formulations, regulatory authorities consistently favor biomaterials like TSP. TSP is broadly embraced as excipients in hydrophilic medication conveyance frameworks because of its remarkable properties, including being carcinogenic, biocompatible, and mucoadhesive. Its flexibility reaches out to filling in as a stabilizer, thickener, folio, discharge retardant, modifier, suspending specialist, consistency enhancer, and emulsifying specialist. TSP goes about as a transporter in clever medication conveyance frameworks for different courses like oral, buccal, colon, and visual applications, as well as in nanofabrication and wound dressing. Past drugs, TSP has acquired significance in the domains of food, beauty care products, dessert shops, and bread kitchens. Various examinations and investigations highlight its multifunctional potential, insisting TSP is a promising normal polysaccharide with broad applications across different businesses.

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