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Original Article

Investigating *Dioscorea polystachya* Starch as a Pharmaceutical Excipient

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ABSTRACT

Background: *Dioscorea polystachya* (DP) starch, a low-cost, abundant, renewable and degradable starch, is being explored as a potential pharmaceutical excipient for drug formulation. **Objectives:** This study aimed to explore and isolate starch from *Dioscorea polystachya* and evaluate the excipients' properties. **Materials and Methods:** To study the phytochemical, physicochemical, morphological, rheological and emulsifying properties. **Results:** The isolated matter yields 40.5% starch from its dry weight of tubers and contains carbohydrates, moisture, lipids, nitrogen and various minerals. DP starch has 22.58±0.22% amylose and exhibits a non-Newtonian flow behaviour. The emulsifying capacity improved with the increasing starch concentration and provided significant emulsion stability through different oil ratios to polysaccharide solution. It showed an excellent foaming ability; however, foam stability gradually reduced over time. **Conclusion:** These findings indicate that *Dioscorea polystachya* starch provides significant excipient properties so that it could be used as an excipient in the pharmaceutical industry.

Keywords: *Dioscorea polystachya*, Starch, Pharmaceutical, Excipient, Phytochemical, Physicochemical.

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INTRODUCTION

Excipients are non-active substances added to tablet production for various reasons, including adding volume to the formulation,[1] ensuring stability,[2] preventing damage,[3] assisting in the manufacturing process of the active ingredient and enhancing drug absorption, solubility, or other pharmacokinetic factors. Excipients encompass a variety of substances, such as filler, binder, disintegrant, glidant, lubricant, anti-adherent, colouring agent and flavouring agent.[4] A binder is incorporated into a tablet formulation to maintain structural integrity following compression, preventing disintegration into individual components.[5] Furthermore, the binder enhances granulation and guarantees the granules' ability to flow freely. Starch paste, sodium alginate, acacia, tragacanth and glucose are viable options for binding tablets during manufacture. The binder is categorized into natural and synthetic polymers, primarily derived from plants, animals and bacteria. Natural polymers such as chitin, chitosan, guar gum, gum karaya, fenugreek seed, soy polysaccharide, gellan gum and mango peel pectin are a few examples.[6] In recent years, pharmaceutical companies have predominantly utilized plant-derived polymers due to their widespread availability and advantages. Natural gum and mucilage are the most commonly utilized plant-derived compounds due to their widespread availability and low cost. Various binding agents can yield different mechanical strengths and medication release characteristics. The presence of binders during the manufacturing process significantly impacts the solubility and dissolving of tablets.

Dioscorea polystachya, also known as Shanyao in Chinese, is mainly distributed in China and has been utilized in traditional Chinese medicine for a long time. It stimulates the generation of bodily fluids, nourishes the liver and kidneys and enhances the vitality of the kidneys and spleen.[7] DP contains more significant levels of starch, commonly utilized in Chinese cooking. Due to their underutilization, these plants can serve as an alternate source of starch in addition to commonly used commercial starches such as potato, rice and maize, also used as staple foods.[8]

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Dioscorea polystachya starch has gained attention as a potential pharmaceutical excipient due to its various properties and potential applications in drug formulation. Compared to other starch sources, *Dioscorea polystachya* starch offers distinct advantages such as low cost, abundance, renewability and degradability. Additionally, the high amylose content of *Dioscorea polystachya* starch makes it particularly attractive for pharmaceutical applications, as it has superior film-forming and binding properties. Furthermore, *Dioscorea polystachya* starch can serve as a versatile excipient due to its ability to act as a thickener, adhesive, encapsulating agent, gelling agent and binding agent. It can contribute to the structure, texture and consistency of pharmaceutical formulations. Moreover, *Dioscorea polystachya* starch has shown potential in improving the stability and bioavailability of drugs, as well as enhancing drug release profiles. This makes it a promising candidate for use in various pharmaceutical dosage forms, including tablets, capsules, powders and topical formulations. Furthermore, the research has also explored the potential of modifying *Dioscorea polystachya* starch through heat moisture treatment and moisture levels to enhance its physicochemical properties and optimize its performance as a pharmaceutical excipient. Additionally, *Dioscorea polystachya* starch has been studied for its role in the development of biodegradable films and packaging materials. These films can be used to partially or completely replace plastic polymers due to the low cost and renewability of *Dioscorea polystachya* starch and its desirable mechanical properties.

MATERIALS AND METHODS

Materials

Tubers of *Dioscorea Polystachya* were collected from the local market in Sungai Petani, Kedah, Malaysia. Ethanol was obtained from John Kollin, Malaysia. Fehling's solution A and B, Wagner's reagent, Molisch's reagent, ascorbic acid, barium chloride, phenol and iodine were purchased from R and M Chemicals, Malaysia.

Isolation of starch from *Dioscorea Polystachya*

The DP tubers were washed extensively with distilled water to eliminate any soil and other contaminants attached to them. Subsequently, the tubers were cut into small segments and immersed in a sodium hydroxide solution (0.05 % w/v) for a day at room temperature.[9] Following the soaking process, the sodium hydroxide solution was poured out and the tubers were rinsed multiple times with ample distilled water until the pH became neutral. The cleaned tubers were combined with adequate distilled water and transferred to a wet mill to obtain a slurry. The slurry underwent filtration using muslin fabric, resulting in the collection and subsequent air-drying of the starch sediment. The desiccated starch powder was measured and the percentage yield (w/w) was computed.

Phytochemical tests

The DP starch underwent multiple phytochemical tests, including the iodine test, emotions test, alcohol test, barcode test and bias test, to detect the presence of starch, mucilage, reducing sugar and glucose.[9]

Physicochemical tests

Moisture, ash, lipid and carbohydrate content

The pH of a solution containing DP starch (1% w/w suspended in distilled water) was measured using a laboratory digital pH meter. The solubility was ascertained through the utilization of both heated and chilled water. The moisture content of DP starch was determined by subjecting 1 g of powdered starch to heating at a temperature of 105°C until a consistent weight was achieved. The ash content was determined by combusting 1 g of the sample at 500°C in a Muffle furnace with a capacity of one litre, specifically the Gaia Science Sdn Bhd (Malaysia), for 12 hr. The lipid content of mucilage powder was quantified using the Soxhlet extraction process, which was subsequently analyzed using gravimetric techniques. The quantification of total carbohydrate content was achieved using absorbance measurements at a wavelength of 490 nm using a UV spectrophotometer.[10]

Analysis of mineral and total nitrogen content

The mineral composition of DP starch powder was examined at the Agriculture, Food and Life department of SGS (Malaysia) Sdn Bhd. The calcium, iron, potassium, phosphorus, aluminium and magnesium levels were measured using an Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) manufactured by Perkin Elmer (Optima 8300, USA). The nitrogen content was determined by employing a protein digestor and subsequent distillation.

Determination of amylose content

The amylose content of the DP starch was assessed using the methodology outlined by Khoomtong *et al.*[11] Precisely 100 µg of DP starch was dissolved in a solution containing 1 µL of 95 % ethanol and 9 mL of sodium hydroxide (1.0 N). The sample underwent gelatinization by boiling the solution for 10 min in a water bath, then cooling it and adding a maximum of 50 mL of water. Extracted 5 mL of starch solution using a pipette, then moved it into a 100 mL volumetric flask. They added 1 mL of 1 N acetic acid and 2 mL of iodine solution. They finally filled the flask with up to 100 mL of distilled water. The absorbance was quantified at a wavelength of 620 nm following 20 min of agitation. The values were replicated three times and the findings are reported as the standard deviation.

Rheological parameters

The rheological examination of the DP starch solutions was conducted using an MCR 302 Anton Paar (Austria) rheometer

equipped with a double gap or Cone or Plate geometry measurement system. The samples, including a 1%, 2% and 5% DP starch solution and a 1% potato starch solution, were subjected to testing within a shear rate range of 0.01-100 s^{-1}. The apparatus was equipped with a 40 mm cone and plate geometry positioned at an angle of 2.008º, rotating on a sleek aluminium Peltier-thermostated surface at 25ºC. A volume of 0.6 mL of fluid sample was utilized.[12] The measurements were replicated triplicate.

Emulsifying properties

The Emulsion Stability (ES) and Emulsifying Capacity (EC) of DP starch and potato starch were assessed using a modified approach described by Gannasin *et al.*[13] The DP starch powder, at a concentration of 1% weight/volume, was combined with distilled water and agitated continuously for 1 hr. Subsequently, it was left to hydrate overnight at 4ºC. An emulsion of Oil-in-Water (O/W) type was created by combining varying proportions of oil and aqueous starch solutions (50:50, 25:75, 10:90 v/v) using a high-speed Silverson Homogenizer (Silverson L4RT, USA) operating at 8000 rpm for 5 min. The emulsions created were subjected to centrifugation using a Kubota 2800 centrifuge from Japan. The centrifugation was carried out at a speed of 1200 revolutions per minute for 5 min. The emulsion capacity was determined by applying the following formula.

$$\text{Emulsion Capacity (EC)} = \frac{\text{Emulsion layer volume (mL)}}{\text{Total volume of emulsion (mL)}} \text{X } 100$$

The previously prepared emulsions were heated in a water bath at 80ºC for 30 min and the emulsions were cooled to room temperature and centrifuged at 1200 rpm for 5 min. The emulsion stability was calculated using the following formula.

$$\text{Emulsion Stability (ES)} = \frac{\text{Emulsion volume after heating (mL)}}{\text{Emulsion layer volume obtained from EC (mL)}} \text{X } 100$$

Foaming properties

The Foam Stability (FS) and Foaming Capacity (FC) of DP starch were examined using the approach described by Sciarini *et al.*,[14] with some adjustments. Starch solutions with 1% and 2% concentrations were created by soaking the starch powder in distilled water for 12 hr at a temperature of 4ºC. The solutions were mixed at 200 revolutions per minute for 10 min. The foamed suspensions were promptly transferred to a graduated measuring cylinder and the foam volume was measured after 30 sec. The foaming capacity was then estimated using the provided formula.

$$\text{Foaming Capacity (FC)} = \frac{\text{Initial foam volume (mL)}}{\text{Total volume of suspension (mL)}} \text{X } 100$$

The foam volume was recorded at 5, 10, 30, 60, 90 and 120 min intervals. The foam stability was calculated using the following formula.

$$\text{Foaming Stability (FS)} = \frac{\text{Foam volume after time (mL)}}{\text{Total volume of suspension (mL)}} \text{X } 100$$

Particle size distribution pattern

The distribution pattern of particle size was studied by subjecting the DP starch powder to drying and then using the SIEVEA 502 Electromagnetic Vibratory Sieve Shaker (China). According to US standards, the sieves were set in descending order, ranging from 1 mm to 0.00012 mm. The weight of 100 g of dried starch powder placed on top of the sieve was measured and the weight that remained on the sieve was determined. The particle size distribution parameters, including particle diameters, span and porosity, were obtained using a Hydrogeosieve XL data sheet[15] produced by J.F. Devlin from the Department of Geology at the University of Kansas.

Statistical analysis

The investigation was conducted in triplicate (n=3) and the values were expressed as the mean±standard deviation. The statistical study was conducted using Statistical software version 12.0 developed by Statsoft Inc. in Tulsa, USA. The data underwent Analysis of Variance (ANOVA) and Tukey's *post hoc* test to compare means, with a significance threshold of 0.05.

RESULTS

Isolation of starch

The extraction of starch from *Dioscorea polystachya* tubers was a simple process. The starch granules settled while other substances remained in suspension. The fibrous components were separated and the percentage yield of starch was calculated to be 40.5%.

Phytochemical and physiochemical analysis

The pH of 1% DP starch solution was 6.89, while corn starch ranged between 4 and 7 as indicated in Table 1. Both results validated the pH prerequisite of the binding agent by USP/NF standards. The DP starch powder was determined to have a moisture content of 14.0 g/100 g (Table 2), which impacts the product's processability, shelf life, use and quality. The lipid percentage of the isolated starch was determined to be 1.63% (Table 2), indicating a comparatively low concentration. The starch's total carbohydrate content, as indicated in Table 2, was 13.31 g/100 g. The separated starch has a total nitrogen content of 1 g/100 g, as indicated in Table 2. Nitrogen is an essential dietary component found in most proteins and nucleic acids. The ash percentage of the separated starch was relatively low, measuring 0.7 g/100 g (Table 2). The assessment of ash content enables the rapid and effortless identification of organic and inorganic components. The ash originates from the inherent mineral constituents of the plant. Table 2 displays the mineral composition of the extracted starch. Potassium is the predominant mineral in starch, whereas aluminium is present in the smallest quantity.

Amylose content

The amylose content of DP starch was assessed using the colorimetric method, yielding a result of 22.58%±0.22%, compared to potato starch with a concentration of 24.10%±0.30%. Starch, in nature, consists of two distinct components: amylose and amylopectin.

Rheological parameters

The samples exhibited a flow pattern consistent with a non-Newtonian profile, as indicated by a Flow behaviour index (n) value below 1, indicating a thinning fluid. The Power Law model and the rheological values of the samples are presented in Table 3. Table 3 displays the Ostwald-de-Waele characteristics for starch solutions at various concentrations. The value of 'K' increased and the value of 'n' decreased in attention. The 'n' values were more than 1, indicating a dilatant flow type (Figure 1).

Emulsifying properties

Figure 2 displays the emulsifying ability and stability of the starch at various water ratios. The data indicates that DP starch has a substantial emulsifying capability ($p<0.01$) and emulsion stability ($p<0.01$) in comparison to potato starch. The emulsifying capability and emulsion stability of various ratios of DP starch exhibited a statistically significant difference ($p<0.01$) when compared to potato starch, which expressed as highly significant difference ($p<0.001$).

Foaming characteristics

The Foaming Capacity (FC) and Foaming Stability (FS) of DP starch are presented in Figure 3. The results indicate that the concentration of starch influences the foaming capacity. Specifically, the foaming capacity of 1% starch (FC=53.3%) was determined to be statistically significant ($p<0.05$), while the foaming capacity of 2% starch (FC=75.1%) exhibited even greater significance ($p<0.01$). The utilization of a 5% concentration of ovalbumin as a reference material resulted in a Fold Change (FC) value of 64.4%. The combination of ovalbumin with 1% or 2% DP starch exhibited a significant increase in FC values of 93.5% and 93.05%, respectively, compared to 5% ovalbumin. This difference was highly significant ($p<0.01$). The FC of DP starch exhibited

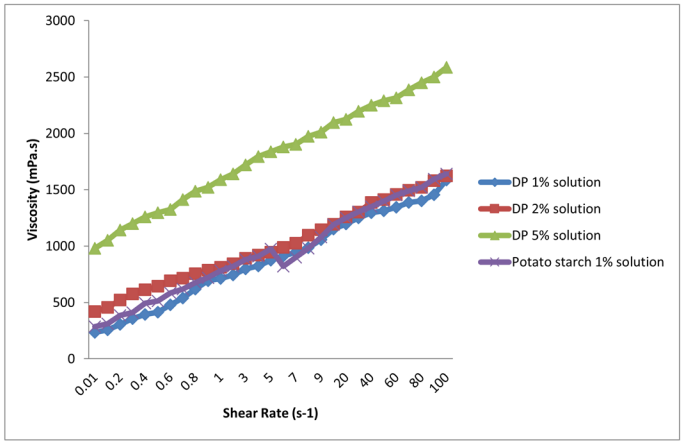

Figure 1: Effect of shear rate on viscosity of starch, it showed that the sample viscosities increased with increasing shear rate from 0.01 to 100 s^{-1} and all samples tended to dilatant flow behaviour.

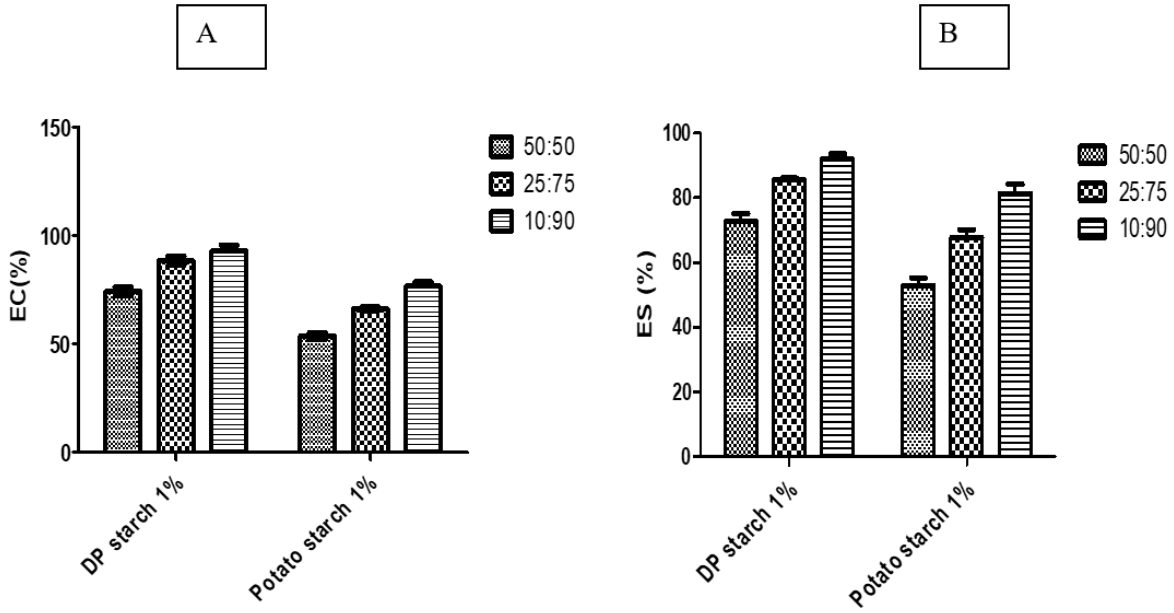

Figure 2: DP starch Emulsifying Capacity (EC) (A) and Emulsion Stability (ES) (B) as a function of different ratios of oil to polysaccharide solution (50:50, 25:75, 10:90, v/v). It shows that the DP starch has a significant emulsifying capacity ($p<0.01$) and emulsion stability ($p<0.01$) as compared with potato starch. The emulsifying capacity and emulsion stability of different ratios of DP starch showed $p<0.01$ and compared with potato starch $p<0.001$, which showed highly significant.

a comparable efficacy to that of potato starch, with a capacity of 95.24%.

DP starch's Foam Stability (FS) at concentrations of 1% and 2% significantly decreased over time. After 5 min, the FS of DP starch at 1% and 2% was 45.5% and 84%, respectively. After 120 min, the FS decreased to 16.5% and 57.5% for the 1% and 2% concentrations respectively. An ovalbumin solution with a concentration of 5% exhibited a filtration speed of 75% after 5 min and 67.5% after 120 min.

Similarly, ovalbumin combined with 2% starch showed comparable stability, which was significantly higher ($p<0.05$) than that of ovalbumin alone at a concentration of 5%.

Particle Size Distribution Pattern Analysis

The particle size distribution pattern was evaluated utilizing the Hydrogeosieve data sheet, resulting in the generation of data and figures. This method facilitates the calculation of particle size distribution parameters, including particle diameters, span and porosity. This indicates that the particles are poorly sorted sandy slit with fines, as shown in Figure 4. The research demonstrated that the DP dried starch powder contains a higher proportion of clay form (98.8%), coarse slit (19.4%) and fine sand (15.2%) sized particles. The span may be determined by using the d10, d50 and d90 measurements. The sample exhibited a span value of 1.39.

DISCUSSION

Isolation of starch

The obtained result surpassed the starch content of *Cyperus* starch (21%) and C. esculentus starch (20.5%). The high production of DP starch makes it a suitable alternative to potato and corn starch for use as a tablet binder[16] The higher starch content in DP starch compared to *Cyperus* and *C. esculentus* starches suggests that DP starch could offer superior binding properties. Tablet binding is a critical process in pharmaceutical manufacturing, where starches are commonly used as binders to impart cohesiveness and strength to tablets. A higher starch content often translates to better binding efficiency, ensuring the integrity and stability of the tablet throughout its shelf life.[17]

Phytochemical and Physiochemical Analysis

Plants contain various polysaccharides, including cellulose, hemicelluloses, pectin, gums, mucilage and starches. Phytochemical tests are conducted to distinguish between starches, gums and glues. Dextrinized and potato starch have low solubility in cold water, while potato starch dissolves rapidly. However, dextrinized starch has limited solubility in hot water. DP starch is a valuable binding agent for tablets, as it dissolves in hot water to facilitate solubility and integration with other excipients. The DP starch solution exhibited a profound blue hue upon adding three drops of iodine solution, showing the existence

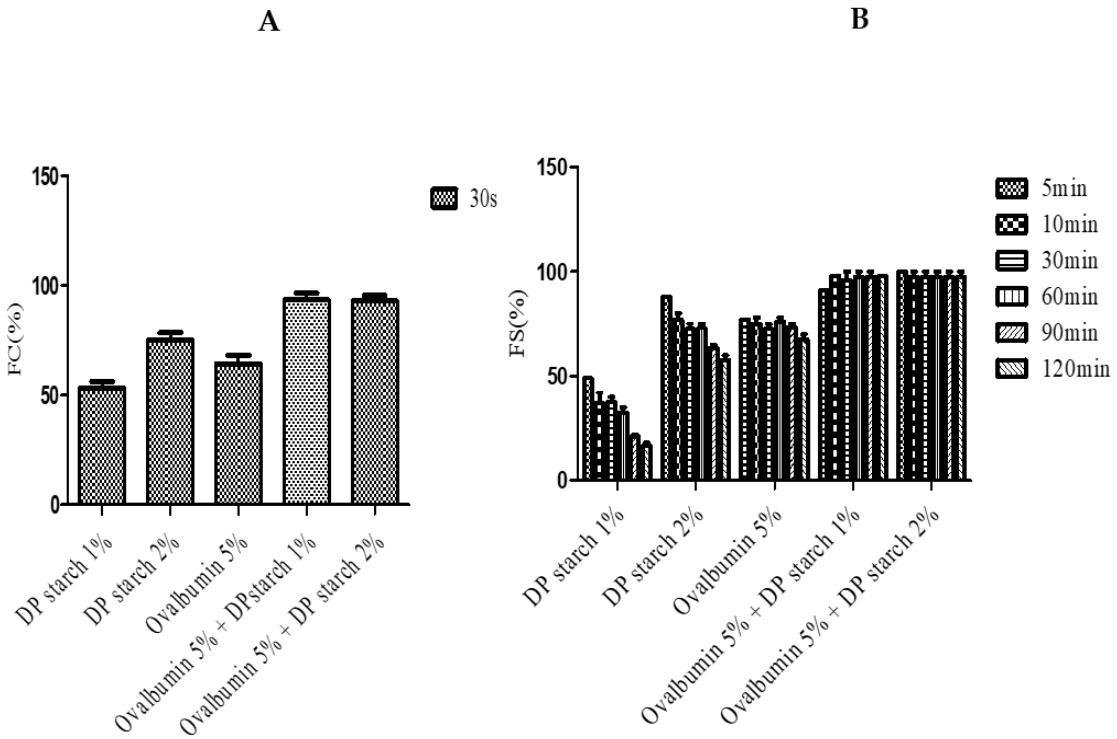

Figure 3: Foaming Capacity (FC) (A) and Foam Stability (FS) (B) of various foaming solutions. The foaming capacity was found to be concentration dependent, which is significant ($p<0.05$) for 1% starch (FC=53.3%) and 2% starch showed significance ($p<0.01$) (FC=75.1%). The 5% ovalbumin used as a standard substance led to an FC of 64.4%. The mixture of ovalbumin and 1% and 2% DP starch showed high significance ($p<0.01$) FC values of 93.5% and 93.05%, respectively, compared with 5% ovalbumin.

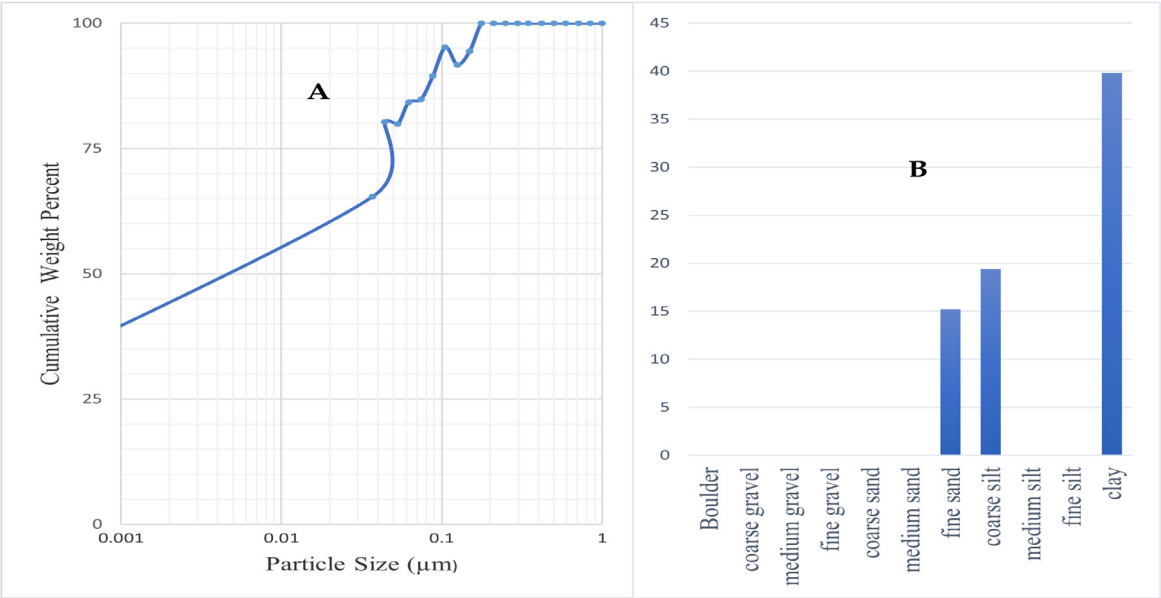

Figure 4: Particle size distribution pattern of DP starch A) Cumulative size distribution B) Grades of particles distributed.

Table 1: **Phytochemical studies.**

Test	Samples	
	Potato starch (USP)	DP starch
Solubility	Insoluble in cold water, readily soluble in hot water.	Insoluble in cold water, slightly soluble in hot water.
pH	4-7	6.89
Iodine test	Deep blue color developed.	Deep blue color developed.
Alcohol test	Slightly Precipitated.	Slightly Precipitated.
Fehlings test	Red color precipitate.	Red color precipitate.
Barfoeds test	Brick red color precipitate.	Brick red color precipitate.
Bials test	Green-blue color formation.	Green- blue color formation.

Table 2: **Physiochemical analysis of power *DioscoreaPolystachya* starch.**

Sl. No.	Parameter	Result
1.	Moisture content	14.0 g/100g
2.	Lipid content	1.63g/100g
3.	Total carbohydrate content	13.13 g/100g
4.	Total nitrogen	1.0 g/100g
5.	Ash content	0.7 g/100g
6.	Mineral content	
	P	0.607 µg/100g
	K	291.55 mg/100g
	Mg	0.180 µg/100g
	Ca	39.10 mg/100g
	Fe	4.66 mg/100g
	Al	0.21 µg/100g

*All the values were calculated based on dry weight of DP starch.

of potato starch, which shares similar characteristics to regular starch. DP and potato starch exhibited a minor formation of solid particles when mixed with an alcoholic solution, indicating a small amount of mucilage. Dried Potato (DP) is rich in starch, moisture and vitamins. It also includes mucilage, amylase, amino acids and glutamine, which can be separated when exposed to alcohol.[18] Both DP starch and potato starch yielded positive findings in the Fehlings and Barfoeds tests, thereby confirming the presence of reducing sugars such as glucose and maltose. The Bials test indicated the presence of ribose and glucose by producing a greenish-blue colour when DP starch and potato starch were used. BeMiller and Whistler *et al.* (2002) state that plants' gums, mucilage and starches have distinct physiological roles. Starches are glucose polymers, gums are galactose with arabinose polymers and mucilage are polysaccharides consisting of rhamnogalacturonan, polygalacturonic acid, galactomannan

Table 3: Ostwald-de-Waele parameters for starch solutions at different concentrations.

Sample	Consistency index (Pa sn) K	Flow behavior index (n)	R2
DP 1% solution	0.82	1.422	0.9964
DP 2% solution	4.04	1.351	0.9867
DP 5% solution	4.65	1.317	0.9752
Potato starch 1% solution	0.84	1.406	0.9915

and arabinoxylan.[19] The findings above have verified that the tubers of *Dioscorea polystachya* possess substantial amounts of starch, making them suitable as a binding agent for tablet manufacturing. This carbohydrate content plays a significant role in determining the product's sweetness, look and texture.

Amylose Content

These findings shed light on the differences in amylose content between DP and potato starch. While both are starches derived from different sources, their compositions vary, influencing their functionality in various applications. Amylose, being a linear polysaccharide, contributes to the viscosity, gel formation and retrogradation properties of starches. Therefore, the disparity in amylose content between DP and potato starch may result in differences in their textural attributes, such as viscosity, gel strength and stability.[20]

Rheological Parameters

According to the Power Law, liquids is classified into three distinct categories depending on the magnitude of their flow behaviour index: A fluid with $n<1$ is classified as a pseudoplastic fluid, a non-Newtonian or shear-thinning fluid. A fluid with $n=1$ is denoted as a Newtonian fluid, whereas a fluid with $n>1$ is classified as a dilatant or shear-thickening fluid. The Consistency index (K) represents the apparent viscosity, whereas the flow behaviour index (n) reflects the shear-thickening properties.

Emulsifying Properties

The emulsifying properties are typically attributed to the adsorption capacity of active surface molecules, which generate fresh droplets during emulsification. This capacity reduces the interfacial tension and prevents the droplets from coalescing by creating a protective layer around them. The emulsifying capability and stability of the emulsion were enhanced as the concentration ratio of DP starch increased compared to potato starch.[21] The elevated starch concentration decreased the interfacial tension between the oil and the aqueous layer during emulsification. The presence of polysaccharide molecules in starch might elevate the viscosity of the surrounding media, thereby minimizing phase inversion and coalescence. With an increase in density, the movement of globules was constrained. Concurrently, the Brownian motion of globules would also be impeded, resulting in the creaming phenomenon. To maintain a stable emulsion, it is preferable to have an optimal viscosity due to its antagonistic impact. The DP starch has a notable moisture content, which results in favorable swelling power and water absorption properties. Under ideal temperature conditions, the presence of moisture will trigger the enzyme's activity and promote the proliferation of microorganisms, potentially compromising the longevity of the formulation. Accurately measuring the moisture level of a substance is crucial for optimizing critical phases in the production process, including drying, packing, storage and transport.[21]

The lipid content of the starch solution will have an impact on both its spreadability and stability. In addition, it will reduce the surface tension and inhibit evaporation. An excipient with a high-fat content can increase the absorption and bioavailability of a medication.

Nevertheless, the plant may extraneous substances attached through interaction with the soil and sand. The term used to refer to this alien substance is non-physiological ash. Ash content above the permissible limit typically suggests a deficient collection and storage process. Furthermore, starch is a superb reservoir of vital minerals, including calcium, phosphorus, potassium, magnesium, iron and aluminium.

Foaming Characteristics

The instability of amylose aqueous dispersions arises from intermolecular attraction and attraction to neighboring molecules. Therefore, the amylose content significantly influences various vital characteristics of starch, including its solubility in water, viscosity, pasting temperature, stability of the gel formed, resistance to digestion by starch granules and the structure of starch crystallinity inside the granules. The amylose content of DP starch and potato starch is similar, suggesting a potential resemblance in certain functional features. Figure 1 demonstrated that the viscosities of the samples rose as the shear rate increased from 0.01 to 100 s^{-1} and all samples tended to dilatant flow behaviour. The discovery was found to be consistent with comparable results published by Dabhadkar *et al.*[22] This behavioural anomaly may be attributed to the disruption of molecular arrangement within the network structure caused by an increase in shear rate. On the other hand, the sample that contains more significant quantities of high-molecular-weight molecules, such as proteins and polysaccharides, has non-Newtonian behaviour and often displays viscoelasticity, as described by Kokol *et al.*[23] When a viscoelastic material is subjected to stress, some energy is converted into heat during deformation, while the remaining energy is retained elastically. The viscosity of a non-Newtonian liquid is influenced by the rate at which shear is applied. As the shear rate rose, the non-newtonian liquids exhibited shear-thickening behaviour,

accompanied by increased density. DP starch comprises complex compounds, including carbohydrates, proteins, moisture, lipids and minerals, which may contribute to its non-Newtonian flow characteristics.

Polysaccharide solutions such as guar gum and xanthan gum could not generate foam independently. Proteins possess strong foaming properties, which can result in a substantial increase in the thickness of water and the formation of a cohesive film around air bubbles, creating a stable foam. The combination of protein and starch interactions can enhance the stability of foams, leading to an increase in FC.[24]

In addition, the combination of ovalbumin and mucilage exhibited notable foaming stability compared to the other mixtures. Concisely, ovalbumin combined with 1% starch exhibited an initial strength of 98% and maintained the same strength throughout.

This analysis indicates that the functional similarity of DP starch and ovalbumin is equivalent to that of potato starch. As viscosity increases, foam formation becomes more likely to create a strong network of biopolymers that prevents air bubbles from merging and the continuous phase from draining in the lamellae. The primary determinant of foam generation and stability is the ability and characteristics of molecules to decrease the interfacial tension.[25]

Particle Size Distribution Pattern Analysis

Span values of more than four suggest that powders have several particle size distributions, whereas values less than 4 indicate a limited particle size distribution. The DP starch powder exhibited a span value of 1.39, suggesting a restricted particle distribution. The particle size influences the pace at which a substance dissolves, hydrates and emulsifies. The drug dissolution fluids and physical stability of the dosage form are influenced by the surface area, which increases as the particle size decreases.[26] The powder mucilage had a porosity (n) of 26%, indicating a tightly packed structure. The stable organization packing necessitated less compression force during tablet compression.

CONCLUSION

These investigations focused on extracting starch from *Dioscorea polystachya* as a potential substitute for pharmaceutical tablet binder, emulsifier, stabilizer, foaming agent and thickening agent. The properties and applications of this starch have recently been investigated. 40.5% of the dry weight of *Dioscorea polystachya's* tubers was obtained by extracting the starch. Starch powder mainly comprises starch, protein, mucilage, lipids, nitrogen and minerals. The starch exhibited notable emulsifying power and maintained emulsion stability across various ratios of starch solution to oil, resembling that of potato starch. It provided potential functions in food formulation as an emulsifying agent and stabilizer.

Furthermore, it exhibited exceptional ability to produce foam and maintain its stability, with its performance being contingent on the concentration. The morphological analysis confirmed that the starch had an irregular structure, characterized by fragmented small particles attached to the surface. These findings suggest that *Dioscorea polystachya* starch has the potential to be a good ingredient for making pharmaceutical dosage forms, similar to potato starch. The starch obtained from *Dioscorea polystachya* has the capacity to perform as a viable substitute to fulfill the increasing need for functional excipients.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

DP: *Dioscorea polystachya*; **ICP-OES:** Inductively coupled plasma-optical emission spectrometer; **ES:** Emulsion stability; **EC:** Emulsifying capacity; **FS:** Foam stability; **FC:** Foaming capacity; **FTIR:** Fourier Transform Infrared; **UV/vis:** Ultraviolet-visible Spectrometry; **ANOVA:** Analysis of Variance; **K:** Potassium; **P:** Phosphorous; **Ca:** Calcium; **Mg:** Magnesium; **Na:** Sodium; **Fe:** Iron; **Zn:** Zinc; **Sr:** Strontium; **Cu:** Copper, **Mn:** Mangenese.

SUMMARY

Dioscorea polystachya (DP), a cheap, renewable, and biodegradable starch, faces therapeutic use. It extracted and studied DP starch's phytochemical, physicochemical, morphological, rheological, and emulsifying properties. Tubers' dry weight yielded 40.5% starch, carbohydrates, moisture, lipids, nitrogen, and minerals. Non-Newtonian flow is seen in DP starch with 22.58±0.22% amylose. Increasing concentration improves foaming, emulsion stability, and emulsifying capacity, while foam stability decreases. These results demonstrate DP starch provides significant excipient properties so that it could be used as an excipient in the pharmaceutical industry.

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