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Review Paper

Application Of Natural Modified Starch as Excipient for Tailored Pharmaceutical Drug Delivery: An Overview

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ABSTRACT

Background:tarch is a natural, renewable biopolymer that is biodegradable, biocompatible, and functionally versatile. Due to its low cost, natural availability, and eco-friendly nature, it is widely used as a pharmaceutical excipient.Objective:The aim of the paper is to highlight the latest developments in the extraction and modification of native starch and its application in the pharmaceutical industry as a potential excipient.Methods:Different methods of extraction have been used to obtain native starch in a pure form and high yield. Additionally, different methods of chemical, physical, and enzymatic modifications have been used to improve the functional properties of the starch, such as solubility, swelling property, viscosity and controlled release properties.Results:Natural and modified starch has potential as the properties include the ability to bind, disintegrate, form films, and sustain the release. Tablets, capsules, hydrogels, films other sophisticated drug delivery systems are the best drug delivery systems where the native starch be used as a potential excipient. Modified starch has been found to have excellent properties when used in delivery system as hydrogel due to swelling capacity sustained release drug delivery due to the improved matrix.Conclusion:The native starch has been found to be a promising and sustainable excipient in the pharmaceuticals. Additionally, the starch has been found to have diverse and excellent functional properties and biocompatibility. Further research has to be conducted to explore the new methods of modifying the starch and using it in the drug delivery system on the basis of their relevant properties

INTRODUCTION

In the pharmaceutical industry, starch is used as a natural biopolymer because of its availability, low

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cost, biodegradability, and bio-compatibility. It is adhesive, filler, disintegrant and film-former and it is commonly applied as an excipient in oral solid dosage forms [1]. Starch is a very fundamental part of drug formulation since it possesses the capacity to gel, swell and form films in certain situations. Its competence in the manufacture of safe, efficient pharmaceutical products is also enhanced by its flexibility and regulatory acceptability [2].

Potato starch is among the various botanical starches that possess distinctive characteristics that ensure it is used in pharmaceuticals. It has a fairly large number of phosphate monoester groups that enhance its ability to be clear in pastes, to swell and to be thicker than cereal starches [3]. Also, the size of potato starch granules is large (15-100 μm). This dimension enhances compressibility and tablet disintegration attributes [4]. It is these properties that render potato starch particularly attractive in modified-release and special dosage forms.

There is however limitations to the use of native potato starch in pharmaceuticals as they are limited to their application. It is not very flowable, extremely sensitive to moisture and low in mechanical strength of tablets. Such problems may impact productivity and stability of the product [2]. Consequently, it requires physical, chemical or enzymatic alteration methods in order to enhance its functionality and modify its properties to suit certain pharmaceutical requirements. Adjusted potato starches would be able to overcome these constraints without compromising benefits of their natural attributes [6].

2. Potential Starch, Structure and Properties

Native starch contains two polysaccharides, similar to all starches, amylose and amylopectin, which are the major components of the substance. The amylose content of potato starch is normally between 20 and 30% and the other 70 and 80 percent of the starch is composed of amylocpectin [4]. The chains of 1, 4-linked glucose are primarily linear molecules of amylose. Conversely, amylopectin is very branched and has alpha 1,4 and alpha 1,6 linkages. Potato starch has a high amylopectin composition, thus it is highly viscous, has high film-forming and gelation capability. They may be applied in pharmaceutical recipes where it is needed to bind or have a controlled release [3].

Physical and chemical characteristics of potato starch are unique to it in comparison to other sources of starch. Its granules are very coarse in size with a diameter ranging between 15 and 100 μm and with a smooth surface [6]. Phosphate monoesters in amylopectin make the starch yield a high swelling power and a clear paste because it enhances the ability of the starches to bind water and expand through expansion in the heating process [3]. Potato starch has a low gelatinization temperature ranging between 58 and 66 °C. This simplifies processing it and it is also acceptable in heat sensitive formulas [4]. The properties cause rapid hydration, efficient disintegration as well as the compression of pills in pharmaceutical processes.

The potato starch has specific advantages when compared to other regular starches such as maize, rice, and cassava. The maize starch is typically less swelling power and smaller in particle size (2 to 30 μm) [12]. Rice starch contains smaller (2 to 8 μm) granules with a lower viscosity and therefore reduced binding capacity, but is potentially more useful in fine powder applications. Although cassava starch contains amylopectin just like potato starch, it lacks the phosphate group resulting in reduced swelling and paste clarity. These are the reasons why potato starch is particularly well suited to processes that require high viscosity, well-formed gels, or rapid disintegration, providing it with a distinctive place in the set of starch-based excipients in pharmaceutical preparations [3, 6].

3 Extraction of Potato Starch

Potato starch is extracted in the following way: washing and grating of tubers. This ruptures the cells and forms slurry which is filtered to eliminate fibers. The starch granules are then separated by the process of sedimentation or centrifugation. It is then washed multiple times to enhance purity and then dried down to a fine powder. This crude process yields high purity starch which is extensively applied in food and pharmaceutical sectors[13].

3.1 Traditional Extraction Methods

Conventional potato starch extraction as Fig. 1 involves physical process in which tubers are broken and starch granules are separated as a result of water-based processes. To start with, the potato is well washed to remove soil and surface dirt. They are then mechanically ground or scraped to puncture the cells to liberate starch [14]. Sieves are then used to remove fibrous material in the starch-water mixture. Table 1 allows the settling of starch through gravity. The liquid is then decanted and the solid is washed a few times to enhance purity. The wet starch cake is then filtered to remove the additional water and dried to achieve appropriate level of moisture in a locked away from [15].

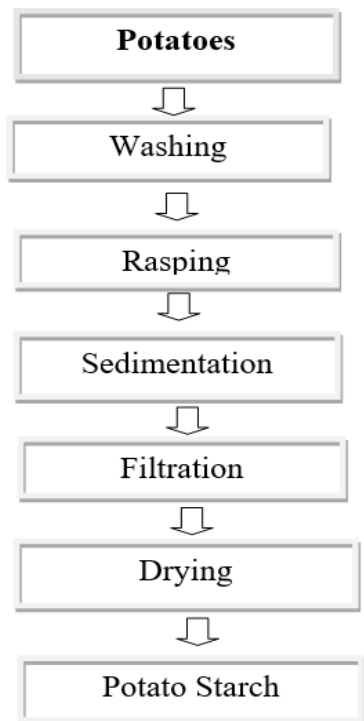

Fig 1: Flowchart of Potato Starch Extraction, Step-Wise Process of Potato to Potato Starch

While this method works well, it has some clear drawbacks. It requires large amounts of water, produces wastewater that needs treatment, and is labor- and time-intensive [16]. Scaling up can be tough due to environmental and economic issues, along with variations in product quality.

Table 1: Different Steps in Traditional Extraction

Step	Description	Advantages	Limitations
Washing and rasping	Cleaning and mechanical disruption	Simple and cost-effective	Energy- and water-intensive
Sedimentation	Starch granules settle by gravity	Low-cost separation	Time-consuming, low throughput
Filtration and drying	Removes water and fibrous matter	Produces usable dry starch	May trap impurities, energy use

3.2 Modern/Green Extraction Approaches

New developments have been made on the more sustainable and efficient techniques as Table 2. Potential extraction based on enzymes, such as celluloses, hemicelluloses or pectinases, assists in disintegration of potato cell walls in a more selective way. This treatment enhances yield of starch and its purity and minimizes mechanical degradation of granules [17]. Ultrasonic-assisted extraction is the other technique which involves high frequency sound waves to generate cavitation and microstreaming. This improves cell disruption and facilitates starch release consuming less water and energy [18]. Also, the studies have investigated organic solvents and supercritical fluids, including supercritical carbon dioxide, to reduce the use of water and enhance selectivity[19]. These contemporary techniques are promising but are not widespread in the industry yet because they are more expensive and they demand more technical expertise.

Table 2: Modern and Green Extraction Approaches

Method	Principle	Advantages	Challenges
Enzymatic (cellulose/pectinase)	Enzymes hydrolyze cell walls	Higher yield, milder process	Cost of enzymes, enzyme inhibition
Ultrasonic-assisted	Cavitation improves release	Faster, less water-intensive	Equipment cost, scale-up issues
Organic solvents/supercritical	Solvents/CO_2 extract starch	Lower water use, high purity	Expensive, safety concerns

3.3 Purification Methods

It is a significant process to purify the solutions in order to eliminate residual proteins, lipids, and phosphate monoesters. These may adversely affect the functional and storage properties as Table 3[20].

Table 3: Purification Methods and their Impact on Quality

Method	Impurity Removed	Impact on Starch Quality	Ref.
Washing & centrifugation	Proteins & lipids	Improves color and stability	[21]
Mild acid washing	Phosphate groups	Reduces retro gradation tendency	[22]
Filtration	Fibers & debris	Enhances compressibility	[23]

3.4 Challenges in Extraction

Despite the advancement in technology, there are still some challenges as Enzymatic inhibition . The natural potato ingredients, such as phenolic compounds and protease inhibitors, can lower the efficiency of using enzymes to extract by disrupting the enzyme activity [24].

4 Modification of Potato Starch

Potassium starch Native potassium starch has limitations. It is easily retrogradable, is weak in terms of mechanical strength, and does not flow well. Such factors limit its application in pharmaceuticals. To address these problems, a number of modification methods are formulated to modify its characteristics to fit certain purposes [28, 29].

4.1 Physical Modifications

Physical methods change the granular structure or crystallinity without altering the chemical makeup. This makes them safe and suitable for food and pharmaceutical applications. Pre-gelatinization partially cooks and dries starch, forming amorphous areas. This allows it to dissolve in cold water and improves compressibility, making it suitable for direct compression in tablet formulations. Different physical modifications are given in Table 4 [30].

Table 4: Physical modifications and their effect on Starch Properties

Physical modification method	Principle / Process	Effect on Starch Properties	Applications	Ref.
Heat-Moisture Treatment (HMT)	Starch is heated at **90–**120 °C with low moisture (10–30%) for a specific time without gelatinization.	Improves thermal stability, increases resistant starch, modifycrystallinity and viscosity.	Functional food ingredients, controlled digestion products, pharmaceutical excipients, biodegradable materials.	[31]
Annealing (ANN)	Hydrothermal treatment performed at high moisture content and temperature below gelatinization for extended periods.	Improves molecular order, increases gelatinization temperature and stability.	Food thickening agents, tablet binders, stabilizers in drug delivery systems.	[32]
Microwave Treatment	Microwave energy causes rapid heating and structural rearrangement of starch molecules.	Alters molecular weight, reduces crystallinity, improves paste properties and digestibility.	Instant food products, starch-based films, controlled-release matrices.	[33]

Ultrasound Treatment	High-frequency sound waves (>20 kHz) create cavitation bubbles that disrupt starch granules.	Decreases particle size, improves solubility, swelling power, and rheological properties.	Nanostructured starch carriers, drug delivery systems, food emulsifiers.	[34]
Extrusion Processing	Starch is processed using high temperature, pressure, and mechanical shear in an extruder.	Produces pre-gelatinized starch, improves water absorption and digestibility.	Instant foods, tablet disintegrants, biodegradable packaging materials.	[35]
High-Pressure Processing (HPP)	Starch is subjected to high hydrostatic pressure without high temperatures.	Modifies granule structure, improves gelatinization behavior and functional stability.	Food gels, encapsulation materials, pharmaceutical excipients.	[36]
Pulsed Electric Field (PEF)	Short bursts of high-voltage electric fields alter starch structure.	Changes crystallinity, hydration, and digestibility properties.	Functional foods, encapsulation matrices, modified starch products.	[37]
Radiation / Electron Beam Treatment	Exposure to ionizing radiation modifies polymer chains in starch.	Causes depolymerization and changes physicochemical properties.	Biodegradable materials, industrial starch products.	[38]

4.2 Chemical Modifications

The functional groups are added to starch through chemical modification, which changes the physicochemical behavior of starch [39]. Acetylation of starch involves replacing hydroxyl groups with acetyl groups. This enhances flow ability and compressibility that consequently makes it perfect in direct compression [40]. Carboxy-methyl groups are added by carboxy-methylation. This increases hydrophilicity and maximum swelling capacity, which increases disintegration and release in tablets [41]. Cross-linking bonds the starch chains together with covalent bonds, this enhances the granular structure as given in Table 5. This allows it to resist acidic conditions, shear and high temperatures [42]. Part of the starch is broken down in the oxidation process, with the addition of carboxyl group and carbonyl. This decreases viscosity and enhances solubility and is applicable in film coating and fast release formulation [43].

Table 5: Different Type of Chemical Modifications and their Application

Type of Chemical Modification	Reagents / Agents Commonly Used	Resulting Changes in Starch Properties	Common Applications	Ref.
Oxidation	Sodium hypochlorite, hydrogen peroxide, sodium periodate, ozone, binuclear	Decreases paste viscosity, depolymerizes starch, reduces retrogradation, and increases hydrophilicityand stability.	Used as drug delivery agents, food additives, thickeners, emulsifiers, paper/textile sizing,	[44]

	manganese catalysts.	Modifies hydroxyl groups into carbonyl and carboxyl groups.	and in biodegradable bioplastic packaging.	
Esterification (e.g., Acetylation)	Acetic anhydride, citric acid, succinic anhydride, adipic acid.	Lowers the gelatinization temperature, increases swelling, solubility, and paste clarity. Prevents retrogradation (aging) and improves freeze-thaw stability.	Stabilizers for infant foods, bakery products, sauces, ice cream, and improving tensile strength in edible starch films.	[45]
Etherification	3-chloro-2-hydroxypropyl trimethyl ammonium chloride (CHPTAC), benzyl bromide, propylene oxide.	Enhances hydrophobicity or creates cationic starch (depending on the agent). Disrupts hydrogen bonding to reduce crystallinity, alters gelatinization temperature, and improves paste clarity.	Wastewater treatment (adsorption), thickeners, binders, texture agents for pharmaceuticals, personal care products, and papermaking.	[46]
Cross-linking	Sodium trimetaphosphate (STMP), sodium tripolyphosphate (STPP), phosphorus oxychloride ($POCl_3$), adipic acid.	Forms intermolecular bonds that reinforce the starch granule. Decreases swelling power and increases resistance to heat, acidity (low pH), shear forces, and digestive enzymes (increases resistant starch).	Canned foods, frozen foods, prolonged-release pharmaceutical capsules, and stable food thickeners.	[47]
Dual Modification	Combination of chemical methods (e.g., Cross-linking + Acetylation) or combined with physical annealing.	Yields tailored functional properties that a single method cannot achieve, such as extreme thermal stability combined with high freeze-thaw resistance.	Highly specialized industrial processed foods, extreme-condition manufacturing, and advanced biofilms.	[48]

4.3 Enzymatic and Genetic Modifications.

The processes to be utilized include enzymatic hydrolysis with alpha-amylase or glucoamylase and these are biological methods that are very specific and environmentally friendly because they selectively hydrolyze starch chains as shown in Table 6. This yields reduced-molecular-weight fractions that portray a controlled release of drugs with regulated solubility and viscosity [49]. The genetic alterations in the potato plants alter the pathways in the synthesis of starch. This leads to high-amylose or waxy starches or starches with modified phosphorylation producing unique functional characteristics in the pharmaceutical and food industries [50].

Table 6: Enzymatic and Genetic Modifications effect on starch properties

Modification type	Method / Enzyme or Genetic Approach	Principle / Process	Effect on Starch Properties	Applications	Ref.
Enzymatic modification	**α-Amylase treatment**	Hydrolyzes α-1,4glycosidic bonds in starch chains, reducing	Improves solubility, digestibility, and	Food thickeners, pharmaceutical excipients,	[51]

		molecular weight and viscosity.	modifies viscosity.	biodegradable materials.	
Enzymatic modification	**Pullulanase (debranching enzyme)**	Hydrolyzes α-1,6glycosidic bonds of amylopectin, producing linear chains.	Increases amylose content and resistant starch formation.	Controlled-release drug delivery, dietary fiber products, functional foods.	[52]
Enzymatic modification	**Glucoamylase treatment**	Converts starch polymers into glucose units by hydrolyzing both α-1,4 and α-1,6 bonds.	Enhances digestibility and reduces molecular size.	Fermentation substrates, sweetener production, food processing.	[53]
Enzymatic modification	**Cyclodextring lycosyltransfe rase (CGTase)**	Converts starch into cyclodextrins through enzymatic cyclization reactions.	Produces cyclic oligosaccharides capable of forming inclusion complexes.	Drug encapsulation, controlled drug delivery systems, pharmaceutical formulations.	[54]
Enzymatic modification	**Amylosubtilin and Bacillus amylase**	Enzymatic hydrolysis modifies starch structure and gel properties.	Improves texture and emulsifying capacity.	Fat replacer in dairy products and functional foods.	[55]
Genetic modification	**GBSSI gene silencing (RNAi technology)**	Suppresses granule-bound starch synthase I responsible for amylose synthesis.	Produces amylose-free or waxy potato starch (high amylopectin).	Paper, adhesives, textile industries, biodegradable materials.	[56]
Genetic modification	**CRISPR-Cas9 genome editing**	Knockout of genes such as **GBSSI** to alter starch composition in potato tubers.	Produces starch completely devoid of amylose with improved functional properties.	Industrial starch production, food processing, starch-based biomaterials.	[57]
Genetic modification	**Starch branching enzyme (SBE) gene editing**	Modification of SBE genes controlling amylopectin branching.	Alters amylose/amylop ectin ratio and increases resistant starch.	Functional foods, nutraceuticals, low-glycemic starch products.	[58]
Genetic modification	**Transgenic overexpressio n of starch biosynthesis enzymes**	Enhances expression of enzymes involved in starch biosynthesis pathways.	Improves starch yield, structure, and processing properties.	Industrial starch production and advanced biomaterials.	[59]

5 Pharmaceutical Applications of Modified Potato Starch

The potential of modified potato starch is an adaptable biopolymer capable of significant prospects in the pharmaceutical industry. It has improved physical and chemical properties, which it has acquired as a result of numerous modifications, which make it a useful component in the traditional and novel drug delivery models. Greater flow capability, swelling, mechanical strength, and stability increase its use in different dosage forms.

5.1 As Excipient

In traditional Formulations**,** potato starch is modified to produce a multifunctional excipient:

5.2 Binder: They are acetylation and pre-gelatinization among others that are some of the modifications applied to enhance compaction properties by enhancing the bondage between the particles. This makes the starch a desirable pill-binding material in the formulation of pills to confer strength and integrity [60].

5.3 Disintegrant: Fast intake of water by acid-treated or cross-linked starch results in swelling of the material, apart the tablet and causes it to dissolve [61].

5.4 Fillers/Diluents: Direct compression fillers are a special form of starches especially with enhanced flow and compressibility

5.5 Coating Agent: Oxidized and acetylated starch are good film forming and suitable for coating agent on tablet [61].

5.6 The Higher Order Drug delivery Systems

Besides the classical uses of excipients, modified potato starch is also a significant ingredient of modern delivery technology:

5.6.1 Sustained-release: Starches (cross-linked and high amylose) are cross-linked to form gel matrices that swell and release drugs at a slow rate and hence they can be utilized in sustained-release formulations [62].

5.6.2 Colon target systems: The starch derivatives enzyme-degradable are applied to deliver drugs to the colon, with the aid of the microbial flora to eliminate the carrier and release the active drug [63].

5.6.3 Micro- particles and nanoparticles: Micro- and nano-carriers made with starch can be used in solubility and bioavailability improvement of drugs with poor solubility and targeted delivery solutions [63].

5.6.4 Hydrogels of controlled release: Cross-linked hydrogels of modified starch are highly water retentious and drug releasing properties and thus can be used in targeted and controlled delivery [64].

Table 7: Comparative Evaluations of Starch and Modified Starch as Pharmaceutical Excipients

S. No.	Study / Case	Starch Type / Modification	Drug / Formulation Studied	Key Findings	Ref.
1	Evaluation of potato starch as pharmaceutical excipient	Native potato starch	Paracetamol tablets	Potato starch showed good binding and disintegration properties and improved tablet hardness and dissolution profile compared with some synthetic excipients.	[65]
2	Drug release from starch–starch glycolatemicro particles	Potato starch + sodium starch glycolate	Model drug (crystal violet dye) in microparticles/films	Cross-linking of starch improved swelling and controlled release behavior; release followed quasi-Fickian diffusion kinetics.	[66]
3	Modified starch derivatives as drug carriers	Citric acid modified starch	Lidocaine hydrochloride hydrogel formulation	Modified starch significantly prolonged drug release and enhanced stability of the gel matrix compared to native starch.	[66]

4	Effect of modification on excipient properties	Thermal, pre-gelatinized and carboxymethyl potato starch	Tablet excipient evaluation	Carboxymethyl and pre-gelatinized starch improved disintegration and water-holding capacity, enhancing drug release and compressibility.	[67]
5	Phosphorylated potato starch matrix tablets	Phosphorylated starch	Sustained-release oral tablets	Modified starch functioned as a matrix former capable of producing controlled drug release profiles over extended time.	[67]
6	Citrate starch as carrier polymer	Citric-acid modified starch	Methylene blue model drug	Starch citrate demonstrated good drug adsorption and sustained drug release potential in hydrophilic gel systems.	[68]
7	Acid-modified potato starch evaluation	Acid hydrolyzed starch	Direct compression tablets	Acid-modified starch improved flowability, compressibility, and tablet hardness compared with native starch.	[69]
8	3D-printed starch tablets	Potato starch and waxy maize starch	Ibuprofen tablets	Tablets prepared by 3D printing showed controlled release from 10 minutes to 6 hours depending on starch type and geometry.	[70]

6 Safety, Regulatory, and Quality Aspects

Modified potato starch, as a pharmaceutical excipient, must meet strict safety, regulatory, and quality standards to ensure patient safety and therapeutic effectiveness. Its use is backed by extensive toxicology data, pharmacopeial standards, and established quality control practices that define its suitability in pharmaceutical products as in Table 8.

Table 8: Safety, Regulatory, Quality Aspects, Challenges and Future Perspectives of Modified Potato Starch

Section	Sub-Section / Topic	Descriptions	Ref.
Safety, Regulatory, and Quality Aspects	Overview	Modified potato starch used as a pharmaceutical excipient must meet strict safety, regulatory, and quality standards to ensure safe and effective use.	
GRAS Status and Pharmacopeial Standards	GRAS Classification	Native starch and its modified forms are GRAS-approved by the FDA, allowing use without premarket approval.	[70]
	USP/NF Standards	USP/NF sets standards for starch types, including tests for identity, moisture, microbes, and viscosity.	[71]
	European Pharmacopoeia	Ph. Eu. sets standards for starch excipients, covering purity, properties, and functionality.	[72]
	Indian Pharmacopoeia	The IP recognizes starch as a pharmaceutical disintegrant and filler, defining acceptable limits for heavy metals, microbial load, and chemical purity.	[73]

Section	Sub-Section / Topic	Descriptions	Ref.
Safety and Toxicity Assessments	Biocompatibility	Natural polysaccharide that is generally biocompatible, non-toxic, and non-immunogenic. Modified derivatives have undergone toxicological assessments	[74]
	Toxicological Evidence	consumption of modified starch is well tolerated, with no significant adverse effects	[74]
	Evaluation of New Derivatives	starch derivatives still require individual toxicological evaluation to ensure safety	[75]
Quality Control Parameters	Purity Testing	Quality control includes evaluation of residual reagents, ash content, heavy metals, and moisture content to confirm chemical purity and integrity.	[75]
	Viscosity and Flow Properties	Measurement of viscosity and flow behavior ensures appropriate functionality	[76]
	Microbial Load	Testing includes total aerobic microbial count and absence of pathogens	[76]
	Functional Performance	Functional characteristics such as swelling index, gelatinization temperature, and disintegration efficiency are evaluated to confirm excipient performance.	[76]
Challenges and Future Perspectives	Overview	Although modified potato starch has great potential as a pharmaceutical excipient and drug delivery material, several scientific, regulatory, and technological challenges remain to be addressed.	[77]
Regulatory Gaps for Modified Starch Types	Lack of Regulatory Framework	While common derivatives such as pregelatinized starch and sodium starch glycolate are pharmacopeially recognized and GRAS classified, many advanced modifications (cross-linked, grafted, or enzymatically modified starches) lack standardized regulatory guidelines.	[77]
	Need for Harmonization	The absence of unified regulatory frameworks can delay approval and application in pharmaceutical products. Updated pharmacopeial monographs and international harmonization are required.	[77]
Scaling up Green Extraction Methods	Sustainable Techniques	Green extraction approaches such as enzymatic processing, ultrasonic extraction, and supercritical fluid extraction provide environmentally friendly alternatives to conventional wet extraction.	[78]
	Industrial Challenges	Large-scale implementation remains difficult due to high equipment costs, process optimization challenges, and variations in raw material quality affecting yield and functionality.	[79]

Section	Sub-Section / Topic	Descriptions	Ref.
Engineering Multi-functional Starches for Precision Delivery	Smart Excipients	Modern pharmaceutical research focuses on responsive excipients capable of reacting to environmental conditions such as pH or enzymatic activity.	[79]
	Advanced Starch Derivatives	Multi-functional starch derivatives such as graft copolymers and enzyme-degradable cross-linked starches could enable targeted and controlled drug delivery systems.	[79]

CONCLUSION

In this review, we will provide the different methods applied in extracting and processing potato starch to be used in pharmaceutical applications. Mechanical and sedimentation-based processes are still very popular, as they are simple. But nowadays, more environmentally-friendly approaches like enzymatic, ultrasonic-assisted, and supercritical fluid methods are more yielding, purer, and less harmful to the environment. Equally, the methods of modification include physical processes such as heat-moisture, annealing and chemical processes such as acetylation, cross-linking, and carboxymethylation and enzymatic and genetic processes. These techniques enable us to customize potato starch to fit a particular purpose, such as controlling potential compressibility, release, and delivery.

Modified starch has a great deal of potential in pharmaceutical sciences as it is a flexible ingredient and carrier. Its ability to be biocompatible with the biological systems, degradability, film forming capabilities and variable physical and chemical properties are reasons why it can be used as binder, disintegrant, filler, coating material and even in highly complex delivery methods such as hydrogels, nanoparticles and 3D-printed dosage. Its multi-functionality is appropriate due to the current trends in personalized and precision medicine.

FUTURE PROSPECTIVE

Nevertheless, there are still certain gaps in the research and difficulties. New modified starches do not have a regulatory consensus and cannot be readily approved and accepted in the market. Also, how to make extraction processes sustainable and increase extraction without compromising the quality and calibrating the process is an active research topic. The direction of future research should be on producing multi-functional responsive starch derivatives towards designing smart drug delivery. They also ought to strive to make the best out of incorporation of these derivatives into new technologies such as nanomedicine and three-dimensional printing, and, at the same time, perform rigorous safety and compatibility analyses. Interaction of researchers, industry players and regulatory bodies will be a major factor towards the realisation of the full pharmaceutical potency of potato starch.

Competing interests

The authors declare that they have no competing interests.

Availability of data and material

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics approval and consent to participate

Not applicable.

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Author contribution

The authors confirm contribution to the paper as follows: study conception and design: Nita Yadav; data collection: Deepak Babu; Draft Manuscript: Gaurav Kumar Chaurasia; Manuscript Review & comment: Ritesh Kumar Tiwari. All authors reviewed the results and approved the final version of the manuscript.

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