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A RESEARCH PAPER ON DETERMINATION AND EVALUATION OF STARCH FROM SOLANUM TUBEROSUM L

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ABSTRACT
The development and evaluation of starch extracted from potatoes (Solanum tuberosum) have gained significant attention due to starch's versatile applications in food, pharmaceutical, and industrial sectors. The present study focuses on the development and comprehensive evaluation of starch extracted from potato (Solanum tuberosum L.), a widely available and economically significant tuber crop. The extraction process employed physical separation techniques involving washing, peeling, grating, and sedimentation to isolate native starch. The yield of starch was quantitatively analyzed, and its physicochemical and functional properties were evaluated to determine its suitability for various industrial applications. Characterization included moisture content, ash content, pH, gelatinization temperature, water and oil absorption capacities, and swelling power. The starch granules were further analyzed using scanning electron microscopy (SEM) for morphological assessment, while Fourier-transform infrared spectroscopy (FTIR) was used to identify functional groups and chemical integrity. Comparative analysis with commercially available starches was conducted to benchmark quality parameters. Results indicated that potato starch exhibits high purity, significant swelling capacity, and a low gelatinization temperature, making it suitable for food, pharmaceutical, and biodegradable plastic applications. The study also highlighted the environmental and economic benefits of utilizing potato waste or low-grade potatoes for starch production, aligning with sustainable resource utilization and circular economy principles. This work contributes to the growing interest in natural starch sources and supports the development of value-added products from agricultural by-products.

KEYWORDS : *Potato Starch, Physicochemical Properties, Functional Properties, Starch Extraction, Industrial Application*

INTRODUCTION

Starch is one of the most abundant natural polymers on Earth and serves as a major carbohydrate reserve in plants. Starch is a complex carbohydrate and starch granules usually contain two major carbohydrates amylopectin and amylose. It has wide applications in the food, pharmaceutical, textile, paper, and biodegradable plastics industries due to its functional and physicochemical versatility. Among the various botanical sources of starch, potatoes (Solanum tuberosum L.) are particularly significant owing to their high starch content, ease of cultivation, and global availability. Starch is widely used in pharmaceuticals due to its non-toxic, non-irritant nature, low cost, and versatility as a pharmaceutical excipient. It plays multiple roles in pharmaceutical production, serving as a binder, disintegrant, diluent, glidant, absorbent, and lubricant.

Potato starch is a non-cereal starch known for its large granule size, high amylopectin content, low protein and lipid levels, and unique functional properties such as high swelling power and paste clarity. These attributes make it a promising material for applications where viscosity, texture, or biodegradability are critical. In recent years, there has been increasing interest in the extraction and valorization of starch from alternative and underutilized agricultural sources as a means to support sustainable development and reduce dependency on conventional sources like maize and wheat.

The extraction and processing of starch from potato tubers involve mechanical separation, sedimentation, and drying, processes that can significantly influence starch yield and quality. Moreover, physicochemical parameters such as pH, moisture content, and thermal properties, along with functional properties like water absorption capacity and gelatinization behavior, are crucial in determining the applicability of starch in different industries.

In this context, the present study aims to extract starch from fresh potatoes using a laboratory-scale method and conduct a thorough evaluation of its physicochemical and functional properties. The goal is to assess its potential as a sustainable and efficient source of industrial starch, thereby promoting the value addition of agricultural produce and minimizing post-harvest waste.

Potato starch, extracted from potatoes, is a carbohydrate composed mainly of large granules. These granules contain amylose and amylopectin, two types of glucose molecules. Amylose forms linear chains while amylopectin creates branched structures, making potato starch highly absorbent. Its high viscosity and binding properties make it a popular thickening agent. Starch starts as a part of the potato's structure and is isolated through simple processes like grating and water extraction.

In industry, potato starch has numerous applications. It's used in the textile industry for yarn sizing, improving durability during weaving. In the paper industry, it enhances paper strength and printability. Additionally, it's found in adhesives and as a biodegradable plastic component. Potato starch's chemical properties make it suitable for varied applications, from food production to manufacturing.

Why potato starch extraction?
Pretreatment extraction is not required for potato starch extraction: Potato starch typically contains fewer impurities than other starches like corn or wheat. It has low levels of protein and fat, making it easier to obtain a pure starch product. Steeping softens hard plant materials, especially grains, and facilitates wet grinding. Steeping is preferred for hard starch sources, and softer plant sources, like potatoes, don't require any treatment before extraction. It is essential to know that the dry milling hard plant materials grains (i.e., barley, oat, rice, corn, legumes) can result in substantial starch granule damage. A high percentage of damaged starch granules may alter the physicochemical properties of starch. Steeping or dry grinding are unnecessary steps in potato starch isolation. Thus, it can be Peeled, sliced into small pieces, and directly slurried in water

STRUCTURE OF POTATO STARCH

3.1 Molecular Structure

Monomers of amylose and amylopectin in potato tubers are mainly glucose, connecting by glycosidic bonds, including α-(1→4) linkage and α-(1→6) linkage. Amylose mainly exists in α-(1→4) glycoside bonds, while a large number of α-(1→6) glycoside bonds exist in amylopectin. Amylose is spatially arranged into single-helix structures, which is the basis of starch molecular structure, while amylopectin has an extra chain extending from the starch monomer at position 6 at the branch end, forming a double helix structure with the straight chain extending at position 4. The number of units forming amylose and amylopectin would greatly affect chain length of starch fine structure. Chain-length distribution (CLD) usually presents the branched structure of amylopectin via size-exclusion chromatography and fluorescence-assisted capillary electrophoresis. Chains with degree of polymerization (DP) < 100 are considered as amylopectin chains, and other chains (DP ≥ 100) are mainly described as amylose chain. Potato starch branched chains could be generally divided as A (DP 6–12), B, and C chain. The A chain could be subdivided into fingerprint A chain (DP 6–8) and cluster A chain (combine other chain to form cluster), while B chain could be divided into B1 (DP 13–24), B2 (DP 25–36), B3 (DP 37–100) chains according to clusters. The B1 chain could be further divided into fingerprint B chain and major short B chain (DP 3–7) . Glucans (DP 10–24) in potato starch decrease with increased starch granule diameter, which is correlated with an increase in the relative abundance of longer chains (DP 45–100). Environmental conditions also could lead to great changes in potato starch molecular structure . For example, A1 chain is the most distributed chain in potato starch during early growth stage and amount of B1 chain subsequently increases with potato growing time. The average A1 chain length of seven Chinese potatoes significantly differs between two locations (16.7% in Yiwu vs. 15.7% in Jinhua

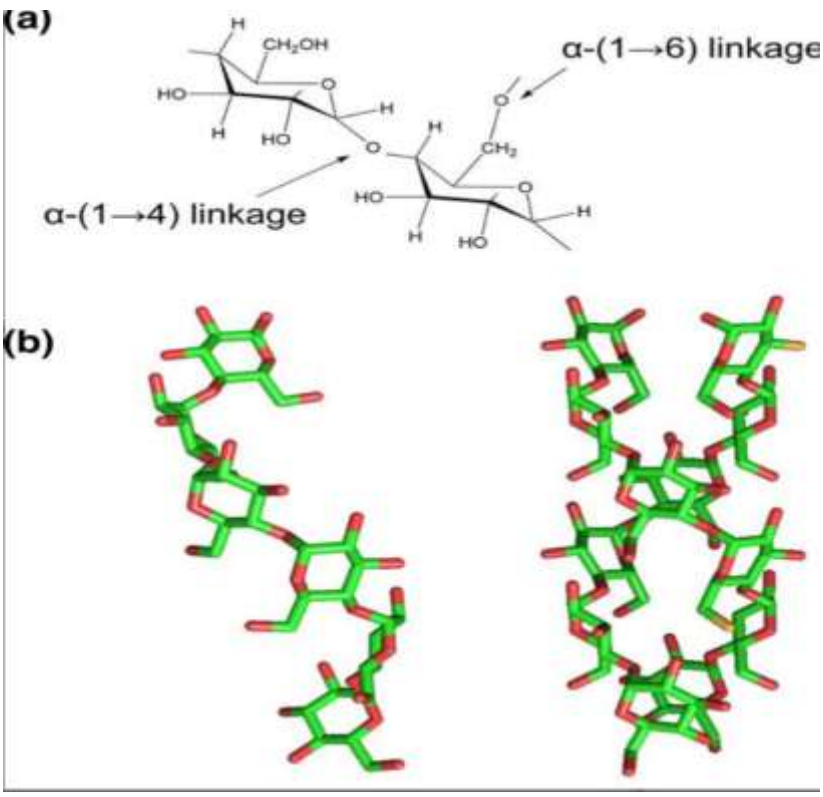

Fig 1: Molecular Structure of potato starch

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MATERIALS AND METHODOLOGY

Materials

A fresh raw potato from an local market, distilled water, peeler, grater or blender, Muslin cloth/cheesecloth, strainer or sieve, spatula, drying rack or tray, the procedure divided into three methods for extraction of starch using physical, enzymatic and alkaline method.

Methods

The process for extraction of starch are as follow

1. **Washing and Peeling**: Wash the potatoes thoroughly to remove dirt and impurities. Peel them to ensure clean starch extraction.
2. **Grating or Blending**: Grate the peeled potatoes using a coarse grater or blend them with water to create a slurry.
3. **Extracting Starch**: Strain the potato slurry through a muslin cloth or cheesecloth into a large bowl. This separates the starch from pulp.
4. **Settling**: allow the liquid to sit for an hour or more. The starch will settle at the bottom of the bowl.
5. **Decanting**: carefully pour off the supernatant liquid, leaving the starch at the bottom.
6. **Washing** : wash the starch with water repeatedly to remove impurities.
7. **Drying**: drain the water thoroughly and air dry the starch.

Fig 2: Potato Starch

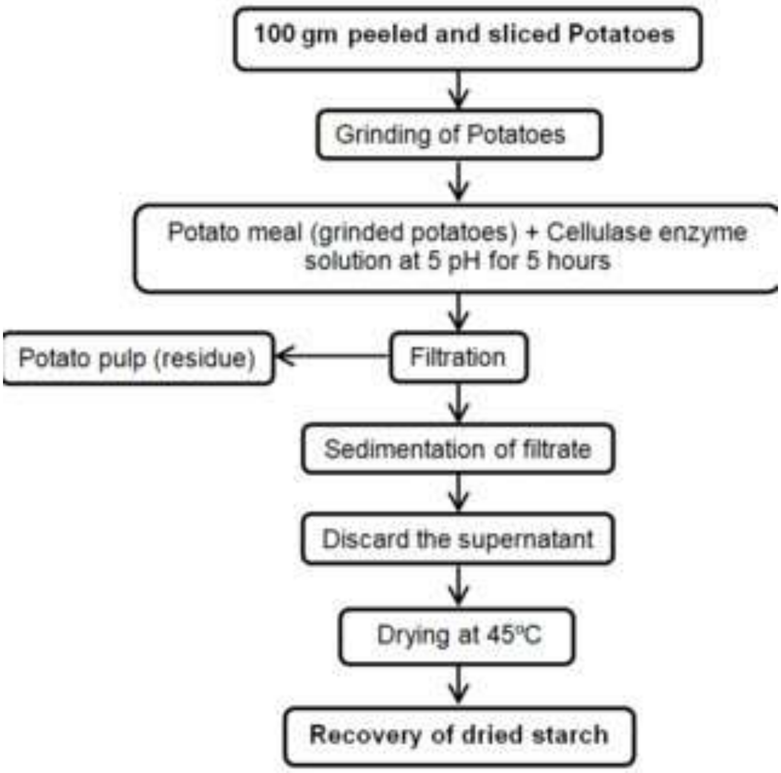

Fig 3: The process flow sheet for potato starch extraction by physical method

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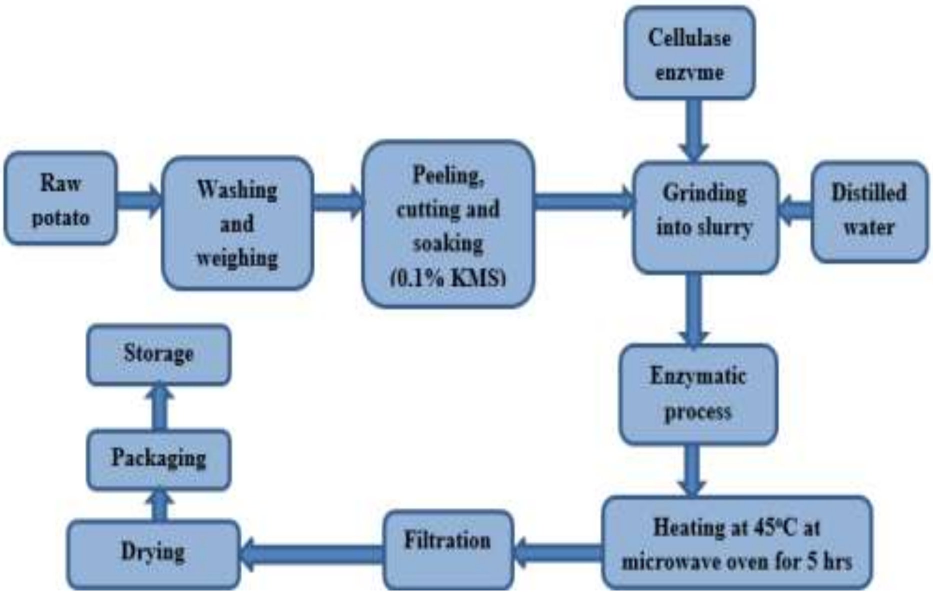

Fig 4: Flow sheet for extraction of starch by enzymatic process

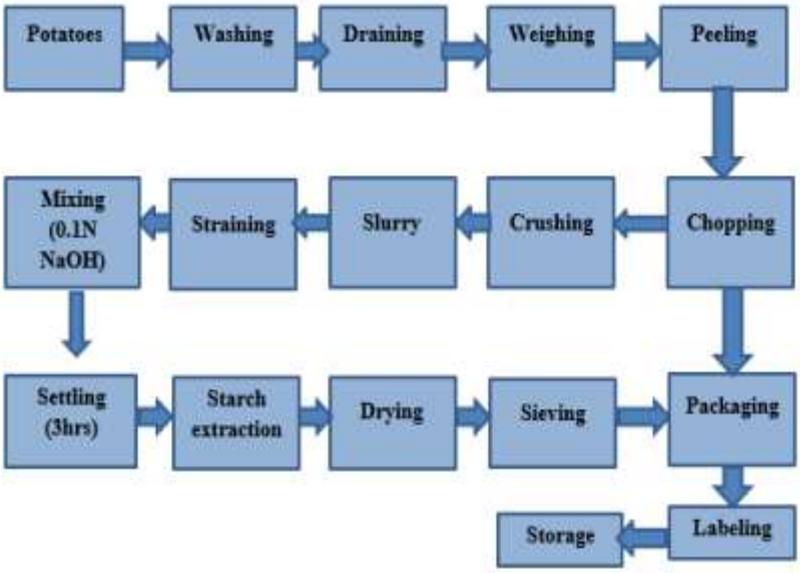

Fig 5: Flow sheet for extraction of starch by alkaline process

BIODIVERSITY OF POTATO STARCH

Potato starch is known as a mixture of two polysaccharides: amylose and amylopectin, wherein the molecular weight of amylopectin (6.1×10^7) is far greater than that of amylose (1.0×10^6). In addition to amylose and amylopectin that account for 84.3–99.0% of starch protein, lipid, and ash are the other minor components in potato starch

Starch Content

Potatoes contain a significant amount of starch, which can vary depending on factors like Variety, Growing condition, Maturity etc. the starch content in potato is found to be 10-20% Starch can be calculated using the formula Starch content(%)=(weight of starch/weight of sample) × 100

Iodine Test

The iodine test is a chemical test used to detect the presence of starch in a sample. When iodine solution (Lugol's iodine) is added to potato starch, it reacts with the amylose component, forming a blue-black complex. This colour change confirms the presence of starch. So the test is positive which show the blue and black colour appear, indicating starch presence.

EVALUATION TEST

Organoleptic Test

Organoleptic tests evaluate the sensory properties of potato starch, including their appearance, texture, taste and odour which can help evaluate the quality and suitability of potato starch for various applications, such as food products, cosmetics and pharmaceuticals. By conducting organoleptic tests, manufacturers can ensure that their potato starch meets the required standards for quality, texture, and sensory properties.

1. Appearance: White or off-white powder, smooth and even texture.
2. Texture: Smooth, fine powder, or slightly gritty.
3. Taste: Neutral, starchy, or slightly sweet.
4. Odor: Neutral or slightly starchy

Physicochemical Tests

Moisture Content Test

Moisture content Indicates the amount of water present in the starch, affecting its storage stability, texture, and functionality. it Helps determine suitable storage conditions and ensures consistency in product quality.

Calculate moisture content using the formula:

Moisture content (%) = [(Initial weight - Final weight) / Initial weight] × 100

pH Test

It presents Acidity or alkalinity in the compound and Reveals the pH level of the starch, influencing its functionality, stability, and compatibility with other ingredients. It Helps predict potential interactions with other ingredients and ensures suitability for specific applications.

Ash Content Test

It shows the property of Inorganic residue And Indicates the amount of inorganic impurities or additives present in the starch. It Helps evaluate the purity and quality of the starch, ensuring compliance with regulatory standards.

Calculate ash content using the formula: Ash content (%) = (Weight of ash / Weight of

sample) ×10

Gelatinization Temperature Test

Reveals the temperature at which starch granules gelatinize, affecting their functionality and texture. And Helps predict cooking behavior, texture, and stability in various applications.

Viscosity Test

Measures the thickness or flowability of starch paste, influencing its functionality and texture. Helps predict performance in various applications, such as thickening, stabilizing, or texturizing.

Amylose and Amylopectin Content

Determines the ratio of amylose to amylopectin, which affect the gelatinization, retro gradation, and textural properties of starch. Iodine binding assays are commonly used, where the amylose-iodine complex is measured spectrophotometrically. In this the amylase contain the 20-25% of the total starch content

Swelling power and solubility

Swelling power and solubility are another crucial properties of potato starch for industrial production, which are always used to perceive the intercourse between water molecules and chains of starch in the semi-crystalline regions of granules during heating .When potato starch is heated in excess water, the crystal structure disrupted and water molecules are linked to exposed hydroxyl groups of amylose and amylopecin through hydrogen bonds, resulting in particle swelling and solubility

Gel consistency

refers to the firmness and texture of a starch gel, which is influenced by factors like gelatinization, amylose content, and water absorption. For potato starch, gel consistency is typically evaluated based on its viscosity, rigidity, and retrogradation properties. The factors affect gel consistency conclude amylose content, gelatinization, water absorption and rheological properties. The result of potato starch showing gel consistency show after cooling the paste can be firm and consistent .

Test	Method	Result
Moisture content(%)	Oven drying method (105°C for 24 hours)	11.2%
Ash content (%)	Muffle furnace at 550°C	0.35%
pH	1% starch solution, measured with pH meter	6.2
Swelling Power (g/g)	85°C for 30 min in water, centrifuged and weighed	12.5 g/g
Solubility (%)	Supernatant from swelling power test dried and weighed	6.8%
Gelatinization Temperature (°C)	Differential Scanning Calorimetry (DSC)	65.4°C
Water Absorption Capacity (%)	Starch mixed with water, centrifuged, and water retained measured	152%
Viscosity	Using Rapid Visco Analyzer (RVA)	3450 cP

Table 1: Evaluation of physicochemical test

Fourier Transform Infrared Spectroscopy (FTIR)
is a technique used to analyze the molecular composition of substances, including potato starch. It works by measuring how infrared light interacts with the sample, identifying functional groups based on their absorption patterns.. The result of FTIR analysis of the sample showed that FTIR spectrum of the sample was obtained at the wavelength in the range of (400-4000nm). The results of the study also showed that FTIR spectra of potato starch typically show peaks corresponding to O-H stretching (around 3300 cm⁻¹), C-H stretching (around 2900 cm⁻¹), and C-O-C bonds (around 1000-1200 cm⁻¹). FTIR spectrum showing characteristic peaks (C–O, O–H, C–H bonds) Peaks at 3400, 1645, 1020 cm⁻¹

Scanning Electron Microscopy (SEM)
is a powerful technique used to analyze the surface morphology and microstructure of potato starch granules. It provides high-resolution images that reveal details about the shape, size, and texture of starch particles. The result of scanning electron microscopy of potato starch granules are typically oval or spherical granules with smooth surface.

Comparative Analysis of starches

Starch Source	Starch content	Amylose Content (%)	Gelatinization Temperature (°C)	Viscosity	Applications
Potato	10-20%	20-30	60-70	High	Food, paper, textiles, biodegradable plastics, pharmaceuticals
Corn	70-80%	25-30	62-72	Medium	Food, beverages, pharmaceuticals, biodegradable plastics
Tapioca (cassava)	70-90%	15-25	60-70	Medium	Food, animal feed, adhesives, textiles
Wheat	60-70%	20-30	52-63	Low-Medium	Food, baking, animal feed, biofuels
Rice	70-80%	15-20	65-75	Low	
Waxy Corn		<5	63-72	High	Food, paper, textiles, adhesives

Table 2: physicochemical test and application of different starches

Advantage
Potato starch has several advantages in pharmaceutical applications, primarily as an excipient in drug formulations. Here are some key benefits**:**

1. Binder in Tablet Formulation: Potato starch is widely used as a binder in tablet manufacturing, helping to hold ingredients together. It improves tablet hardness and disintegration properties, ensuring proper drug release.
2. Disintegrant for Fast Drug Release**:** Acts as a disintegrant, allowing tablets to break down quickly in the digestive system. Enhances bioavailability by ensuring rapid dissolution of active pharmaceutical ingredients.
3. Filler in Capsules and Powders: Used as a filler in capsules and powdered formulations to provide bulk and improve flow properties. Helps maintain uniformity in drug dosage.
4. Stabilizer in Liquid Formulations**:** Potato starch stabilizes suspensions and emulsions, preventing separation of ingredients. Improves viscosity in liquid medications.
5. Natural and Biodegradable Alternative: Being a plant-based excipient, potato starch is biodegradable and non-toxic. Preferred over synthetic excipients due to its biocompatibility and safety profile.
6. Modified Starch for Controlled Drug Release: Pregelatinized and cross-linked potato starch is used for sustained-release formulations. Helps in controlled drug delivery, reducing dosing frequency.

Disadvantage

1. Low Nutritional Value: Potato starch is primarily composed of carbohydrates and lacks essential nutrients like proteins, vitamins, and minerals.
2. Digestive Issues: Some individuals may experience bloating or gas due to the resistant starch content. Excessive consumption can lead to mild gastrointestinal discomfort.
3. Poor stability in High Temperatures: Potato starch breaks down under extreme heat, limiting its use in certain pharmaceutical formulations. It may lose its thickening properties when exposed to prolonged heating.
4. Limited Functionality in Drug Delivery: Compared to modified starches, native potato starch has less control over drug release. It may not be suitable for sustained-release formulations without chemical modifications.
5. Potential for Allergic Reactions: Although rare, some individuals may have sensitivities to potato starch, leading to mild allergic reactions.
6. Susceptibility to Microbial Growth: Potato starch is prone to microbial contamination if not stored properly. It requires adequate preservation to prevent spoilage.

APPLICATION OF POTATO STARCH

Currently, attentions on potato starch used for food and pharmaceutical purposes have rapidly increased due to its low cost, availability, biodegradability, and environmental friendliness (Figure). In general, food consumption, industrial utilization, seed potato, and animal feed account for about 68, 14, 8, and 4% of annual potato yields. In particular, potato starch is mainly used as additive and raw degradable material in food utilization, while tablet disintegrating agent, drug carrier, and medic material for medicine use.

Fig 6: A image on Application of potato starch in different fields

Medic Fields

Potato starch also is applied on pharmaceutical and biomedical fields owing to its biocompatibility, total degradability without toxic residues, low cost, wide availability, renewability, and thermoplastic behavior. For example, potato starch is used as antihemorrhagic material to block the bleeding point with less harm as traditional antihemorrhagic, based on its excellent absorb water and expand capacities. The potato starch-based adhesion prevention barrier agent could prevent the formation of adhesions and provide antihemorrhagic ability . The superabsorbent properties of acryloylated potato starch ester grafted with acrylic acid show remarkable water absorption capacity (127 g/g) and potentiality to be antihemorrhagic agents. Potato starch is also introduced as drug carrier in cancer and nasal administration of insulin due to its biocompatibility to human body, which could address the issues like low target specificity and potency of conventional drug delivery system For example, potato starch loaded with thymol after film formation could endow the film with considerable antibacterial properties . Moreover, potato starch could be used as tablet disintegrates, pharmaceutical diluents, and binder glue for tablets. Tablets mixed with potato starch and potato dextrin (1:1) could completely release diprophylline within 2 h, which is significantly better than that of pure potato starch tablets (released less than 75% after 8H) .The tablet disintegrated made with 2.5–10% potato starch showed higher ability of crushing strength and drug release efficiency than that of tablet disintegrate made with corn starch. In addition, potato starch could also be compounded with other materials to make high-value medical consumables.

Biodegradable plastics: Use modified starch to develop biodegradable plastics.

Food packaging and film

Compared with synthetic plastic packaging, potato starch-based packaging has advantages of environmentally friendly degradability and less harmful to human body. To improve the functionality of potato starch-based packaging materials, additives like glycerol, cellulose, and gelatin are also usually added to enhance fluidity, hydrophobicity, and mechanical strength .The development of 3D printing technology allowed potato starch to create new structures with enough strength. 3D printing food materials based on potato starch show great printing qualities like structural and physicochemical properties. A nanocomposite film with UV resistant and higher transparency based on potato starch is developed as sustainable package . potato starch can also be made into fiber or cellulose for food packaging . Compared with free carvacrol, the encapsulation of carvacrol with nanofibers made from potato starch significantly increase the thermal stability, delay the peak thermal decomposition rate from 150 to 300°C but kept 83.1% of antioxidant ability with 40% carvacrol loaded. Meanwhile, various edible potato starch-films are always made under certain conditions for food storage, such as antibacterial film .

Future Trends

The future of potato starch is shaping up with exciting trends across various industries. Here are some key developments:

1. Sustainability & Eco-Friendly Innovations: The demand for biodegradable and plant-based materials is driving research into starch-based bioplastics. Potato starch is being explored as a renewable alternative to synthetic polymers in packaging and industrial applications.
2. Advanced Extraction Techniques: Innovations in enzymatic and microwave-assisted extraction are improving starch yield and purity.The industry is shifting towards green solvent extraction to reduce environmental impact.
3. Growth in Food & Pharmaceutical Applications: Potato starch is gaining popularity in clean-label food products, replacing artificial thickeners. In pharmaceuticals, modified starches are being developed for controlled drug release and better excipient functionality.

4. Market Expansion & Economic Growth: The global potato starch market is expected to grow at a CAGR of 3.5% until 2034, driven by increasing demand in food, pharma, and industrial sectors. The industry is focusing on price parity to make plant-based alternatives more accessible.
5. Challenges & Future Opportunities: Supply chain disruptions and climate-related yield losses are concerns for potato starch production. Research is ongoing to enhance starch stability, texture, and nutritional benefits for broader applications

CONCLUSION

potato starch stand out as a natural, sustainable, and multifunctional ingredient, proving its significance in various fields. Its biodegradability, health benefits, and pharmaceutical applications make it a promising material for future innovations. However, modifications and stabilization techniques are necessary to enhance its thermal resistance and broaden its use in advanced formulations.

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