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TAMARIND SEED POLYSACCHARIDE – A POTENTIAL PHARMACEUTICAL EXCIPIENT

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ABSTRACT

Background: Tamarind seed polysaccharide is a natural non-ionic polysaccharide extracted from the refined endosperm of *Tamarindus indica* bean seeds. The polysaccharide present in tamarind kernel powder is called tamarind seed polysaccharide. It is a seed gum with potential pharmaceutical applications, which includes their use as binders and disintegrants in tablets, emulsifiers, suspending and gelling agents as well as modified release excipients in sustained and targeted drug release tablets due to its high drug holding capacity.
Aim: This review focuses on the various pharmaceutical potentials of Tamarind seed polysaccharide (TSP) as an excipient in both traditional and novel drug delivery systems.
Methods: This review specifically focuses on the various pharmaceutical applications and uses of tamarind gum and modified TSP as an excipient in both traditional and novel drug delivery systems, using information's from Google scholars, Scopus, Research gates, Textbooks and other online sources.
Findings: Tamarind seed polysaccharide being of natural origin has some advantages over synthetic polysaccharides such as relatively low toxicity, cost, biodegradability, availability and accessibility. They can also be modified in different ways to obtain tailor made materials for drug delivery systems and thus can compete with the available synthetic excipients.
Conclusion: In conclusion, the use of TSP in pharmaceutical formulations could provide a sustainable and eco-friendly alternative to synthetic polymers, which could lead to the development of safer and more effective drug delivery systems.

Keywords: *Tamarindus Indica*, Tamarind Seed Polysaccharides, Gum, Modification

1.0 Introduction

Plant gums are fast gaining popularity in the field of pharmaceutics and have been the focus of many studies in drug delivery as excipients. They have been evaluated as binders, diluents, fillers, disintergrants and sustained release polymers in various drug delivery systems. The advantages of natural gums that have contributed to the growing interest in them include

- They are of natural origin.
- They are abundant, readily and locally available in nature.
- Low cost
- They are relatively safe
- They are biodegradable [1]

Some natural gums that have shown important pharmaceutical relevance include Gum Arabic, Xanthan Gum, Tragacanth gum, tamarind seed gum, guar gum. Several

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studies have been carried out to investigate the versatility of Tamarind seed gum (also referred to as tamarind seed polysaccharide (TSP)) as a pharmaceutical excipient as such this review is limited to Tamarind seed polysaccharide (TSP) which is obtained from the kernel of *Tamarindus indica*.

Tamarindus indica L., also commonly known as tamarind tree, is a large evergreen tree with a spreading crown. It is a leguminous tree (**Genus:** Tamarindus; L. **Species:** T. indica; family: Fabaceae). The fruits of the tree are edible and the tree is widely distributed and commonly found in various parts of Africa which include Sudan, Cameroon, Nigeria, Kenya, Zambia, Somalia, Tanzania and Malawi [2], [3].

Structural Formula:

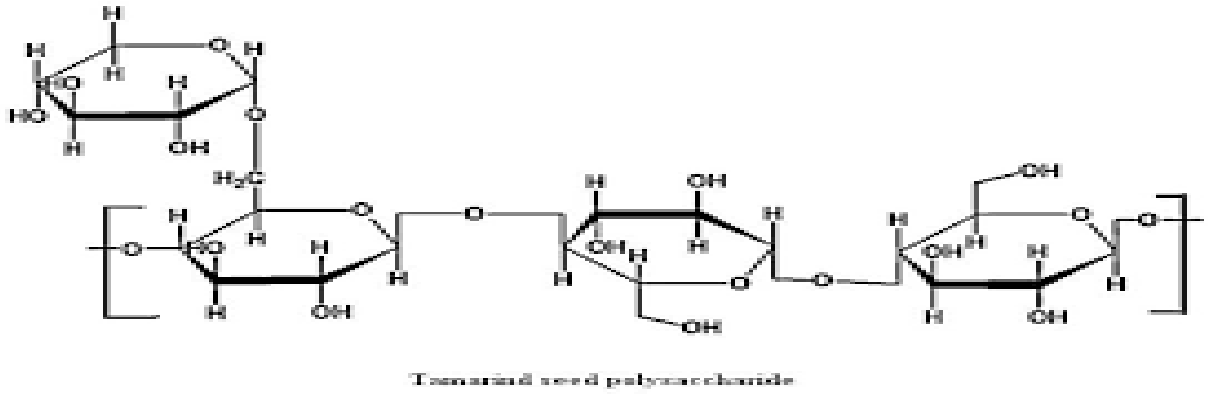

Figure 1: Tamarind seed polysaccharide [8]

2.1 Structure and Chemical Composition

Tamarind Seed Polysaccharide (TSP) a highly branched carbohydrate polymer is chemically a galactoxyloglucan (neutral xyloglucan) [9]. A monomer of mainly three sugars- glucose, xylose and galactose in a molar ratio of 3:2:1 [4]. With a chain length which varies from 300-3000 glucose units [10], [11].

It is composed of (1 → 4)-β-D- glucan backbone substituted with side chains of α-D-xylopyranose and β-D-galactopyranosyl (1 → 2)-α- D-xylopyranose linked (1 → 6) to glucose residues [8]. One galactopyranosyl unit is attached to one of the xylopyranosyl

2.0 Tamarind Seed Polysachharide

The seeds of the tamarind fruit are smooth, glossy and flattened oblong. Tamarind Seed Polysachharide (TSP) is also referred to as Tamarind gum (TG), tamarind xyloglucan, tamarind seed xyloglucan, and tamarind galactoxyloglucan is a byproduct of tamarind pulp which is obtained from the endosperm, of the seed kernel of *Tamarindus indica* [4]. The tamarind seed polysaccharide constitutes about 60-65 % of the tamarind seed components [5], [6], [7].

Chemical name: Galactoxyloglucan

Molecular Weight: 52,350 Daltons

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units through b-D- (1-2) linkage. The configuration of TSP gives the product a 'mucin-like' molecular structure [12].

2.2 Physico-Chemical Properties of Tamarind Gum

i. It has a creamy white to light tan colour.
ii. It is insoluble in organic solvents such as acetone, ethanol, ether, methanol and in cold water, buhydrates quickly in cold water but does not reach maximum viscosity. It dissolves completely in hot water at temperatures above 85°C, yielding a highly viscous mucilaginous gel which shows a typical non-newtonian rheologic behaviour and pseudoplastic properties with a broad pH tolerance as well as muco-mimetic, mucoadhesive and pseudoplastic properties [13], [14], [15]
iii. TSP solution exhibits typical non-newtonian flow properties common to most other hydrocolloids. The rheological properties of tamarind kernel powder suspension showed that suspension behaved like non-newtonian, pseudoplastic fluid [9], [16]
iv. Tamarind seed polysaccharide possesses various properties like high viscosity, adhesivity, non-carcinogenicity, broad pH tolerance and biocompatibility. It is also found to be a potential emulsifier, nontoxic and non-irritant with haemostatic activity [13], [17].
v. High drug holding capacity, high swelling index and high thermal stability, make it a suitable excipient for drug delivery system, with excellent viscosity enhancer showing mucomimetic, mucoadhesive and bioadhesive activities [13].

3.0 Isolation and Purity Assessment of TSP

Various techniques are employed in the isolation of TSP which can be either chemical or enzymatic methods [18], [19], [20]. The methods employed have been described below

3.1 Enzymatic Method

This method involves using protease and also using a combination of protease and high-intensity ultrasound. The kernel powder mixed with ethanol is treated with protease. After which it is centrifuged and the supernatant is added to ethanol for precipitation, which is then separated and dried.[21] , [22].

3.2 Chemical Method

The seed powder is soaked in water and boiled. The mucilage is filtered and an equal amount of acetone is added to precipitate the polysaccharide, which is then concentrated and dried.

Elimination of proteins is the main objective in the isolation of TSP. Purity of TSP is confirmed by the absence of protein, which may denature forming insoluble precipitates [21], [22].

The purity of TSP is characterized by various phytochemical tests which should show negative results for proteins, steroids, saponins, alkaloids, flavonoids, tannins and phenols and positive results for the presence of carbohydrates, confirmed by the Molisch's test, Barfoed's test and Benedict's test and

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also positive results for the presence of mucilage and reducing sugars [10], [23].

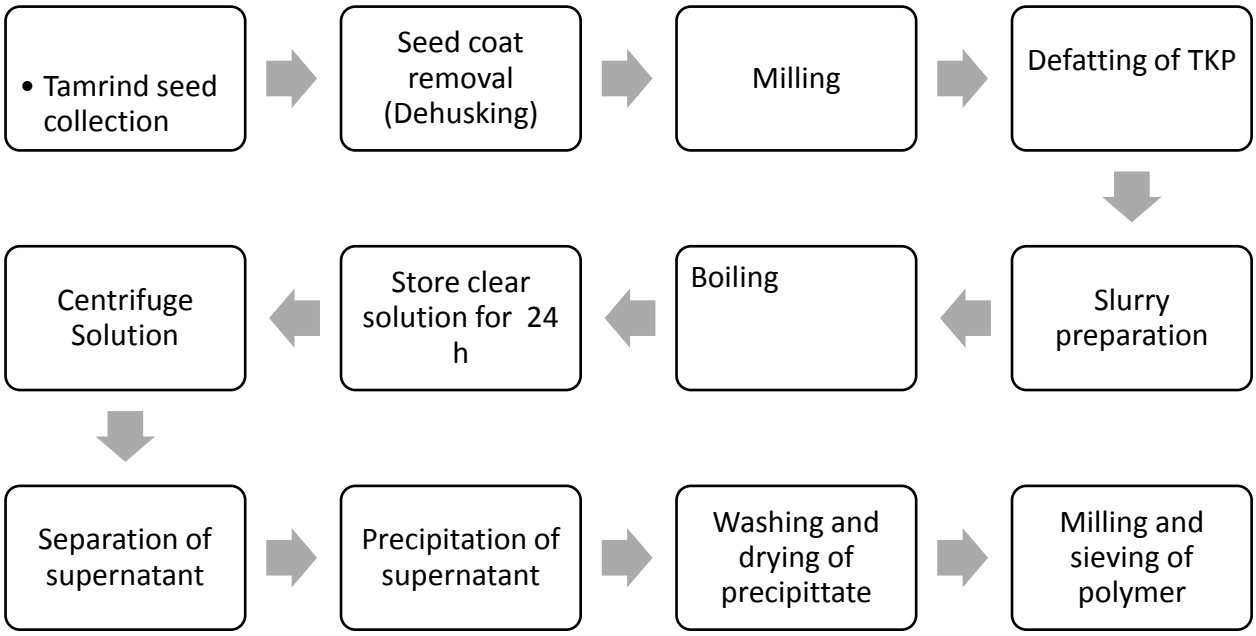

Figure 2: Schematic representation of the extraction and purification of TSP (method I)

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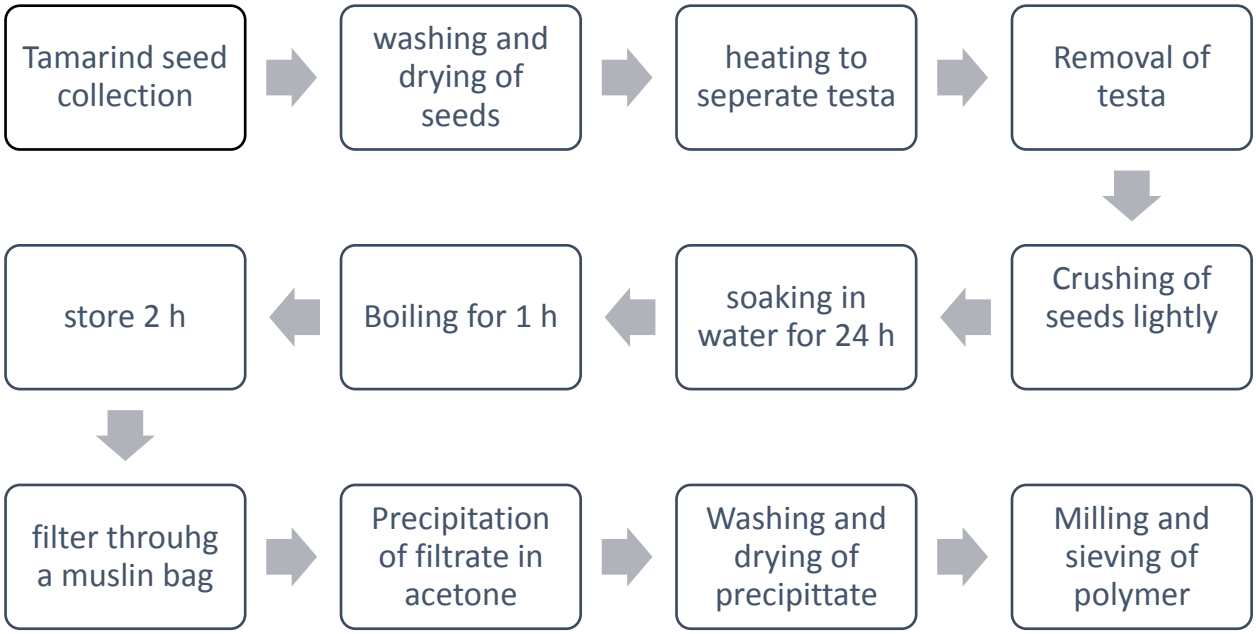

Figure 1: Schematic representation of the extraction and purification of TSP (method II)

4.0 Pharmaceutical Applications TSP

Currently, tamarind seed polysaccharide has gained popularity for its usefulness in the preparation of various pharmaceutical dosage forms [8].

Tamarind Seed Polysaccharide is a multifunctional polymer, which plays the role of stabilizer, thickener, gelling agent, binder, release retardant, modifier, suspending agent, viscosity enhancer, emulsifying agent, as a carrier for novel drug delivery systems for oral, buccal, colon, ocular systems, nanofabrication, wound dressing, food, cosmetics, confectionery, bakery etc. The Film forming property with high tensile strength and flexibility makes it a good excipient for ocular preparations. This film is transparent, non-hygroscopic, non-sticky and retains its form even on rough handling [6], [10].

4.1 Suspending and Emulsifying Agent in Liquid Orals

A study on TSP as a suspending agent in the formulation of Nimesulide suspension showed that TSP acts as a stable suspending agent that reduces the rate of settling and permits redispersion of any settled particulate matter [24].

4.2 Binders in Solid Dosage Forms

Tamarind seed polysaccharide has been studied as an excipient in tablets like binders, matrix formers and release modifiers in pharmaceutical tablet formulations. It has proven to be an effective binder for wet granulation and direct compression in various tablets, and it also was observed that these tablets exhibited lower drug release profiles of the enclosed drug from the matrix is in acidic medium and a much higher release rate in the alkaline media, making TSP a potential

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candidate for lower gastrointestinal tract targeted drug delivery [25]. This property was attributed to the hydrophilicity, viscosity and higher swelling of tamarind seed polysaccharide [26].

In a formulation sustained release tablets of tramadol HCl, using TSP as a binder in direct compression, it was observed that the formulation containing 30% of TSP maintained the zero-order release for 24 h by swelling, diffusion and erosion. The order of increasing the release retarding effect observed with various polymers was HPMC K4M < TSP [18].

4.3 Matrix Oral Drug Release Modifiers

Deveswaran *et al* 2009, [24] formulated Diclofenac sodium matrix tablets by wet granulation technique using TSP as the release retardant, it was observed that the drug release was a period of 12 h. with a zero-order release profile. It was also observed that an increase in polymer content resulted in a decrease in the drug release from the tablets.

Sustained release matrix tablets of lamivudine were developed by using combination of TSP with ethyl cellulose by direct compression method for the treatment of HIV. The drug release was characterized and found to decrease with an increase in TSP concentration and with the addition of ethyl cellulose. Drug release showed close relationship with Higuchi and zero-order kinetics [27].

Phani Kumar *et al 2011*, [18] in a study found TSP to be an effective rate control polymer in retarding the release of Tramadol HCL from matrix tablets over a 24 h period as compared with HPMCK4M, Sodium CMC, and Guar gum, which proved it suitable for a once a day administration.

4.4 Carrier for Colon Targeted Delivery

TSP is degraded in the colon making it a suitable polymer for development of colon targeted drug delivery. Mishra and Khandare, 2011 [28] studied the use of TSP as a carrier for colon drug delivery using ibuprofen as the model drug. Ibuprofen matrix tablets containing different concentrations of tamarind seed polysaccharide were formulated by wet granulation technique to protect the drug in upper gastrointestinal tract. Results from *in vitro* drug release study show that the matrix tablets where able to deliver the drug to the colon with restricted release in upper GIT.

The study showed that TSP is susceptible to enzymatic degradation in the colon and hence making it a promising biodegradable carrier for colon drug delivery.

4.5 As Emulsifier

Tamarind Seed Polysaccharide demonstrated a good emulsifying property when used in low concentration as compared to acacia gum in a study carried out by Kumar *et al;* [23], the study showed that 2% w/v TSP is more effective as an emulsifier as compared to 10%w/v of acacia gum in a study on castor oil emulsion [29].

4.6 Preparation of Ophthalmic Drug Delivery

Tamarind Seed Polysaccharide has proven to be useful in the production of gelled ophthalmic solutions used as artificial tear for the treatment of dry eye syndrome at a concentration 0.7-1.5 % and also as a vehicle for sustained release of ophthalmic drugs at a concentration between 1-4 %. The gelled

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solution has pseudoplastic rheological behavior mucoadhesive properties[9]

5.0 Drawback of TSP

Tamarind Seed Polysaccharide is a natural polymer as such it is not devoid of drawbacks such as

- Presence of impurities.
- It has a dull color with an unpleasant odour.
- Microbial contamination.
- Insoluble in water
- Varying chemical constituents resulting from different sources.
- Degraded in an aqueous environment.

However; these draw backs can be controlled or eliminated by the modification of TSP to make it even more versatile.

6.0 Modification and Pharmaceutical Application of Tamarind Gum

Modified TG have improved properties compared to native TSP, making them useful in various pharmaceutical applications. Some of the modifications that have been carried out include

- Carboxymethylation,
- Acetylation,
- Hydroxyl-alkylation
- Thiolisation
- Grafting of tamarind gum
- Partial degradion TG
- Methoxyethylation
- Cyanoethylation
- Succinylation

These modifications have resulted in the alteration of the solubility, swelling and drug delivery profile of TSP.

The modification of tamarind gum improves its properties such as solubility, viscosity, swelling, stability, and drug release kinetics, making it a promising material for pharmaceutical applications as well as expanding its applications in the pharmaceutical industry to include novel drug delivery system [30], [31], [32].

The table below lists some form of modification that have being carried out and studied on TG and the benefits of the modification to pharmaceutical industry and drug delivery.

Modification of tamarind gum	Pharmaceutical Advantage(s)
Carboxymethylated tamarind gum	• Addition of carboxymethyl group increases the hydrophilicity of TG and resists its biodegradation [33] • CMTG is soluble in cold water improves properties of native TG like unpleasant odor, dull color, water solubility, swelling, viscosity, bioadhesion, and biodegradability, thus making it appropriate for pharmaceutical applications [34] • Enhanced mucoadhesive properties [35], [36]. • Has been applied as sustained-release matrix [37], [38]

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Succinylated tamarind gum (STG)	• Has been applied as a sustained-release matrix for the delivery of diltiazem hydrochloride[39]. • Mucoadhesive polymer for the delivery of insulin via the nasal route[40] **USES:** sustained-release matrix for the delivery of diltiazem hydrochloride[39] • mucoadhesive polymer for the delivery of insulin via the nasal route[40]
Thiolation of tamarind gum	• Significant improvement in mucoadhesive strength compared to unmodified tamarind gum[41]. • Served as a potential as a carrier for the targeted delivery of anticancer drugs [42] **USES:** It was used in mucoadhesive topical delivery of metronidazole [43]
Cyanoethylation of tamarind gum	• Cynoethylation improves the properties like cold water solubility, viscosity, and biodegradation of TG. It is used in non-food applications [44]. • Cyanoethylation of tamarind gum in combination with sodium alginate caused an improvement in drug release kinetics [45] • Improved its solubility and swelling properties [46] • Improved mucoadhesive properties [47]
Methoxyethylation of tamarind gum	• It was observed that the degree of methoxyethylation significantly affected the rheological behavior of the gum, where higher degrees of methoxylation lead to a decrease in viscosity [48], [49] • Improved the mucoadhesive strength of the gum [50]

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Amination of tamarind	• Amination improves properties like hydrophilicity, swelling, controlled drug release behavior and mucoadhesion of TG. Aminated TG forms strong gel in water. Also, aminated TG exhibits antimicrobial activity [51]. • Aminated TG exhibited a higher bioadhesion strength than the sulfated and carboxymethylated [14], [52] • Increased thermal stability and improved solubility in water [14] • **USES:** It has been used in the development of buccoadhesive patch of pentazocine [52]
Acetylation of tamarind gum	• Improved water solubility of tamarind gum Acetylated tamarind gum showed good mucoadhesive properties, suggesting its potential use in oral drug delivery systems [53] **USES:** As a sustained-release matrix for the delivery of the antihypertensive drug, enalapril maleate[54]
Sulfonation of TG	• Sulfated TG may be used as release retardant in bioadhesive drug delivery [55], [56]
Partially degraded TG	• partial degradation of tamarind gum resulted in the formation of low molecular weight derivatives with improved solubility and swelling properties [57] **USES: C**ontrolled-release matrix for the delivery of the antihypertensive drug Ramipril, partially degraded tamarind gum matrix exhibited sustained drug release over a period of 12 hours, making it a potential polymer for drug delivery of other drugs with similar pharmacokinetic profiles [58] • As a matrix for the delivery of the antifungal drug, ketoconazole. Partially degraded tamarind gum matrix exhibited sustained drug release over a period of 10 hours [59]
Grafting of tamarind gum	• Significant improvement in the water solubility and swelling properties of tamarind gum [60], [61] • Improved mucoadhesive properties and sustained release of the drug [60], [62], [63]

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7.0 Safety Evaluation for Pharmaceutical Applications

Acute toxicity and chronic toxicity studies carried out to determine the safety of TSP have revealed it to be non-toxic even at high doses. So, the use of TSP in pharmaceutical products is proven to be an acceptable as excipients [10].

8.0 Conclusion

The *Tamarindus indicus* tree from which TG is obtained is widely distributed and readily available making it a cheap alternative to synthetic polymer, the isolation and characterization of Tamarind Seed Polysaccharide involves a simple cost-effective method which make it desirable.

Studies have shown that TSP used in drug delivery is effective as a binder, emulsifier, vehicle in ocular drug delivery, and as polymer in controlled drug delivery system proving its versatility making TSP a promising polymer of pharmaceutical relevance from natural origin.

These studies have suggested Tamarind Gum has immense potential as a biocompatible and biodegradable polymer for various pharmaceutical applications and the modification of Tamarind Gum has been shown to be a promising approach for improving the properties of the natural polymer and its potential use in the pharmaceutical industry. It also highlights how the modification of tamarind gum enhances the properties of the polymer, making it a more versatile excipient for drug delivery systems.

These studies provide important information on the physicochemical properties of the gum in its natural state and modified form. These studies also provide evidence of the potential of Tamarind Gum and Modified Tamarind Gum as a versatile pharmaceutical excipient with a possible wide range of applications in drug delivery systems. Its biocompatibility, biodegradability, and low toxicity make it a promising natural polymer for pharmaceutical formulations.

However, further research is needed to explore its potential in other areas of drug delivery and formulation such as in novel delivery systems like the nano-delivery and polymer-drug conjugate (PDC).

In conclusion, the use of TSP in pharmaceutical formulations could provide a sustainable and eco-friendly alternative to synthetic polymers, which could lead to the development of safer and more effective drug delivery systems.

CONFLICTS OF INTEREST: Authors declare no conflicts of interest

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