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ISOLATION AND ANALYSIS OF MAIZE AND POTATO STARCHES: A STUDY ON THEIR PHARMACEUTICAL AND INDUSTRIAL USES

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ABSTRACT

This study compares newly developed starches from two prominent sources: maize (Zea mays) and potato (Solanum tuberosum), evaluating their suitability as pharmaceutical excipients based on their distinct starch compositions and functionalities. The research meticulously examined organoleptic and physicochemical characteristics, including viscosity, swelling capacity, moisture sorption capacity, pH, and various flow properties such as angle of repose, Carr's index, and Hausner's ratio. Both starches met the required identification and solubility criteria. Maize starch demonstrated lower Carr's index, Hausner's ratio, and moisture sorption capacity in comparison to potato starch, indicating superior flow properties and stability under different humidity levels. Conversely, potato starch exhibited higher hydration and swelling capacities, suggesting its potential as a more effective tablet disintegrant than maize starch. These results highlight maize starch's advantageous flow properties, positioning it well for pharmaceutical formulations that demand efficient powder handling and processing.

KEYWORDS: Maize starch, Potato starch, extraction, characterization

INTRODUCTION

Starch, a polysaccharide made up of amylose and amylopectin, is one of the most common organic substances on Earth. Due to its special qualities, it is a necessary component of many sectors, including those that deal with food, clothing, cosmetics, plastics, adhesives, paper, and especially medicines [1]. Starch is highly regarded in the pharmaceutical industry for its multifunctional role as an excipient, which includes filling, binding, disintegration, gliding, and lubricating [2]. These qualities are crucial for the formulation and production of various dosage forms, particularly tablets.

Maize (*Zea mays*), also known as corn, is a staple crop with great importance in global agriculture. Maize, which originated in Central America, has become a popular cereal grain farmed in a variety of climates around the world. Its adaptability and diversity have made it a valuable source of food, feed, and industrial raw materials. One of the most important products obtained from maize is starch, a polysaccharide used in a variety of industrial applications [3].

As an excipient, maize starch is widely employed in the pharmaceutical industry. It can be used in tablet formulations as a lubricant, glidant, disintegrant, binder, and filler. Because maize starch is always of high quality and readily available, it is a favoured option for these applications [4]. Its physicochemical characteristics, including flowability, swelling capacity, viscosity, and moisture sorption, are important determinants of its performance and acceptability in medication compositions.

Potato (*Solanum tuberosum*) is one of the world's most frequently farmed tuber crops, noted for its nutritional value and culinary versatility. Potatoes are a common food in many places of the world, despite coming from the Andean region of South America. In addition to being vital for nourishment, the potato plant is a major industrial source of starch, a polymer of carbohydrates made up of amylose and amylopectin. Potato starch is an important substance for food processing, textiles, paper, adhesives, and pharmaceuticals due to its special qualities.

The high amylopectin content and big granule size of potato starch set it apart from other starches [5]. These attributes bestow distinct physicochemical attributes. Since potato starch is utilized as an excipient in a variety of dosage forms in the pharmaceutical business, these qualities are especially beneficial.

The current study aims to evaluate the potential of starch extracted and characterized from potatoes and maize as medicinal excipients [6]. This study compares their organoleptic and physicochemical properties, including viscosity, swelling capacity, moisture sorption capacity, pH, flow rate, Carr's index, and Hausner's ratio. Furthermore, the identification and solubility tests are performed to ensure their appropriateness for therapeutic application.

MATERIALS AND METHODOLOGY

Extraction of Starch from Maize and Potato

Starch extraction from potatoes (*Solanum tuberosum*) and maize (*Zea mays*) requires a series of meticulous processes to obtain high-quality starch granules. The first step in the process for potatoes is to choose mature, healthy tubers, which are then cleaned to get rid of dirt and debris. After being thoroughly washed, the potatoes are diced, peeled, or grated. They are then combined with cold water and blended to create a slurry [7,8]. This mixture is run through cheesecloth or a fine mesh filter in order to extract the liquid starch extract from the fibrous particles. After allowing the liquid to settle and collecting it, the starch sediment is removed by decanting the supernatant. The sediment is spread out on drying trays and dried at low temperatures after being repeatedly cleaned with clean, cold water to get rid of contaminants. The starch is ground into a fine powder after drying and kept in airtight containers.

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The extraction procedure for maize begins with the selection of mature, healthy kernels that have been well cleaned. After soaking in water for a full day to soften the kernels, they are drained and blended or wet milled into a thin slurry. To separate the fibrous debris and starch from this slurry, a fine mesh sieve or muslin cloth is used. After gathering and letting the liquid starch extract settle, the supernatant is carefully decanted to remove the starch sediment. To ensure cleanliness, this sediment is repeatedly cleaned with distilled water [9]. After being cleaned, the starch is spread out on drying trays and heated at 50°C until it reaches an equilibrium weight. In order to keep the dried starch stable and suitable for a range of uses, it is ground into a fine powder and kept in sealed containers to avoid contamination and moisture absorption.

Characterization of Starch [10-12]

Solubility Test:

One gram (1g) of each starch (Maize and Potato) was weighed and added to beakers containing 1ml, 2ml, 10ml, 1L, and 10L of distilled water at 25°C. The mixture was stirred, and solubility was observed. The same process was repeated using 65% alcohol as the solvent.

Iodine Test:

Following the BP (2010) starch identification protocol, 1g of each starch (Maize and Potato) was boiled with 15ml of water and then allowed to cool. A few drops of 0.1N iodine solution were added to 1ml of the resulting mucilage, and any colour changes were recorded.

Determination of pH:

One gram (1g) of each starch (Maize and Potato) was mixed with 100ml of distilled water to form mucilage. The pH of the mucilage was measured using an electronic pH meter.

Moisture Content Determination:

One gram (1g) of the starch powder was weighed and then dried in an oven at 105°C for about 1 hour. The powder was re-weighed until a constant weight was achieved. The percentage of moisture content was calculated using the formula:

Moisture content = $(W_i/W_f) \times 100$

where, Wi - initial weight of the powder before drying
Wf - final weight of the powder after drying

Measurement of Starch Flow Properties [13-15]

Angle of Repose: The flow properties of starch particles were evaluated by measuring the angle of repose using the fixed height method. A funnel was positioned with its tip fixed at a

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specified height (h) above a horizontal surface covered with graph paper. Starch powders were poured through the funnel until they formed a conical pile, with the apex just touching the funnel's tip. The angle of repose (θ) was then calculated using the formula:

$\tan(\theta) = h / r$

where, h - height of the funnel tip above the horizontal surface
r - radius from the centre of the base of the cone to the point where it touches the horizontal surface.

The mean angle of repose was determined based on three independent measurements to ensure the reliability and consistency of the findings.

Measurement of Starch Density [16-19]

Bulk and Tapped Densities:

Bulk and tapped densities of the starch were determined using 50g (Wp) of the starch powder. The powder was carefully taken into a 100 ml graduated cylinder, and the volume occupied (Vp) was recorded. The powders were then tapped on a wooden surface from a height of 7 inches until no further volume change occurred, noted as tapped volume (VpT). Bulk density (Bd) and tapped density (Td) were calculated using the formulas:

Bulk Density = Wp / Vp

Tapped Density = Wp / VpT

Carr's Index and Hausner Ratio:

Carr's index, a measure of powder flowability, was calculated as the percentage difference between tapped density and bulk density divided by tapped density. Hausner ratio, indicating starch flow properties, was determined as the ratio of tapped density to bulk density.

Determination of Starch True Density:

Starch true density was assessed using the specific gravity bottle method with xylene as the medium. The specific gravity bottle was initially filled with xylene, its weight recorded as (a). After cleaning, 2g of starch powder was added (w), and the bottle refilled with xylene, stirred, and left to settle. Final weight (b) was recorded to calculate starch true density (l) using:

$L = [w / \{(a + w) - b\}] \times S$

Where, S = 0.86 that is specific gravity of xylene

Swelling Capacity:

Swelling capacity was determined by measuring the volume occupied by 5g of starch powder (Vx), dispersed in 85 ml distilled water for 24 hours. Volume of sediment (Vv) was noted, and swelling capacity (S) calculated as:

$S = (Vv-Vx/Vx) \times 100$

Moisture Sorption Capacity:

Moisture sorption capacity was evaluated by weighing 2g of starch powder (W) in a tarred petri dish, exposed to distilled water in a desiccator for five days. Weight gain (Wg) indicated absorbed water (Wa) calculated as

$Wa = Wg - W$

Hydration Capacity:

Hydration capacity involved placing 1g starch in a 15ml centrifuge tube with 10ml distilled water, shaking, standing, then centrifuging. Weight of wet starch (WS) was recorded, and hydration capacity determined as

Hydration capacity=WS / WD

Where, WS – weight of the sediment formed
WD - weight of the dry sample.

Porosity and Packing Fraction:

Powder porosity (E) used bulk density (Bd) and true density (Dt); packing fraction (Pf) as ratio of bulk density to true density (Dt).

Phytochemical Screening

Phytochemical screening of both the starches was carried out.

RESULTS AND DISCUSSION

Identification Tests

Both maize and potato starches were discovered to be insoluble in water and 95% alcohol at room temperature. They showed positive mucilage and iodine test results. Potato starch exhibited more acidic pH than maize starch, as shown in Table 1. Both starches showed pH values close to neutral, falling within the permitted range. This neutrality may decrease the likelihood of interactions with active medicinal components. Colour, odour, and taste, as well as solubility tests, all conformed to requirements, with potato starch appearing yellowish and maize starch being white. Both starches turned out to be tasteless.

Table 1: Results of Identification tests

Parameter	*Maize Starch*	*Potato Starch*
Colour	White	Yellowish
Odour	Odourless	Odourless
Taste	Tasteless	Tasteless
Test for mucilage	Positive	Positive
Iodine Test	Positive	Positive
pH	6.3	5.8
Solubility test	Insoluble in water and ethanol	Insoluble in water and ethanol

Physicochemical Properties

The physicochemical properties of maize and potato starches exhibited notable differences that influence their use in pharmaceutical formulations. Potato starch demonstrated a higher hydration capacity, meaning it absorbs more water than maize starch. This higher water absorption is due to the finer particle size of potato starch, which increases the surface area available for water interaction. This makes potato starch an effective disintegrant in tablet formulations, as it swells and breaks down the tablet upon contact with fluids, aiding in the release of active ingredients.

Potato starch also showed a higher moisture content compared to maize starch, likely due to its larger particle size that retains more moisture. Managing moisture content is critical in pharmaceutical formulations because excessive moisture can degrade active ingredients and compromise product stability. Consequently, potato starch with higher moisture content needs careful handling and storage to maintain formulation stability. In contrast, maize starch, with its lower moisture content and moisture sorption capacity, offers better stability in humid conditions, making it suitable for formulations that require long-term integrity.

Potato starch exhibited a greater swelling capacity, indicating a higher volume increase when absorbing water. This is advantageous for disintegrants, as the swelling promotes tablet disintegration, enhancing the bioavailability of active pharmaceutical ingredients. On the other hand, maize starch showed higher porosity and a better packing fraction, which means it has a more open structure and packs more efficiently. These characteristics improve the flowability of maize starch and reduce problems like capping and lamination during tablet production, making it ideal for direct compression formulations. Understanding these physicochemical properties enables the optimal selection of starches for developing effective pharmaceutical products.

Table 2: Results of Physicochemical tests

Parameter	*Maize Starch*	*Potato Starch*
Hydration capacity	2.00	2.35
Moisture Content (%)	8.58	9.12
Swelling Capacity (%)	55.3	68.3
Porosity (%)	60	51
Packing fraction	0.47	0.38

Starch Flow Properties

The angle of repose, which assesses the flowability of powdered materials, showed that maize starch had a lower angle of repose than potato starch. This suggests that maize starch has better flow qualities, allowing it to flow more easily and consistently, which is critical for tablet manufacturing efficiency. Maize starch has a lower angle of repose, which means that it is less likely to form clumps and is easier to handle and process.

Maize starch showed a higher bulk density, indicating a more compact packing structure when poured into a container without tapping. Maize starch also had a higher tapped density, which was determined by tapping the container to settle the starch. These observations resulted in a lower Carr's index and Hausner ratio for maize starch, which confirms its superior flow properties. The lower Carr's index and Hausner ratio suggest that maize starch has less interparticle friction and is more compressible, making it better suited for direct compression in tablet formulations.

Potato starch possessed a higher angle of repose, which led to higher Carr's index and Hausner ratio values. These results indicate that potato starch has inadequate flow characteristics than maize starch, with higher interparticle friction and less effective packing. The higher values suggest potential difficulties in handling and processing potato starch in tablet formulations, since it may be more prone to problems such clogging and irregular flow during production.

Table 3: Results of Flow properties

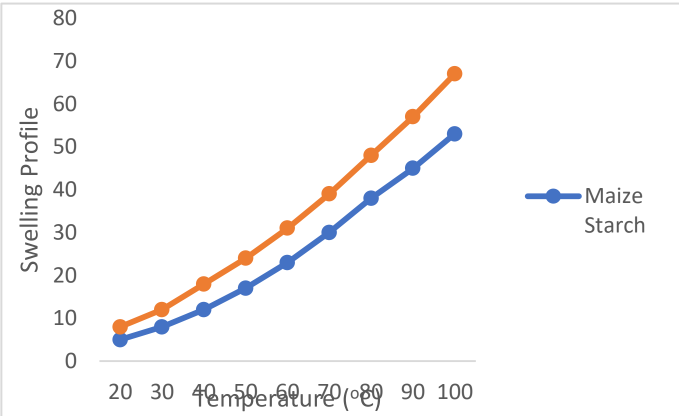
Parameter	*Maize Starch*	*Potato Starch*
Angle of Repose	27	33
Bulk Density	0.68	0.47
Tapped Density	0.87	0.62
Carr's Index	22.30	23.69
Hausner Ratio	1.20	1.31

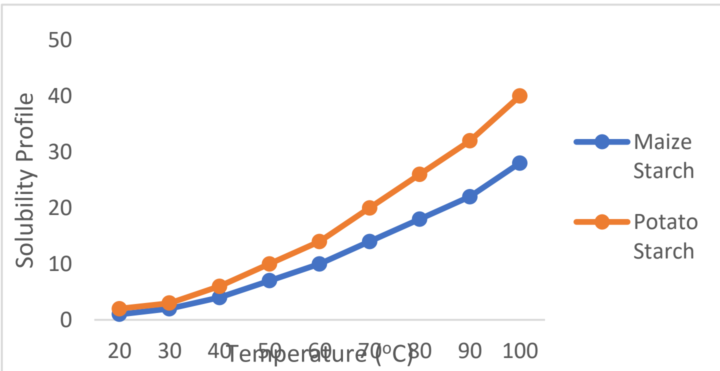
Phytochemical Screening

The phytochemical analysis of potato and maize starches shows that both contain valuable compounds, including alkaloids, flavonoids, tannins and phenolic compounds. Potato starch has a higher content of alkaloids and tannins, which could impact its use in pharmaceuticals and food products. On the other hand, maize starch, with its lower levels of alkaloids and tannins, may be more suitable for applications requiring minimal amounts of these compounds. The antioxidants present in both starches can improve the stability and shelf-life of products, making them beneficial ingredients across various industries.

Table 3: Results of Phytochemical Screening

Screening Test	*Maize Starch*	*Potato Starch*
Alkaloids	+	++
Flavonoids	-	+
Saponins	-	-
Tannins	+	++
Glycosides	-	-
Phenolic Compounds	+	+





CONCLUSION

This study emphasizes the unique benefits of maize and potato starches as pharmaceutical excipients. Maize starch, characterized by its lower Carr's index, Hausner ratio, and moisture sorption capacity, offers superior flow properties and stability across varying humidity levels. These attributes make maize starch particularly well-suited for pharmaceutical formulations that demand efficient powder handling and processing. Its excellent flowability, evidenced by a lower angle of repose, ensures smoother manufacturing processes, minimizing issues such as clogging and inconsistent flow. Higher bulk and tapped densities of maize starch enhance its compressibility, making it an ideal choice for direct compression in tablet formulations.

Potato starch demonstrates higher hydration and swelling capacities, suggesting its effectiveness as a tablet disintegrant. These properties enable potato starch to absorb more water and swell significantly, facilitating faster tablet disintegration and improving the bioavailability of active pharmaceutical ingredients. The higher angle of repose and increased interparticle friction of potato starch indicate potential handling and processing challenges, requiring careful application. Both starches contain beneficial phytochemicals like alkaloids, flavonoids, tannins, and phenolic compounds, which provide antioxidant properties that can enhance the stability and shelf-life of pharmaceutical products. Ultimately, these findings highlight the need to select the appropriate starch based on the specific requirements of the pharmaceutical formulation to optimize performance and efficacy.

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