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Extraction and Comparative Characterization of Starch from Seed Kernels of Two Mango Varieties in Rajshahi

Bahktiar Ahmed Sajib[1], Ajmain Hasnat Alvi [1], Md. Mostafa Kamal[1,] and Pabitro Prosad Mondal[2]*

[1]Department of Mechanical Engineering, Rajshahi University of Engineering & Technology (RUET), Rajshahi-6204, Bangladesh

[2]Department of Materials Science and Engineering, Rajshahi University of Engineering & Technology (RUET), Rajshahi-6204, Bangladesh

ABSTRACT

Mango seed kernels represent an underused agro-waste stream with potential as a sustainable starch source. This study compares starch extracted from two Bangladeshi cultivars, Mangifera indica ‘Gopalbhog’ and ‘Fazli’, to elucidate varietal effects on yield and physicochemical behavior. Mature fruits (10 kg per cultivar) were treated; kernels were preconditioned in 0.5% (w/v) sodium bisulfite (1:2 kernel:solution) for 24 h at 4 °C, wet-milled (800 rpm, 10 min), screened (100 mesh), and the starch separated by cold settling (12 h, 4 °C). Drying was performed at 70 °C for 36 h. Structural and functional properties were quantitatively characterized through FTIR (4000–500 cm^{-1}), UV–Vis (200–1400 nm), and gravimetric water absorption capacity (WAC) analyses to establish structure–function relationships between the cultivars. Starch yields were 25.2% (‘Gopalbhog’) and 20.8% (‘Fazli’), while WAC values were 152.2% and 146%, respectively. FTIR crystallinity indices (A_{1047}/A_{1022}) were 0.77 (‘Gopalbhog’) and 0.75 (‘Fazli’), indicating slightly greater short-range order in ‘Gopalbhog’. UV–Vis λmax values were 211 nm (A = 1.122) and 213 nm (A = 0.532). The higher order of ‘Gopalbhog’ reflects reduced hydratability, whereas ‘Fazli’s higher swelling suggests complementary applications in films, coatings, and hydrogels.

Keywords: Mango Kernel, Starch, Eco-Friendly Biopolymer.

1. Introduction

Starch is one major renewable biopolymer with wide applications in food, pharmaceutical, cosmetics, and material industries due to its biodegradability, abundant availability, and suitable techno-functional properties [1]. Wide-scale production and consumption of mangoes in regions such as Rajshahi, Bangladesh, generate large volumes of agro-industrial by-products, especially the seed kernels. These seed kernels are often sold as waste and cause environmental disposal issues; they have huge potential to act as economic sources of indigenous starch [2], [3]. Hence, extraction of native starch from mango seed kernel aligns with waste valorization and circular bioeconomy goals by converting fruit waste into value-added ingredients [4]. Recent works have largely focused on optimizing the extraction parameters of mango seed kernel starch (MKS) and assessing its inherent functional properties, i.e., yield, water absorption, swelling power, solubility, and FTIR-based structural features [5], [6]. However, the works are generally descriptive and often limited to the examination of single cultivars, so they are devoid of any comparative or quantitative estimate of the varietal differences. Besides, the UV–Vis spectroscopic optical characterization of the mango seed starch has drawn comparatively much less attention. Although it is important for determining optical absorption characteristics, purity of extracts, and detection of minor impurities or chromophores [7]. Water binding or absorption by starches is one key functional attribute for most industrial applications, determining texture, hydratability, and shelf characteristics. Investigations have indicated that extraction conditions (procedure, pH, temperature) have marked effects on water absorption or solubility in mango seed starch, often associated with amylose/amylopectin ratio and granular pattern as revealed through FTIR spectral characteristics [8]. Determinations of yield by these functional analyses enable estimation of processing effectiveness and economic viability for practical implementation [9]. For Bangladesh (particularly Rajshahi), mango production is one of the highest nationally within mango-producing areas, and thus mango seed waste is plentiful. There are few detailed physicochemical and spectroscopic studies among the indigenous varieties of mango to examine the impact of compositional variation of varieties on the functionality of the starch. This research thus seeks to fill the existing gap by isolating and characterizing starch derived from two predominant mango varieties in Bangladesh—Mangifera indica ‘Gopalbhog’ and ‘Fazli’ to assess varietal distinctions in yield, FTIR spectral attributes, water absorption capacity, and UV–Vis absorption profiles under regulated drying conditions. The underlying hypothesis posits that structural and compositional discrepancies between these two cultivars are reflected in quantifiable differences in crystallinity, hydratability, and optical behavior. The originality of this investigation is rooted in its quantitative correlation of molecular-level characteristics (such as FTIR crystallinity index, UV–Vis absorbance intensity, and water absorption capacity) with functional performance, thereby offering the first comparative analysis of the starch structure–property

*Corresponding Author Email Address: mostafakamal2048@gmail.com

relationships pertaining to Bangladeshi mango seed kernels. Additionally, this study underscores the potential for valorizing mango seed waste from Rajshahi as a sustainable and environmentally friendly source of starch for prospective biodegradable packaging applications.

2. Extraction And Characterization of Starch

The detailed extraction process of starch from mango seed kernel is depicted in Fig. 1. Mature and ripe mangoes of two varieties, *Mangifera indica* 'Gopalbhog' and *Mangifera indica* 'Fazli', were sourced from a local marketplace in Rajshahi, Bangladesh, with 10 kg of each variety. After fruit consumption, the seeds were stored at 4 °C, and kernels were harvested within 10 days for starch extraction.

Fig. 1: Detailed starch extraction process from mango seed kernel.

The kernels were treated by soaking in 0.5 % (w/v), 1:2 kernel: solution, 4 °C, 24 h to prevent enzymatic discoloration and microbial growth. Soaking and concentrating conditions were applied directly by following the protocol of [10], where the same treatment effectively inhibited enzymatic discoloration during the isolation of mango kernel starch. Afterwards, the kernels were crushed with distilled water at a speed of 800 rpm for 10 minutes using a kitchen blender (Black+Decker, 500 W), and the resulting slurry was strained through a 100-mesh sieve to remove coarse fibers and collect the starch suspension for sedimentation. Starch separation was performed by cold sedimentation (12 h at 4 °C) rather than centrifugation. The mixture was kept at 4 °C for 12 h, the supernatant discarded, and the precipitate washed repeatedly and redispersed in distilled water until a smooth, white starch consistency was achieved [11].To dry the starches, the Fazli and Gopalbhog were oven-dried for the first 36 h at 70 °C. 5 h of sun-drying were further conducted on the Fazli material to ensure full removal of moisture. Initial kernel moisture content was not experimentally assayed herein; future study will include moisture measurement to permit yield normalization by dry weight. Ground and powdered dehydrated starch were stored in airtight containers at room temperature. Characterization also involved the use of Fourier Transform Infrared (FTIR) spectroscopy (IRTracer-100, Shimadzu, Japan) at wavenumbers of 4000–500 cm^{-1} to check for the presence of functional groups. Gravimetric Water Absorption Capacity (WAC) was measured using the following equation (1):

$$WAC\ (g\ H2O/g) = \frac{W1-W0}{W1} \times 100\% \qquad (1)$$

where W_0 is the weight of dry starch (g) and W_1 is the weight of swollen starch [12]. UV-Vis spectrophotometry (Shimadzu UV-2600, Japan) at wavelengths ranging from 200–1400 nm was used to determine the optical properties of the starch samples [13].

3. Results And Discussions

3.1 Fourier Transform Infrared Spectroscopy

The FTIR spectra of both starch samples (*Fazli* and *Gopalbhog*) are represented in Fig. 2. In general, both spectra exhibit the typical absorption bands of native starch but with differences in intensity, baseline shift, and peak appearance. In the high-frequency range (approximately 3700–3600 cm^{-1}), the broad band observed corresponds to O–H stretching vibrations of hydroxyl groups and hydrogen-bonded water. The red (*Fazli*) spectrum exhibits a slightly higher absorbance peak than the black (*Gopalbhog*) one. In the region near 2920 cm^{-1}, faint peaks present in both spectra coincide with the aliphatic stretching modes of –CH and –CH_2 groups of the glucopyranose rings. Relative peak intensities between the two cultivars are similar, suggesting comparable compositions of alkyl backbones [14]. Moving toward the fingerprint region (1500–600 cm^{-1}), sharper differences become apparent [15]. Both spectra display numerous bands assignable to C–O, C–C, C–O–C stretching, and ring vibrations of anhydroglucose subunits of the starch molecule.

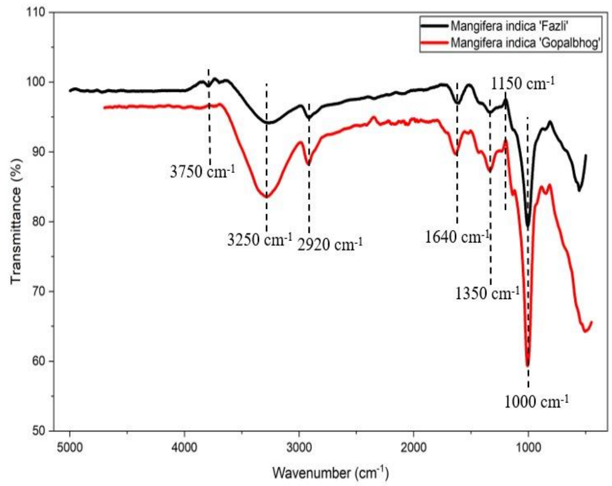

Fig. 2: FTIR Spectrum of *Mangifera indica* 'Gopalbhog' and *Mangifera indica* 'Fazli'

The quantitative analysis was enhanced through the utilization of the absorbance ratio A_{1047}/A_{1022}, a metric that is commonly recognized as an indicator of short-range crystallinity in starch. Based on the measured FTIR data, the computed ratios were approximately 0.77 for Gopalbhog and approximately 0.75 for Fazli. Although both ratios are less than 1, which is characteristic of predominantly amorphous native starches, the marginally higher ratio for Gopalbhog implies a slightly superior degree of double-helical or crystalline organization within its polysaccharide framework. An elevated 1047/1022 ratio is indicative of more pronounced C–O stretching in ordered regions, while an increased relative intensity near 1022 cm^{-1} signifies amorphous or hydrated areas. On the mechanistic level, this spectroscopic distinction parallels functional evidence: starches exhibiting the higher level of short-range order tended to have lower water absorption and swelling, while those containing higher proportions of amorphous regions showed higher hydratability (WAC) [16]. Thus, the concomitantly higher crystalline index of Gopalbhog parallels its comparatively lower water-absorption trend relative to Fazli.

3.2 Starch Yield

Starch yield from *Mangifera indica* cultivars ‘Gopalbhog’ and ‘Fazli’ kernels was measured to determine extraction efficiency linked with both varieties. With a total of 10 kg mangoes, Gopalbhog provided 1.25 kg kernels, covering 12.5% of the total fruit weight, while Fazli provided 0.98 kg kernels weighing 9.8% of the fruit weight. Extraction of starch from these kernels provided a yield of 315 g (25.2% kernel weight) for Gopalbhog and 204 g (20.8% kernel weight) for Fazli, as illustrated in Fig. 3.

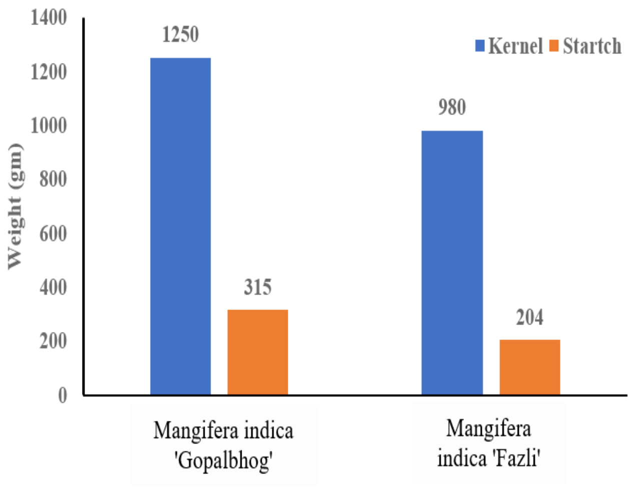

Fig. 3: Representation of yield of starch from MKS by block diagram

The yields listed agree with previous mango kernel starchy studies: for the Chokanan mango kernel, the application of a water–salt extraction (WSE) method produced 28.59% starchy content, while water extraction (WE), and alkali extraction (AE) yielded 15.51%, and 22.73%, respectively [17]. Given the fact that the methodology applied cold sedimentation after aqueous blending , the yields of 25.2% (Gopalbhog), and 20.8% (Fazli), therefore, fall within the reported interval of wet processes and are very close to AE/WSE standards once the varietal, and procedure-related deviations are considered. Given the fact the original moisture content of the kernel was not evaluated, the yields presented are given based on fresh-kernel weight; future studies will normalize yields to dry kernel mass so the yields may be directly compared to previously established reports. The relatively bigger size of Fazli mangoes both in terms of fruit as well as kernel size compared to that for Gopalbhog did not translate into greater kernel yield. Instead, it was observed that Fazli provided less mature kernels even at full ripeness. This may explain the lower starch yield from Fazli kernels. The relatively greater yield from Gopalbhog may largely be attributed to fully grown kernels from this variety having greater deposition of starchy materials. The findings point to Gopalbhog having greater efficiency in terms of both kernel proportion and per kernel starchy content suitable for extraction and thus highlight kernel maturity and varietal difference in determining starch yield.

3.3 Water Absorption Capacity (WAC)

The WAC of extracted *Mangifera indica* ‘Gopalbhog’ and ‘Fazli’ kernel starch was measured to assess their hydratability. A sample weighing one gram was taken in a 15 mL centrifuge tube followed by addition of 10 mL of distilled water. The solution was centrifuged at 6000 rpm for 5 min and was left undisturbed. The supernatant was carefully removed, and the weight of swollen starch was recorded [18]. The masses of swollen starch turned out to be 2.522 g and 2.2461 g for Gopalbhog and Fazli, respectively. The WAC values by using mentioned formula (1) turned out to be 152.2% and 146.1%, respectively. The comparative evaluation is displayed in Fig. 4.

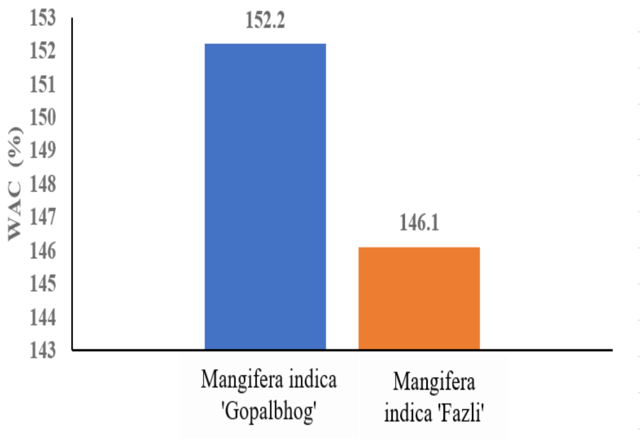

Fig. 4: Comparison of WAC among *Mangifera indica* ‘Gopalbhog’ and *Mangifera indica* ‘Fazli’.

Although with widely varied water-absorption/holding ranges for mango seed starch across cultivars as also extraction/processing treatments (≈90.2%–185%) described this variation between 'Gopalbhog' (152.2%) and 'Fazli' (146.1%) lies within limits of literature variation [19], [20], which indicates the hydrophilicity of both samples to be the same. Further measurements should be undertaken repeatedly to ensure statistical significance and to relate WAC better to the starch microstructure and amylose–amylopectin composition.

The findings support that Gopalbhog starch exhibits slightly more WAC than Fazli starch. That disparity may arise from differences in granular structure, amylose-to-amylopectin ratio, and intrinsic porosity in these two mango varieties’ extracted starches. Greater WAC indicates greater hydratability and swelling capabilities, which would be desirable in food and industrial formulations having high water retentivity.

3.4 UV-Visible Absorption Spectroscopy

UV–Vis absorption spectra from *Mangifera indica* ‘Gopalbhog’ and ‘Fazli’ starches (Fig. 5) show intense absorbance in the ultraviolet (≈200–300 nm), a range characteristic of native starches and indicative of electronic transitions from hydroxyl, carbonyl, or residual impurities. This agrees with results in other literature: bands around ~240 nm and ~270 nm in flour samples were related to protein/phenolic-type impurities instead of amylose or amylopectin [21]. Quantitative measurement was integrated to reveal these spectral shifts. Peak absorbance (λmax) was 211 nm for Gopalbhog, where the corresponding absorbance was 1.122, and 213 nm for Fazli, the absorbance of which was 0.532. Baseline correction was performed using distilled water as the reference blank to eliminate instrumental background noise. Greater absorbance intensity of the Gopalbhog starch does not necessarily equate to higher purity but may be the result of slight deviations of chromophoric residue content, traces of protein or phenolic substance, or amylose/amylopectin ratio**.** Absorption absence significantly past ~300 nm outwards towards the visible region ensures that the two starches are relatively pure and bear no strong visible chromophores.

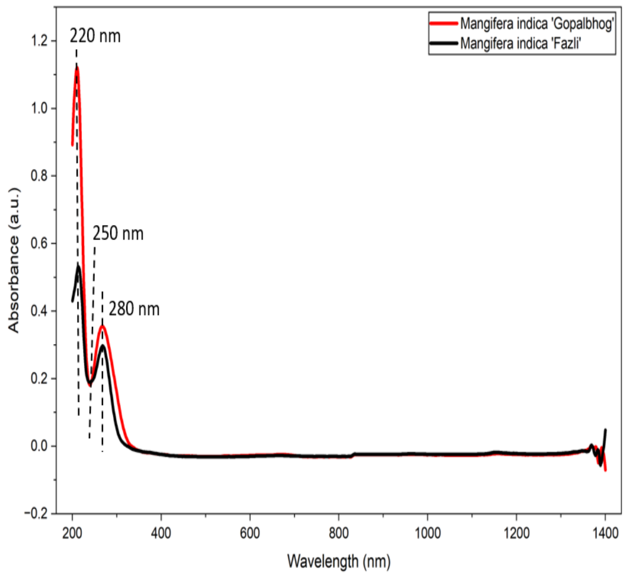

Fig. 5: UV-visible absorption spectroscopy of *Mangifera indica* ‘Gopalbhog’ and ‘Fazli’

This baseline-corrected observation confirms that both starches exhibit minimal visible absorption, consistent with native polysaccharides lacking conjugated double-bond systems. Comparable UV absorption (200–400 nm) with minimal visible absorption has also been documented in starch-based films, evidencing that the starch by itself does not impart visible coloration unless modified or mixed with other compounds [22].

3.5 Appearance Of Extracted Starch

The Mangifera indica ‘Gopalbhog’ starch was seen to be a vivid white, while ‘Fazli’ had a faint off-white appearance. These visually apparent differences reflect the UV-Visible absorbance spectra in that ‘Gopalbhog’ had larger absorbance levels at ultraviolet wavelengths, which would tend to indicate it might be purer or contain fewer colored impurities than ‘Fazli’ starch as shown in Fig.6. These spectral differences often reflect differing molecular makeup as well as trace residual compounds influencing apparent coloration in the starch.

Fig. 6: Appearance of *Mangifera indica* ‘Gopalbhog’ and *Mangifera indica* ‘Fazli’

3.6 Mechanistic Discussion

The compositional and microscopic characteristics of the starch are the key to the definitive functional characteristics displayed by the two mango varieties. Those starches containing higher amylopectin content generally have higher water absorptions and swelling because of the branched nature and increased sites of hydration, while amylose-rich or more crystalline area inhibits water access, leading to reduced WAC. ‘Gopalbhog’ having slightly higher values of the A_{1047}/A_{1022} ratio means higher short-order molecular packing, well matching the comparatively lower water uptake by the variety relative to ‘Fazli’. ‘Fazli’ would, therefore, contain a slightly higher fraction of amorphous sections or shorter amylopectin branches, favoring hydration and swelling.Such compositional changes may even impact spectral contrasts within the UV–Vis region, through the slight modifications of absorbance intensity within the 200–300 nm region, resulting from the action of retained phenolic compounds or protein–polysaccharide interactions.

4. Conclusion

This research effectively recovered and identified the starch of the Mangifera indica varieties ‘Gopalbhog’ and ‘Fazli’ seed kernels. Though the ‘Fazli’ variety presented the larger kernel size, relative immaturity made the yield of the starch lower (204 g; 20.8 %) than ‘Gopalbhog’s’ yield (315 g; 25.2 %). Functional tests showed the ‘Gopalbhog’-extracted starch to present higher water-absorption ability (152.2 %) and higher, though slightly increased, crystallinity, while ‘Fazli’ presented higher hydrophilia and higher swelling ability (146.1 %). UV–Vis spectral scanning confirmed both the starch varieties to be largely polysaccharidic, including slight color impurities. Variations in starch types have a significant impact on their industrial applicability: the enhanced intermolecular arrangement of ‘Gopalbhog’ starch supports uses that necessitate film durability and barrier performance, including biodegradable coatings and packaging films, while the increased hydratability of ‘Fazli’ starch renders it more appropriate for hydrogels, adhesives, or composite formulations that depend on moisture retention. Applicability of the packaging of the biodegradable material is substantiated by the present literature [23], where the mango-seed-derived bioplastics were reported to have low water-vapor permeability (2.16×10^{-7}–6.29×10^{-7} $g\cdot day^{-1}\cdot m^{-1}\cdot Pa^{-1}$).In general, starch yield, crystallinity, and hydrophilicity differ by cultivar, and therefore, selective selection of mango varieties may tailor starch functionality specifically for green-biopolymer applications.

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8. Nomenclature

Symbol	Meaning	Unit
FTIR	Fourier Transform Infrared Spectroscopy	-
UV-Vis	Ultraviolet-Visible spectroscopy	-