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Tailoring Assam Magic Rice Starch through Oxidative Modification for Enhanced Pharmaceutical Applications

Asha Das [a, c], Abdul Baquee Ahmed [b, c, *], Zartaj Washmin Banu[c], Tapash Chakraborty [c], Jun Moni Kalita [c]

[a] Assam Science and Technology University, Guwahati, Assam, India

[b] School of Pharmaceutical Sciences, Girijananda Chowdhury University, Tezpur, Assam, India.

[c] School of Pharmaceutical Sciences, Girijananda Chowdhury University, Guwahati, Assam, India.

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KEYWORDS
Starch, Assam Magic Rice,Isolation, Characterization, modification, Physicochemical Properties

ABSTRACT:

Objective:

To evaluate the physicochemical properties and oxidative modification of starch isolated from Assam Magic Rice (Komal Chawl) and assess its suitability as a pharmaceutical excipient.

Methods:

Native starch was extracted by alkaline deproteination method and oxidized using sodium hypochlorite. Characterization was performed by Fourier-Transform Infrared (FTIR) spectroscopy, Differential Scanning Calorimetry (DSC), X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Rapid Visco Analyzer (RVA). Functional properties were determined through swelling power (SP), water solubility index (WSI), particle size distribution, and micromeritic parameters (Carr's Index, Hausner's Ratio).

Results:

FTIR confirmed oxidation by the appearance of carbonyl bands at ~1711 cm^{-1}. DSC showed a reduction in peak gelatinization temperature from ~80 °C (native) to ~65 °C (oxidized). XRD indicated a shift from A-type to Vh-type crystallinity. SEM revealed rougher granule morphology, and dynamic light scattering showed a decrease in particle size from 655 nm to 280 nm. Amylose content decreased from 17.2% to 14.0% and amylopectin from 56.8% to 35.0%. Flow properties improved, with Carr's Index reduced from 30.35% to 22.93% and Hausner's Ratio from 1.36 to 1.24. Oxidized starch exhibited greater hydrophilicity, lower swelling power, and enhanced solubility.

Conclusion:

Oxidative modification of Assam Magic Rice starch produced significant structural, thermal, and functional changes. The modified starch demonstrated improved micromeritic properties, reduced particle size, and superior hydrophilicity, supporting its potential application as a direct compression and controlled-release pharmaceutical excipient.

1. Introduction

Rice (Oryza sativa L.) is one of the most significant cereal crops globally, serving as a primary source of nutrition for a substantial portion of the human population. In densely populated Asian countries such as India, China, Indonesia, Japan, Iran, Korea, Pakistan, Sri Lanka. India, the second-largest producer of white rice globally, contributes about 20% of the world's

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production, serving as a dietary staple in its eastern and southern regions. Rice, a key carbohydrate source with starch stored in its endosperm, is consumed naturally (e.g., cereal grains) and diversely used in foods like bakery items, confectionery, baby foods, ice cream, meat products, snacks, soups, and soft drinks. Additionally, starch also serves as a substrate for producing its hydrolysis products such as glucose syrups and maltodextrins [1], [2].

The indigenous rice germplasm of the state, Assam boasts vast genetic diversity, with Bora (glutinous) and Chokuwa (semi-glutinous) rice, key to Assamese culture, grown during the wet season despite their low yield potential. Chokuwa rice, valued for its commercial and cultural significance in Assam, is used in breakfast, social, and religious ceremonies. Known locally as 'Komal Chawl' (soft rice) or Assam Magic Rice (AMR), it becomes soft but not sticky when cooked. The defining characteristic of this group of rice is that, Parboiled Chokuwa rice softens with water soaking and can be eaten directly with curd, milk, or curry without cooking [2].

AMR has gained attention for drug delivery applications, with its starch showing comparable efficacy as a binder in studies. Studies have also shown AMR starch to be a promising direct compression agent and excipient. However, The use of native starch as an excipient is limited by its moisture adsorption, which can alter its structure and affect the drug's biopharmaceutical and pharmacokinetic properties [3], [4], [5].

To enhance the applicability of starch in drug delivery and other industrial sectors, Starch's physicochemical and physico-mechanical properties can be tailored for drug delivery and industrial uses through physical, chemical, genetic, or enzymatic modifications targeting its hydroxyl groups. Chemical modification, widely studied for its non-destructive nature, enhances oxidized starch's functional properties, improving characteristics like gelatinization, pasting, solubility, swelling, and retrogradation, influenced by the starch's genetic origin and reaction conditions [6].

This study was designed to comprehensively characterize the physicochemical and functional properties of starch extracted from AMR. Additionally, it aimed to explore the effects of oxidation modification on the starch to enhance its functional attributes. The investigation focused on evaluating the potential of the modified starch for applications in pharmaceutical industries, particularly as an excipient in drug formulation and delivery systems, thereby contributing to its broader industrial utility.

2.Materials and Methods:

2.1.Materials:

Samples of AMR were procured from local farmers in the Chhaygaon region of Kamrup (Rural) district, Assam, India, during the months of November and December. All other reagents and chemicals utilized in the study were of analytical grade and were used as received, without any additional purification.

2.2.Extraction of starch from AMR:

The alkaline (0.2 %NaOH) de-proteination method was followed to isolate the starch from AMR. The rice samples were dehulled using traditional equipment known as Ural and subsequently ground into powder using a laboratory grinder. Approximately 500 g of rice flour (sieved through #44 mesh) was mixed with a sufficient volume of 0.2% sodium hydroxide (NaOH) solution. The mixture was stirred for 4 hours using a magnetic stirrer and then stored overnight under refrigerated conditions (2–8 °C) to allow the starch granules to settle. After decanting the supernatant, fresh NaOH solution was added to the settled granules, and the mixture was stirred again for 4 hours at room temperature. The procedure was repeated four times to isolate the solid starch phase, which was washed with 0.2% NaOH, blended, and filtered. The starch was subsequently blended with distilled water for washing, followed by continuous stirring for 4 hours. The solid starch phase was washed multiple times until it reached a neutral pH (pH 7). The starch residue was then collected and dried in a hot air oven at 40 °C for 72 hours. The dried starch was ground into a fine powder, sieved, and stored in a desiccator for further analysis. This method followed the protocol outlined by Pachau et al. (2018), with slight modifications [7].

2.3. Preparation of oxidised AMR Starch:

The oxidation modification of AMR (native starch) was performed following the method described by Biduski et al. (2016), with minor modifications [8]. A starch dispersion (35gm) with distilled water (100 mL) was prepared in a glass reactor, heated at 40 °C; and then the pH was adjusted to 9.5 with NaOH (0.5 mol/L) solution.

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Sodium hypochlorite was gradually introduced into the starch dispersion (1.5 g active chlorine per 100 g of starch, dry basis) over 30 minutes, with the pH maintained at 9.5 using 1mol/L NaOH and 1 mol/L hydrochloric acid (HCl) for an additional 50 minutes. The reaction was then neutralized using 1mol/L HCl. The starch slurry was subsequently filtered and rinsed with distilled water before being dried in a hot air oven at 40 °C for 18 hours.

2.4. pH, ash value and moisture content:

The pH of the samples was measured using a digital pH meter (Mettler Toledo, Seven Compact™ S210). A 20% (w/v) dispersion of both AMR starch (native starch) and oxidized AMR starch (oxidized starch) was prepared in distilled water, stirred for 10 minutes, and then analysed for pH. The ash content was determined for both samples by weighing 2.5 g of each sample. The samples were initially heated over a burner in air to remove smoke, followed by combustion at 550 °C in a muffle furnace. The percentage ash content for both oxidized and native starches, was calculated by dividing the weight of the ash by the oven-dry weight of the powdered sample. Moisture content was determined using Equation 1 and expressed as the percentage of weight loss during drying (% LOD). A sample size of 2.5 g was dried at 105 °C in an oven for 5 hours, with drying continued until the weight remained constant between successive measurements [7]

Equation 1:LOD

$$LOD = \frac{Weight\ of\ water\ in\ sample}{Total\ weight\ of\ wet\ sample} \times 100$$

2.5. Particle size:

The polydispersity index (PDI) and particle size distribution of the nanoparticles were analysed using Dynamic Light Scattering (DLS) with a Zetasizer (Malvern Nano S90). The average apparent diameter (D) and PDI were measured at a temperature of 25°C with a detection angle fixed at 90°. Prior to analysis, the nanoparticles were dispersed in distilled water [9].

2.6. Determination of swelling power (SP) and WSI:

The SP and WSI of native and oxidized starch samples were determined following the method described by Gani et al. (2012), with slight modifications [10]. Initially, 0.5 g of starch samples were dispersed in 25 mL of distilled water in a test tube which was then heated at 75 °C for 30 minutes in a water bath, with continuous and vigorous shaking at 5-minute intervals. The mixture was then centrifuged at 3000 rpm for 15 minutes, and the supernatant was carefully decanted onto a petri dish. The supernatant was subsequently dried in an oven at 105 °C for 10 hours. The dried residues from both the supernatant and the sediment were then weighed. The SP and WSI were determined using the following equations:

Equation 2: Water solubility Index

$$WSI = \frac{Weight\ of\ Sediment}{Weight\ of\ dry\ sample} \times 100$$

Equation 3: Swelling Power

$$SP = \frac{Weight\ of\ Sediment}{(Weight\ of\ dry\ starch\ sample \times 100 - WSI)} \times 100$$

2.7. Pasting properties:

The pasting properties of the rice starches were analysed using a Rapid Visco Analyzer (Rheolab QC, Anton Paar, Austria). Method for determination of pasting properties was followed from Ashogbon et. al 2012 with modifications [11]. 3g sample of both native and oxidised starch was dispersed in 25mL of water and stirred within an RVA container.

2.8. Amylose and Amylopectin content:

The previously described method, which uses the idea of Iodine binding, that amylase's helical coils absorb iodine to produce a blue complex that can be detected colorimetrically, was modified to ascertain the amount of amylose and amylopectin [12]. In short, 100 mg of the powdered sample was weighed with addition of 1 mL of ethanol, followed by 10 mL of 1 N NaOH, and was left overnight. The volume was adjusted to 100 mL. 2.5 mL of the sample was taken; 20 mL of distilled water was added followed by 3 drops of phenolphthalein. It was Titrated with 0.1 N HCl until the pink colour disappears. 1mL of iodine reagent was added, and the volume was adjusted to 50 mL, then the absorbance was read at 590 nm. Prepare standard amylase solutions (0.2, 0.4, 0.6, 0.8, and 1 mL), develop the colour using the same procedure, and generate a standard curve. Dilute 1mL of iodine reagent to 50mL with distilled water for the blank. Calculate the amount of amylose in the sample using the standard curve and the following equation:

Absorbance corresponds to 2.5ml of test solution = ‘x’ mg amylose

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100 ml contains = (‘x’ ÷ 2.5) × 100mg amylose = % amylose

The amylopectin content is determined by subtracting the amylose content from the total starch content.

2.9.DSC analysis:

DSC analysis of native and oxidized starch samples was conducted using a DSC instrument (METTLER TOLEDO) over a temperature range of 40 °C to 350°C. The heating rate was set to 10°C/min, with nitrogen purging maintained at a flow rate of 20mL/min.

2.10. FTIR analysis:

FTIR spectroscopy was employed to identify the functional groups present in the starch samples. Additionally, the FTIR spectra were used to analyse any new functional groups introduced into the starch structure because of the modification. Absorbance measurements for both native and oxidized starch powders were recorded within the range of 400 to 4000 cm^{-1} using an FTIR spectrophotometer (Bruker, Model ALPHA).

2.11.SEM:

The morphological characteristics were examined using SEM. (Make: HITACHI, JAPAN, Model: SU8010 series). The analysis was performed for starch samples at an accelerating voltage of 15 kV.

2.12.XRD Analysis:

XRD analysis was conducted using an X’Pert Pro XRD system equipped with an x'Celerator solid-state detector. The starch samples were scanned over a 2θ range of 5° to 40° at a scanning rate of 4° per minute, with a step size of 0.02° throughout the measurement.

2.13. Micromeritics:

Micrometric properties have a direct impact on bulk flow, formulation uniformity, and surface area-dependent processes such as dissolution and chemical reactivity. Bulk and tapped densities were measured by placing 25 g of the sample into a 100 mL glass cylinder, followed by tapping the powder until a consistent volume was achieved. The angle of repose, Carr's compressibility index and Hausner's ratio were calculated by the following equation [13].

Angle of repose (θ) = tan -1h/r

Carr’s Index (CI) =Tapped density - Bulk density / Tapped density×100

Hausner ratio (HR) =Tapped density/bulk density

In this context, h and r denote the height and radius of the starch powder cone, respectively, which are utilized for the calculation of the angle of repose.

2.14. Statistical Analysis: Microsoft Excel was used to compare the native and oxidised starch groups across a number of parameters using an unpaired Student's t-test. A p-value of less than 0.05 was considered statistically significant.

3. Results and discussion:

3.1. Physiochemical Properties:

As presented in Table 1, the oxidized starch exhibited low swelling power, water solubility index compared to native starch. Swelling power was affected by oxidation process; it was observed that the swelling power was reduced from 8.46±0.41 % in native starch to 6.01±0.18 % in oxidised starch. The oxidation process leads to the depolymerization of both amylose and amylopectin chains, with amylose being more prone due to its linear structure and greater accessibility (Wang & Wang, 2003). Tester and Morrison (1990) reported that amylopectin is primarily responsible for the pasting and swelling properties of starch granules, while amylose and lipids act to inhibit granule swelling. Wang and Wang (2003) observed a reduction in the swelling power of oxidized common corn starch, aligning with these findings [14], [15].

In general, WSI increased with the extent of oxidation, with oxidized starches exhibiting higher WSI values compared to the native starch. This enhancement is likely attributable to improved hydration resulting from the introduction of new functional groups, consistent with previous reports [15], [16]. The water molecules in natural hydrocolloids like gum, starch facilitates the enzyme activation, which supports the development of living organisms. Excipients derived from natural sources, such as rice starch which are widely utilized in pharmaceuticals are required to be profiled for moisture content and several pharmacopoeias have established an acceptable moisture

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content limit of up to 15%. Which is complying with the reported moisture content in Table 1 [17]. The average particle size in Zeta Sizer of the native starch, 655nm varied from the oxidised starch, 280 nm indicating decrease in particle size after oxidation resonating with the findings of Okekunle et.al.2020 [18].

Table 1: Physicochemical Properties of native starch and oxidised starch.

Parameters	Native starch	Oxidised starch
Ash Value (%)	0.46±0.02	0.32±0.03
Moisture Content (%)	7.32±0.30	9.18±0.41
Swelling Power	8.46±0.41	6.01±0.18
Water Solubility Index (%)	3.17±0.23	5.57±0.29

Values are the means ±SD of n=3

3.2. Statistical Analysis:

To determine the significance of differences between native and oxidized starch samples, an unpaired two-tailed Student's t-test (assuming normality and equal variances) was performed for ash value, moisture content, water solubility index (WSI), and swelling power. The results showed that the ash value differed significantly between native (0.46 ± 0.02%) and oxidized starch (0.32 ± 0.03%) with t = 6.73 and p = 0.0025 (< 0.05), confirming a statistically significant reduction after oxidation. The moisture content was higher in oxidized starch (9.18 ± 0.41%) compared to native starch (7.32 ± 0.30%), though the difference was not statistically significant (t = –0.16, p = 0.88).

The swelling power decreased from 8.46 ± 0.41 % (native) to 6.01 ± 0.18 % (oxidized), also not statistically significant (t = 1.01, p = 0.34). The WSI increased from 3.17 ± 0.23 % (native) to 5.57 ± 0.29 % (oxidized), but this difference was not statistically significant (t = –1.59, p = 0.15). Although some differences were not statistically significant, the observed trends in reduced swelling power and increased solubility support the physicochemical modifications expected after oxidation. All statistical analyses were performed in Microsoft Excel (version 2021), and $p < 0.05$ was considered statistically significant.

3.3. Amylose and Amylopectin content:

Sticky or glutinous rice is such a special group of rice cultivars grown for its culinary and cultural importance throughout Northeast India and in Assam is classified into two groups Bora (Glutinous) and Chokuwa (Semi-glutinous) based on the amylose content [19]. Starch is composed of amylose and amylopectin, two highly polydisperse homopolymers of anhydroglucose, which occur in varying ratios depending on the botanical source, genetic factors, and environmental conditions[20]. The physical, textural, and pasting properties of rice starch are influenced by the ratio of amylose to amylopectin, as well as the branching structure of amylopectin molecules. Amylopectin consists of highly branched α-(1→6) glucan chains, whereas amylose is primarily composed of linear α-(1→4) glucan chains[20]. The amylose and amylopectin content of Native AMR and Modified AMR was found to be 17.20%, 56.80% and 14%, 35% respectively, Which aligns with the previous report that The amylose content in Komal Chawl (Chokuwa) variety of rice is around 10 to 20% and a higher level of amylopectin [19], [21]. with decreasing values after oxidation resonating with the studies on rice and corn starches oxidized by sodium hypochlorite showed that the amylose content decreased after oxidation, with amylose being more affected then amylopectin [22], [23]. resolving the problem of large nanoparticles with high amylose content [24]. The incomplete mass balance is because of the presence of minor starch components, such as lipids, proteins, moisture, ash, and other bound materials which reduces the combined percentage of amylose and amylopectin to less than 100%.[23]

Table 2: Amylose and amylopectin content.

Parameters	Native Starch
Amylose	17.20% *
Amylopectin	56.80%*

*On dry basis

3.4. FTIR and DSC

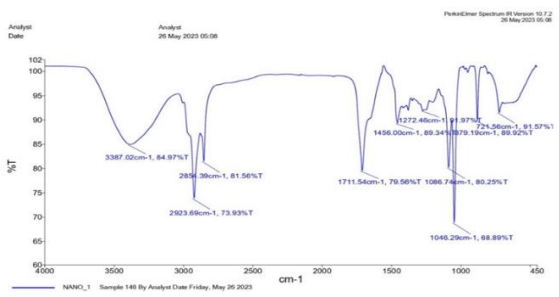

Figure 1: FTIR spectrum of native starch extracted from Assam Magic Rice (Komal Chawl), displaying

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characteristic absorption bands of starch. Key peaks include O–H stretching (~3269 cm⁻¹), C–H stretching (~2907 cm⁻¹), C–O–C stretching (~1149 cm⁻¹), and glycosidic linkage vibrations (~997 cm⁻¹), confirming the presence of intact polysaccharide functional groups.

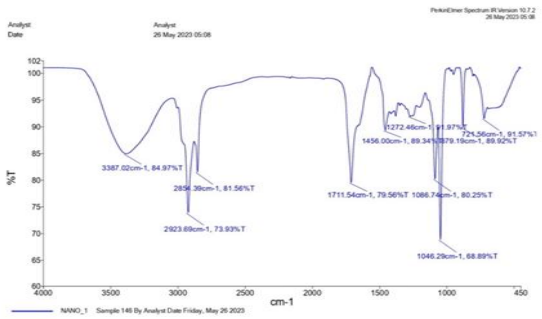

Figure 2: FTIR spectrum of oxidized starch from AMR, showing characteristic polysaccharide bands along with new functional group peaks introduced via oxidation. The appearance of a carbonyl stretching peak at ~1711 cm⁻¹ confirms the formation of carboxyl groups, while the decreased intensity of the O–H stretching band (~3209 cm⁻¹) indicates partial oxidation of hydroxyl functionalities.

The FTIR spectra tracing for both Native starch and oxidised starch displayed characteristic features typical of starch, as depicted in Figure 1. The presence of hydrogen bonding in starch was confirmed by a peak at 3209.51 cm¯1, corresponding to O–H stretching and vibrational modes characteristic of hydrogen bonds. peak in 2907 cm−1 and 1149 cm−1 which can be attributed to C-H bond stretching and C-O-C stretching respectively [25]. The Absorption peaks observed at 1633.77 cm¯1 and 997 cm¯1 were influenced by O-H bending and glycosidic bond vibrations [26]. On successful oxidation of the rice starch an additional absorption peak at 1711 cm−1 was observed it is assigned to the C= O stretching vibration (Figure 2). The results demonstrate that the native starch was effectively oxidized by sodium hypochlorite, and hydroxyl groups were changed to carbonyl/carboxyl groups [27]. Simultaneously, the intensity of the O-H stretching vibration weakened, suggesting that the native starch underwent successful oxidation by oxygen, with hydroxyl groups being converted into carbonyl and/or carboxyl groups (Table 3) [28].

Table 3 : Comparative FTIR Spectral Analysis of Native and Oxidized Starch Samples.

Feature	Native Starch	Oxidized Starch	Implication
O–H Stretch (~3300 cm⁻¹)	Strong, broad	Still present but less intense	Indicates partial oxidation of hydroxyl groups
C=O Stretch (~1710 cm⁻¹)	Absent	Present at 1711.54 cm⁻¹	Confirms introduction of carbonyl/carboxyl groups
C–O/C–H bands	Present at ~1150 –1000 cm⁻¹	Shifted, some more intense	Structural rearrangement due to oxidation
Fingerprint Region	Stable	Slight differences, new peaks	Starch backbone still present, with modifications

The DSC thermograms of native (S1) and oxidized (S2) starch samples reveal significant thermal transitions (**Error! Reference source not found.**), with the oxidized starch exhibiting a lower onset temperature (~38 °C), peak gelatinization temperature (~65 °C), and conclusion temperature (~115 °C) compared to the native starch (To ~42 °C, Tp ~80 °C, Tc ~120 °C). These shifts indicate a reduction in thermal stability and crystallinity of the starch granules due to oxidation. The reduced peak area in the oxidized starch also suggests a lower enthalpy of gelatinization, reflecting the disruption of intermolecular hydrogen bonding and a more amorphous structure.

Overall, the DSC analysis confirms that chemical oxidation of Komal Chawl starch weakens its granular integrity, decreases its thermal resistance, and enhances its processability, supporting its potential application in industries requiring modified starches with lower gelatinization thresholds.

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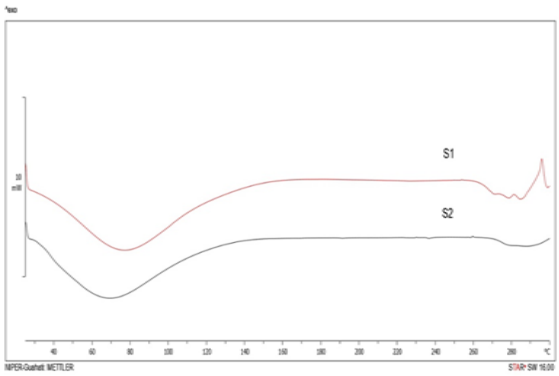

Figure 3: : DSC thermograms of native starch (S1) and oxidized starch (S2) derived from AMR. The oxidized starch (S2) exhibits a lower onset (~38 °C), peak (~65 °C), and conclusion (~115 °C) temperature compared to native starch (To ~42 °C, Tp ~80 °C, Tc ~120 °C), indicating reduced thermal stability and crystallinity due to oxidative modification.

Table 4: Thermal transitions of native and oxidized starch samples as determined by DSC.

Sample	Onset Temperature (To)	Peak Temperature (Tp)	Conclusion Temperature (Tc)	Observation
S1 (Native)	~42°C	~80°C	~120°C	Broad, strong endothermic peak — gelatinization of native starch
S2 (Oxidized)	~38°C	~65°C	~115°C	Lower, shifted endothermic peak — indicates reduced thermal stability

3.5. XRD:

X-ray diffraction serves as an essential technique for analysing alterations in the relative crystallinity patterns of starch granules under standardized conditions. The XRD pattern for native and oxidised starches is depicted in Figure 4. The XRD studies of the rice types at 2Θ of 17º, 18º, 19.5 ºand 23º confirmed that the native starch extracted from AMR is Type A starch showing the peaks at 15.06º, 17.01º, 18.06º and 23.15º. The oxidised starch showed difference in peak values, intensities and relative crystallinity which is in agreement to previous finding that there can be changes in the XRD pattern of native starch and hypochlorite oxidised starch [29].

The oxidised starch showed Vh type crystallinity [30], making it a chemically modified resistant starch (RS4) making it beneficial in ways such as low glycaemic index, stimulates the growth of good bacteria in gut, small particle size [31]. though the contribution of amylopectin in its Vh crystallinity is negligible additionally there is also no quantitative relation between Amylose content and Vh Crystallinity [32]

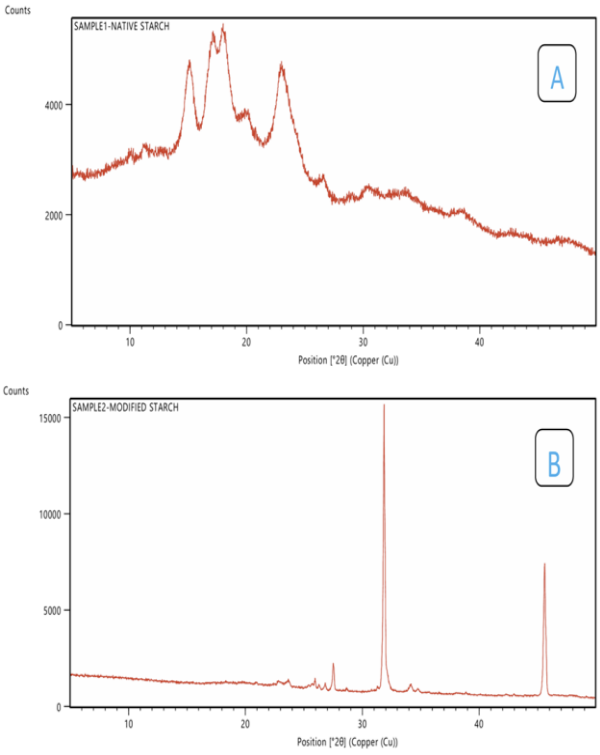

Figure 4: XRD patterns of starches extracted from AMR. (A) Native starch exhibits characteristic A-type crystallinity with peaks at 15.06°, 17.01°, 18.06°, and 23.15° (2θ). (B) Oxidized starch shows altered peak positions and reduced intensity, indicating a transition

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to Vh-type crystallinity, typically associated with chemically modified resistant starch (RS4).

3.6. Micromeritics:

Bulk and tapped densities offer essential information regarding the particle packing arrangement and the compaction behaviour of a powder. Hausner's ratio (HR) and Carr's index (CR) serve as quantitative measures of flowability and compressibility. Additionally, parameters such as angle of repose (AR) offer valuable information regarding the flow properties of powders. The United States Pharmacopoeia (USP) categorizes the flowability of powders and granules based on parameters such as Carr's Index (CI), Angle of Repose (AR) and Hausner's Ratio (HR). Powders with excellent flowability exhibit a CI of less than 10%, an HR of 1.00–1.11, and an AR of 25–30°. Good flowability corresponds to a CI of 11–15%, an HR of 1.12–1.18, and an AR of 31–35°, while fair flowability is defined by a CI of 16–20%, an HR of 1.19–1.25, and an AR of 36–40°. Passable flowability is indicated by a CI of 21–25%, an HR of 1.26–1.34, and an AR of 41–45°, whereas poor flowability is characterized by a CI of 26–31%, an HR of 1.35–1.45, and an AR of 46–55°. Additional classifications, such as "very poor", describe powders with increasingly limited flow properties [33]. The present study determined the flowability parameters for native starch and oxidized starch. The angle of repose was measured at41.44±0.58 ° and 39.01±0.20 °, Carr's index at 30.35±0.34 % and22.93±0.16 %, and Hauser's ratio at 1.36±0.04 and 1.243±0.04 for native starch and oxidized starch, respectively. These results indicate that oxidized starch exhibits enhanced flowability compared to native starch, aligning with the pharmacopoeia standards for flowability parameters.

Table 5: Flowability characteristics of native and oxidised starch.

Parameters	**Native starch**	**Oxidised Starch**
Bulk Density	0.399±0.01	0.448±0.03
Tapped Density	0.535±0.03	0.640±0.04
Carr's index	30.35±0.34	22.93±0.16
Hausner's ratio	1.36±0.04	1.24±0.04
Angle of repose	41.44±0.58	39.01±0.20

Values are the means ±SD of n=3

3.7. Pasting Properties:

Table 6: characteristics parameters of pasting properties of native and oxidised starch

Sample	Peak viscosity (cp)	Through (cp)	Breakdown (cp)	Final Viscosity (cp)	Peak time
Native Starch	376± 4	17.1± 0.1	358.7± 0.6	17.1± 0.1	12.0± 0.05
Oxidised Starch	251± 4	19.4± 0.1	230.9± 0.4	19.4± 0.1	12.0± 0.05

Values are the means ±SD of n=3

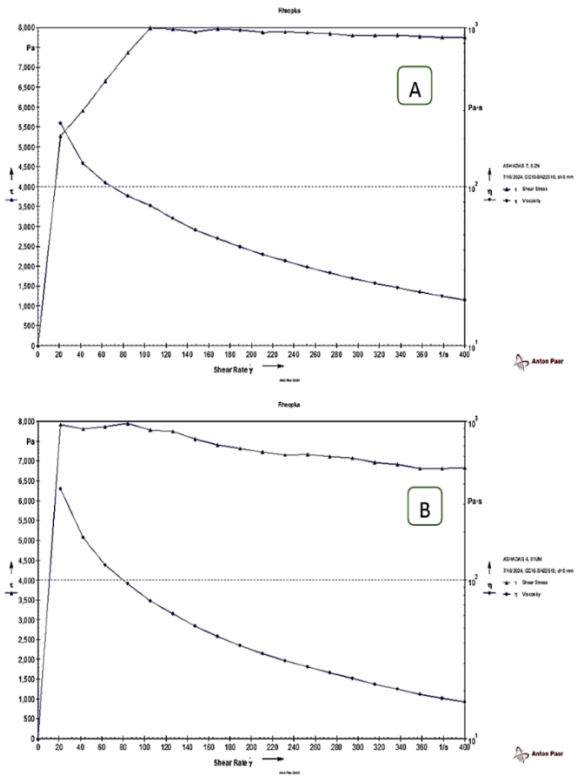

Figure 5 Pasting profiles of rice starches from AMR analysed under standard heating conditions (95 °C for 13 minutes), where η = viscosity, τ = shear stress, γ̇ = shear rate. (A) Native starch and (B) oxidized starch

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both exhibit pseudoplastic, shear-thinning behaviour. Oxidized starch shows reduced peak viscosity and stability, indicating modified gelatinization and flow characteristics suitable for pharmaceutical and food applications.

Figure 5 shows the viscograms of native starch and Oxidised Starch at three different shearing rate 0 to 400s- and it was observed that in standard heating mode both the native starch and Oxidised Starch showed pseudoplasticity with viscosity rapidly decreasing with increasing shear rate, shear thinning behaviour, these findings are consistent with the pasting characteristics reported in table 6. This also resonated with the reported findings by Zhu 2020[34].

3.8.SEM:

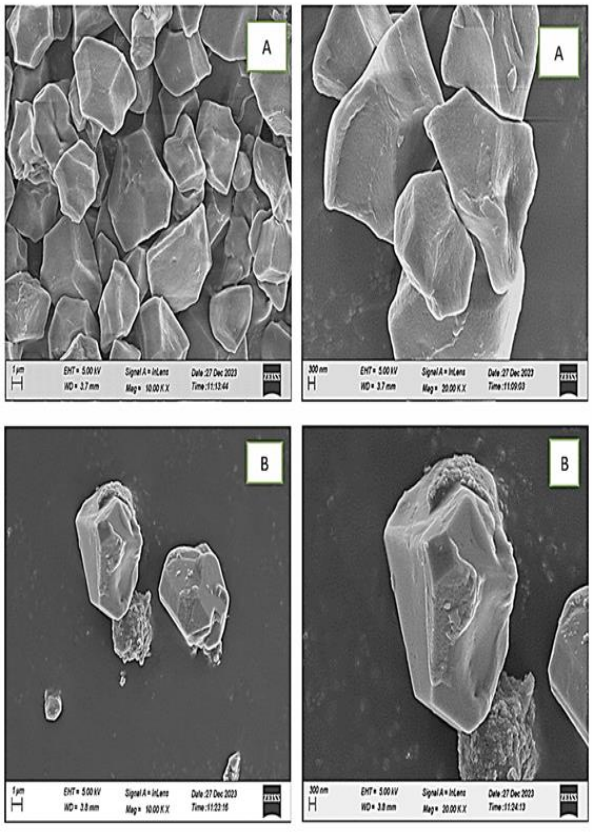

Figure 6: SEM images of starch granules extracted from AMR. (A) Native starch shows smooth, well-defined polyhedral granules. (B) Oxidized starch granules exhibit roughened surfaces and fissures, indicating structural disruption and surface erosion caused by sodium hypochlorite oxidation.

The morphology of starch granules was analysed using scanning electron microscopy (Figure 6). Consistent with previous studies, the micrographs of rice starch exhibited polyhedral granules in both native and oxidized forms [35]. It was observed that upon oxidation the starch granules showed rough surfaces compared to the native starch granules, this can be explained that the starch particles cracked upon oxidation due to starch crystalline structure weakening. Sangseethong et al. (2010) studied the effect of reaction time with hypochlorite and hydrogen peroxide on the physicochemical characteristics of cassava starch. Their findings revealed that oxidation with sodium hypochlorite resulted in granules with a rougher surface and noticeable fissures, Similar findings were also repeated by Varnier et al 2017 [16], [36], [37].

4.Conclusion:

In this work, the starch was successfully extracted and oxidatively modified from AMR, illustrating drastic modifications of its physicochemical and functional properties. Oxidation added carbonyl groups, decreased crystallinity, and changed thermal and pasting behaviour, as evidenced by FTIR, DSC, and XRD studies. The modified starch displayed better flow, decreased particle size, and increased water solubility—attributes beneficial for use in pharmaceuticals. Morphological alterations seen through SEM further validated structural modification. These results suggests that oxidised AMR starch has potential as a versatile excipient. However further investigation is required including direct formulation studies and drug delivery evaluations with model drugs to fully validate its pharmaceutical applicability.

References:

[1] D. K. Reddy and M. G. Bhotmange, “Isolation of starch from rice (Oryza sativa L.) and its morphological study using scanning electron microscopy,” *International Journal of Agriculture and Food Science Technology*, vol. 4, no. 9, pp. 859–866, 2013.

[2] R. P. Borkakati, R. K. Chowdhury, K. Kurmi, and R. C. Borah, “Biochemical parameters in indigenous Chokuwa (semi glutinous) rice of Assam and their variability,” *New Agriculturist*, vol. 24, no. 2, pp. 185–188, 2013.

[3] P. Rajak, L. K. Nath, and B. Bhuyan, “Application of Assam Bora Rice Starch as a Binder in Formulation of Paracetamol Tablets,” *International Journal of Pharmacy and Pharmaceutical Sciences*, vol. 6, no. 5, pp. 118–120, 2014.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 695-705 | ISSN:2251-6727

[4] M. Z. Ahmad, S. Akhter, M. Anwar, M. Rahman, M. A. Siddiqui, and F. J. Ahmad, "Compactibility and compressibility studies of *Assam Bora* rice starch," *Powder Technology*, vol. 224, pp. 281–286, July 2012, doi: 10.1016/j.powtec.2012.03.004.

[5] P. Kalita, A. B. Ahmed, S. Sen, and R. Chakraborty, "Citric acid esterified Glutinous Assam bora rice starch enhances disintegration and dissolution efficiency of model drug," *International Journal of Biological Macromolecules*, vol. 227, pp. 424–436, Feb. 2023, doi: 10.1016/j.ijbiomac.2022.12.149.

[6] N. Masina *et al.*, "A review of the chemical modification techniques of starch," *Carbohydrate Polymers*, vol. 157, pp. 1226–1236, Feb. 2017, doi: 10.1016/j.carbpol.2016.09.094.

[7] L. Pachuau, R. S. Dutta, T. B. Devi, D. Deka, and L. Hauzel, "Taro starch (*Colocasia esculenta*) and citric acid modified taro starch as tablet disintegrating agents," *International Journal of Biological Macromolecules*, vol. 118, pp. 397–405, Oct. 2018, doi: 10.1016/j.ijbiomac.2018.06.086.

[8] B. Biduski *et al.*, "Impact of acid and oxidative modifications, single or dual, of sorghum starch on biodegradable films," *Food Chemistry*, vol. 214, pp. 53–60, Jan. 2017, doi: 10.1016/j.foodchem.2016.07.039.

[9] O. Adeoye and G. Alebiowu, "Flow, packing and compaction properties of novel coprocessed multifunctional directly compressible excipients prepared from tapioca starch and mannitol," *Pharmaceutical Development and Technology*, vol. 19, no. 8, pp. 901–910, Dec. 2014, doi: 10.3109/10837450.2013.840843.

[10] A. Gani, S. Wani, F. Masoodi, and R. Salim, "Characterization of rice starches extracted from Indian cultivars," *Food sci. technol. int.*, vol. 19, no. 2, pp. 143–152, Apr. 2013, doi: 10.1177/1082013212442189.

[11] A. O. Ashogbon and E. T. Akintayo, "Morphological, functional and pasting properties of starches separated from rice cultivars grown in Nigeria," *International Food Research Journal*, vol. 19, no. 2, pp. 665–671, 2012.

[12] I. M. Park, A. M. Ibáñez, and C. F. Shoemaker, "Rice Starch Molecular Size and its Relationship with Amylose Content," *Starch Stärke*, vol. 59, no. 2, pp. 69–77, Feb. 2007, doi: 10.1002/star.200600568.

[13] L. Pachuau, H. Lalhlenmawia, and B. Mazumder, "Characteristics and composition of Albizia procera (Roxb.) Benth gum," *Industrial Crops and Products*, vol. 40, pp. 90–95, Nov. 2012, doi: 10.1016/j.indcrop.2012.03.003.

[14] R. F. Tester and W. R. Morrison, "Swelling and Gelatinization of Cereal Starches. I. Effects of Amylopectin, Amylose, and Lipids," *Cereal Chemistry*, vol. 67, no. 6, pp. 551–557, 1990.

[15] Y.-J. Wang and L. Wang, "Physicochemical properties of common and waxy corn starches oxidized by different levels of sodium hypochlorite," *Carbohydrate Polymers*, vol. 52, no. 3, pp. 207–217, May 2003, doi: 10.1016/S0144-8617(02)003041.

[16] N. L. Vanier, S. L. M. El Halal, A. R. G. Dias, and E. Da Rosa Zavareze, "Molecular structure, functionality and applications of oxidized starches: A review," *Food Chemistry*, vol. 221, pp. 1546–1559, Apr. 2017, doi: 10.1016/j.foodchem.2016.10.138.

[17] R. C. Rowe, P. J. Sheskey, and M. E. Quinn, Eds., *Handbook of Pharmaceutical Excipients*, 6th ed. London, UK and Washington, DC, USA: Pharmaceutical Press and American Pharmacists Association, 2009.

[18] M. O. Okekunle, K. O. Adebowale, B. I. Olu-Owolabi, and A. Lamprecht, "Physicochemical, morphological and thermal properties of oxidized starches from Lima bean (Phaseolus lunatus)," *Scientific African*, vol. 8, p. e00432, July 2020, doi: 10.1016/j.sciaf.2020.e00432.

[19] S. Roy *et al.*, "Genetic diversity analysis of specialty glutinous and low-amylose rice (Oryza sativa L.) landraces of Assam based on Wx locus and microsatellite diversity," *J Biosci*, vol. 45, no. 1, p. 86, June 2020, doi: 10.1007/s12038-020-00059-w.

[20] J. M. Herrero-Martínez, P. J. Schoenmakers, and W. Th. Kok, "Determination of the amylose–amylopectin ratio of starches by iodine-affinity capillary electrophoresis," *Journal of Chromatography A*, vol. 1053, no. 1–2, pp. 227–234, Oct. 2004, doi: 10.1016/j.chroma.2004.06.048.

[21] S. Rathi and R. N. Sarma, "Microsatellite diversity in indigenous glutinous rice landraces of Assam," *Indian Journal of Biotechnology*, vol. 11, no. 1, pp. 23–29, 2012.

[22] "A comparison of native and acid thinned normal and waxy corn starches: Physicochemical, thermal, morphological and pasting properties," *LWT - Food Science and Technology*, vol. 40, no. 9, pp. 1527–1536, Nov. 2007, doi: 10.1016/j.lwt.2006.12.012.

[23] S. Risdhiyanti Nuswantari, "Effect of Chemical Modification By Oxidation and Esterification Process On Properties of Starch: A Review,"

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 695-705 | ISSN:2251-6727

Eduvest, vol. 2, no. 12, pp. 2885–2896, Dec. 2022, doi: 10.59188/eduvest.v2i12.709.

[24] H. Marta, D. I. Rizki, E. Mardawati, M. Djali, M. Mohammad, and Y. Cahyana, "Starch Nanoparticles: Preparation, Properties and Applications," *Polymers*, vol. 15, no. 5, p. 1167, Feb. 2023, doi: 10.3390/polym15051167.

[25] R. Colussi *et al.*, "Structural, morphological, and physicochemical properties of acetylated high-, medium-, and low-amylose rice starches," *Carbohydrate Polymers*, vol. 103, pp. 405–413, 2014, doi: 10.1016/j.carbpol.2013.12.070.

[26] P. Kalita, A. B. Ahmed, S. Sen, L. Pachuau, and M. Phukan, "Synthesis and characterization of citrate soft rice starch: A new strategy of producing disintegrating agent for design drug and resistant starch," *International Journal of Biological Macromolecules*, vol. 240, p. 124475, June 2023, doi: 10.1016/j.ijbiomac.2023.124475.

[27] Y.-R. Zhang, X.-L. Wang, G.-M. Zhao, and Y.-Z. Wang, "Preparation and properties of oxidized starch with high degree of oxidation," *Carbohydrate Polymers*, vol. 87, no. 4, pp. 2554–2562, Mar. 2012, doi: 10.1016/j.carbpol.2011.11.036.

[28] X. Chen, S. Yan, H. Wang, Z. Hu, X. Wang, and M. Huo, "Aerobic oxidation of starch catalyzed by isopolyoxovanadate Na4Co(H2O)6V10O28," *Carbohydr Polym*, vol. 117, pp. 673–680, Mar. 2015, doi: 10.1016/j.carbpol.2014.10.066.

[29] D. Kuakpetoon and Y.-J. Wang, "Structural characteristics and physicochemical properties of oxidized corn starches varying in amylose content," *Carbohydrate Research*, vol. 341, no. 11, pp. 1896–1915, Aug. 2006, doi: 10.1016/j.carres.2006.04.013.

[30] A. Buléon, P. Colonna, V. Planchot, and S. Ball, "Starch granules: structure and biosynthesis," *International Journal of Biological Macromolecules*, vol. 23, no. 2, pp. 85–112, Aug. 1998, doi: 10.1016/S0141-8130(98)00040-3.

[31] Z. Ma and J. I. Boye, "Research advances on structural characterization of resistant starch and its structure-physiological function relationship: A review," *Crit Rev Food Sci Nutr*, vol. 58, no. 7, pp. 1059–1083, May 2018, doi: 10.1080/10408398.2016.1230537.

[32] D. M. Dries, S. V. Gomand, J. A. Delcour, and B. Goderis, "V-type crystal formation in starch by aqueous ethanol treatment: The effect of amylose degree of polymerization," *Food Hydrocolloids*, vol. 61, pp. 649–661, Dec. 2016, doi: 10.1016/j.foodhyd.2016.06.026.

[33] "United States Pharmacopeia General Chapter 〈1174〉: Powder Flow." The United States Pharmacopeial Convention, May 2024. [Online]. Available: https://www.uspnf.com

[34] L. Zhu *et al.*, "Characteristics of pasting properties and morphology changes of rice starch and flour under different heating modes," *International Journal of Biological Macromolecules*, vol. 149, pp. 246–255, Apr. 2020, doi: 10.1016/j.ijbiomac.2020.01.161.

[35] B. Arns *et al.*, "Impact of heat-moisture treatment on rice starch, applied directly in grain paddy rice or in isolated starch," *LWT - Food Science and Technology*, vol. 60, no. 2, Part 1, pp. 708–713, Mar. 2015, doi: 10.1016/j.lwt.2014.10.059.

[36] K. Sangseethong, S. Lertphanich, and K. Sriroth, "Physicochemical Properties of Oxidized Cassava Starch Prepared under Various Alkalinity Levels," *Starch/Stärke*, vol. 61, no. 2, pp. 92–100, 2009, doi: 10.1002/star.200800048.

[37] Y. Azeh, Y. Paiko, A. Abubakar, B. Garba, and O. Ameh, "Isolation, Modification and Characterization of Tiger-Nut, Maize, Cassava and Potato Starch," *Journal of Applied Sciences and Environmental Management*, vol. 22, no. 5, p. 713, June 2018, doi: 10.4314/jasem.v22i5.21.