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# Preparation and characterization of carboxymethylcellulose obtained from groundnut shell (*Arachis hypogae*)

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## Abstract

Background: Carboxymethylcellulose (CMC) is a vital constituent in pharmaceuticals, foods, cosmetics and other various sectors. Cellulose is a natural biodegradable polysaccharide component found in the cell wall of plants. This study presents the preparation and characterization of carboxymethyl cellulose derived from the shell of *Arachis hypogaea* which is an agricultural waste product.

Method: Groundnut shell α-cellulose was first isolated from the powder using standard method. Groundnut shell CMC was synthesized from the α-cellulose by mercerization using sodium hydroxide which promotes hydroxyl group activation and then followed by etherification with monochloroacetic acid to modify the cellulose structure. Various characterization such as FTIR spectroscopy, X-ray diffraction and SEM imaging were done to determine the physical and structural characteristics of the resulting CMC. Groundnut shell CMC (GS-CMC) was examined for its physiochemical and micromeritic properties.

Result: The extraction yield of GS- CMC was about 72% with a swelling index of 46.7%. GS- CMC exhibited excellent flow with an angle of repose of 28.07° and Carr's index of 9.03%. The degree of Substitution (DS) obtained for GS-CMC is 2.2 which is indicative of high degree of substitution of carboxymethyl cellulose. The FTIR spectroscopy analysis of Groundnut shell CMC showed robust absorption band at 1587 cm which serves as confirmation for the presence of the COO group, signifying the successful Carboxymethylation process.

Conclusion: Carboxymethyl cellulose was successfully derivatized from α-cellulose obtained from groundnut shell powder. GS-CMC could possibly be explored further for its potential applications in the pharmaceutical industry.

**Keywords:** *Arachis hypogea;* Carboxymethylcellulose; Groundnut shell; α-cellulose; X-ray diffraction

## 1. Introduction

Cellulose is the one of the dominant biopolymer/natural polysaccharide on earth, forming the primary structural component of the cell walls of plants. Polymerized through β-1,4-glycosidic linkages of D-glucose, cellulose is a linear, hydrophilic, and biodegradable polymer primarily made up of carbon, hydrogen, and oxygen, classifying it as a carbohydrate [1].

Industrial use of cellulose began to gain momentum in 1870 when the Hyatt Manufacturing Company developed a cellulose-based polymer that could melt into a liquid and solidify into a hard, brittle form upon cooling. This innovation enabled the application of cellulose in numerous commercial products requiring a durable, thin coating [2]. However,

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until 1992, all cellulose was extracted exclusively from natural plant sources such as wood, cotton, and other fibrous materials. A major breakthrough occurred when Japanese chemists Kobayashi and Shoda successfully synthesized cellulose chemically, leading to cheaper and more efficient methods for large-scale production and advanced modification [2].

Structurally, cellulose consists of crystalline and amorphous regions and is typically integrated into a structural framework of hemicellulose, lignin, and inorganic extractives. Hemicellulose, although structurally distinct, plays a supporting role by forming a network that stabilizes the cellulose microfibrils. Unlike cellulose, hemicellulose is composed of various sugar units arranged in short chains. Lignin, a complex aromatic polymer, contributes to plant stiffness and resistance to microbial degradation [3, 4].

Among the numerous cellulose derivatives, carboxymethylcellulose (CMC) is one of the most important due to its solubility in water, film-forming capabilities, and ability to modify viscosity and stabilize emulsions. Carboxymethylcellulose is derived through the reaction between cellulose and monochloroacetic acid in the presence of an alkali-rich medium, introducing carboxymethyl groups onto the cellulose backbone [5]. The characteristics of carboxymethylcellulose are primarily determined by the degree of substitution (DS), which indicates the substitution level of hydroxyl groups present on the glucose units replaced by carboxymethyl groups. These characteristics influence its solubility, viscosity, ionic sensitivity, and overall performance in diverse applications such as pharmaceuticals, food processing, paper manufacturing, and biomedicine [6, 7]. In laboratory materials, cellulose is used as the coating of the stationary phase in thin layer chromatographic plates (TLC). Cellulose fibers are also used in liquid filtration, sometimes in combination with diatomite or other filtration media to increase a filter bed of inert materials. Cellulose is further utilized in making water loving and highly absorbent sponges.

In recent years, interest in alternative, sustainable cellulose sources have increased [8]. Agricultural waste products are particularly attractive due to their availability, natural, low cost, and environmental friendliness. One such material is the groundnut shell**,** the fibrous outer layer of *Arachis hypogaea L.*, commonly discarded during peanut processing. Groundnut shells, which constitute 21–29% of the fruit's total mass, are rich in lignocellulosic material, containing approximately 44.8% cellulose, 5.6% hemicellulose, and 36.1% lignin [9, 10]. Though high in lignin, making them less biodegradable, their abundant cellulose content makes them a promising feedstock for value-added products like CMC.

Utilizing groundnut shells not only adds value to agro-industrial waste but also supports the advancement of eco-friendly and cost-effective alternatives for commercial cellulose derivatives. However, comprehensive studies on the formulation and analysis of carboxymethylcellulose from this source remain limited. Therefore, this research seeks to prepare and characterize carboxymethylcellulose (CMC) derived from groundnut shell α-cellulose as an alternative cellulose source and provide useful insight into its applicability in pharmaceutical industrial and biomedical fields.

## 2. Materials and methods

### 2.1. Materials

The chemical reagents and materials outlined below were utilized through the study: sodium hydroxide (NaOH), isopropanol (75 mL), monochloroacetic acid (MCA), methanol, glacial acetic acid (90%), ethanol (70%), and distilled water. All reagents were of analytical grade. The raw material, groundnut (*Arachis hypogaea*) shells, were obtained locally from Ubogo Market, Udu Local Government Area, Delta State, Nigeria.

### 2.2. Sample pre-treatment

The groundnut shells were first thoroughly rinsed in distilled water to extract dirt and impurities. The washed husks were then dried in the sun for 120 hr and further dried in a hot-air oven at 50 °C for 48 hr to eliminate residual moisture. The dried shells were milled into fine powder and sieved with a 300 µm grading mesh screen to ensure particle uniformity.

### 2.3. Extraction of alpha-cellulose

Cellulose was isolated from the pre-treated groundnut shell powder using a modified method based on Adinugraha *et al.* [11] and Pushpamalar *et al.* [12]. A total of 200 g of groundnut shell powder were immersed in heated distilled water for 1 hr and extracted. The residue was then alkalized with 20% w/v NaOH in a 10:1 liquid-to-solid ratio and heated at 90–100 °C for 2 hr. The resulting slurry was sieved and washed numerous times with distilled water until a neutral pH was achieved. The recovered cellulose was oven-dried at 60 °C for 8 hr and weighed.

The cellulose yield (%) was determined using the following equation:

$$\%Y = \frac{\text{Mass of cellulose(g)}}{\text{Mass of groundnut shell(g)}} \quad \text{(Eqn. 1)}$$

### 2.4. Synthesis of groundnut shell carboxymethyl cellulose (GS-CMC)

Synthesis of carboxymethylcellulose from groundnut shell-derived cellulose involved two major steps which comprises of alkalization and etherification carried out under a heterogeneous reaction condition.

For alkalization, 50 g of dried groundnut shell cellulose was mixed with 750 mL of isopropanol in a 1000 mL beaker and was observed for 5 min. Subsequently, 400 mL of 120g sodium hydroxide (aqueous) was added dropwise under continuous stirring using a magnetic stirrer for 1 hr. This treatment is commonly referred to as mercerization and it promotes hydroxyl group activation.

The etherification phase followed, where 80 g of monochloroacetic acid was introduced at 70 °C and stirred continuously for 1 hr. To prevent polymer degradation and preserve the degree of substitution (DS), the reaction time was carefully monitored [13]. The resulting slurry was soaked in methanol for about 4 hours and was adjusted to a neutral pH subsequently with 90% glacial acetic acid till the pH stabilized between 6 and 8.

The GS-CMC was isolated by repeated rinsing with 70% ethanol to eliminate reaction residues. Finally, the purified product was sieved and dried in the oven 24 hr at 60% [14].

### 2.5. Micrometric property analysis

#### *2.5.1. Flow rate*

The flow rate of the carboxymethylcellulose powder was assessed with the funnel method [15]. A 20 g sample of GS-CMC was placed in a funnel (orifice diameter: 1.4 cm; efflux tube length: 4.5 cm), and the time taken for the complete powder released was recorded. Flow rate was calculated as:

$$\text{Flow rate} = \frac{\text{weight(g)}}{\text{time(secs)}} \quad \text{(Eqn. 2)}$$

#### *2.5.2. Angle of repose*

The fixed-funnel method was used to analyze the static angle of repose. A funnel was mounted 4 cm above a flat surface, and GS-CMC powder was allowed to flow until it formed a conical heap. The angle was calculated using:

$$\text{Tan } \theta = \frac{2h}{d} \quad \text{(Eqn. 3)}$$

where *h* is the height and *d* is the base diameter of the powder heap.

#### *2.5.3. Bulk and tapped densities*

A 25 g sample of the GS-CMC powder was weighed and placed in a 50 mL graduated cylinder. The bulk volume ($V_0$) was recorded. The tapped volume($V_{100}$) was determined by tapping the cylinder 100 times. The densities were calculated as:

$$\text{Bulk/ Tapped density} = \frac{\text{Mass of powder(g)}}{\text{Bulk volume(ml)}} \quad \text{(Eqn. 4)}$$

Hausner ratio and Carr's index were also derived from these values.

#### *2.5.4. True density*

True density of GS-CMC powder was analyzed using xylene displacement in a pre-weighed pycnometer. 1g quantity of GS-CMC powder was transferred in a dry pre-weighed pycnometer and the rest filled with 50ml liquid paraffin as the immersion fluid, the weight of the pycnometer filled with only liquid has previously been established and density of the powder was computed using:

$$D_t = \left(\frac{(W2 \div V) \times W3}{W3 - W4 + W2 + W)}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eqn. 5)}$$

Where, V=Volume of the pycnometer (ml), W=Weight of the empty pycnometer(g), $W_1$=Weight of filled pycnometer (g), $W_2$=Different between $W_1$ and W, $W_3$=weight of Dry GS-CMC, $W_4$=Weight of Liquid + GS-CMC sample.

## 2.6. Physicochemical characterization

### *2.6.1. Percentage yield*

The cellulose yield (%) derived from groundnut shell and the GS-CMC yield (%) synthesized from the derived cellulose was determined based on the dry weight of groundnut shell cellulose. The cellulose yield expressed in percentage (%) was determined by calculating the amount of groundnut shell using the formula below:

$$\text{Yield of cellulose (\%)} = \frac{weight\ of\ cellulose\ obtained}{\text{weight of groundnut shell(g)}} \times 100 \ldots\ldots\ldots\ldots\ldots \text{(Eqn. 6)}$$

The GS-CMC yield (%) was determined by expressing the net dry weight of the obtained carboxymethylcellulose as a ratio to 50g of cellulose, as seen in the equation below.

$$\text{Yield of GS-CMC (\%)} = \frac{weight\ of\ cmc\ obtained}{\text{weight of Alpha cellulose(g)}} \times 100 \ldots\ldots\ldots\ldots\ldots \text{(Eqn. 7)}$$

### *2.6.2. Swelling index*

A tapped volume of 3 mL of dry GS-CMC powder was measured, then water was added up to 10ml of the measuring cylinder. After 24 hr, the swollen volume was recorded. The swelling index was calculated as:

$$\text{Swelling index} = \frac{Vf - Vi}{Vi}\ x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eqn. 8)}$$

Where Vf is the final volume and Vi is the initial volume.

### *2.6.3. Cellulose test*

Schulzes solution (Chlor -Zinc iodide) stains cellulose. A 20g of anhydrous zinc chloride was dissolved in 8.5ml of water and the mixture was allowed to cool. A 1 g sample of potassium iodide and 0.5 mL of iodine were dissolved in 29 mL of water. This solution was gradually added in drops into the zinc chloride solution until the iodide precipitate persists on agitation. This mixture was added to 1g of cellulose and observed for a colour change.

### 2.6.4 *Solubility test*

The solubility of GS-CMC was tested by dispersing samples in both distilled water and ethanol and observing dissolution behaviour.

### *2.6.4. Moisture content (loss on drying)*

Approximately 1 g of GS-CMC was dried in the oven at 105 °C until a continuous weight was attained. The moisture content was calculated as:

$$\text{Moisture content} = \frac{M2 - M3}{M} X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eqn. 9)}$$

Where $M_2$ is pre-drying weight, $M_3$ is post-drying weight, and $M$ is sample mass.

### *2.6.5. pH determination*

A 1 g sample of GS-CMC powder was dispersed in 100 mL of purified water and the pH was determined using a digital 220V PHS-3C 0~60℃ 0.01 accuracy LCD digital display laboratory pH Meter [15].

### *2.6.6. Ash content*

A 3 g sample of GS-CMC was incinerated in a muffle furnace at 600–650 °C for 6 hr. The residue (white ash) was weighed to determine the total ash content, following the method of Kadam *et al.* [16].

### 2.7. Degree of substitution (DS)

The Degree of substitution of the synthesized GS-CMC was evaluated via potentiometric back-titration, as described by Koh [17]. About 4g sample of GS-CMC was stirred in ethanol, acidified with nitric acid to form H-CMC, and repeatedly washed and dried. A 0.5 g sample was then treated with NaOH and titrated with HCl. DS was calculated using:

$$A = \frac{BC-DE}{F} \quad \text{..... (Eqn. 10)}$$

$$\text{Degree of substitution } x = \frac{0.162\ X\ A}{1-(0.058\ X\ A)} \quad \text{..... (Eqn. 11)}$$

Where,
*A* is milliequivalents of acid consumed per gram of carboxymethylcellulose
B = volume(ml) of Sodium hydroxide (NaOH) solution added,
C = Normality of sodium hydroxide added
D = volume(ml) of chloric acid consumed
E = Normality (N) of the chloric acid used
F = mass (g) of the specimen used.

### 2.8. Spectroscopic and structural characterization

*2.8.1. FTIR analysis*

Fourier Transform Infrared Spectroscopy (FTIR) was conducted to confirm the presence of specific functional groups in both cellulose and synthesized CMC. Spectra were recorded between 4000–650 $cm^{-1}$.

*2.8.2. X-ray diffraction (XRD)*

The crystallinity of the GS-CMC derived from groundnut shell was examined using X-ray diffraction analysis. Measurements were taken using Cu-Kα radiation, within a 2θ range of 10° to 70° under standard generator conditions.

## 3. Results

### 3.1. Percentage yield

The α-cellulose yield (%) and carboxymethyl cellulose (%) yield derived from groundnut shell reflects the efficiency of the extraction and modification processes. In this study, α-cellulose was obtained with a yield of 76.8%**.** The resulting CMC yield synthesized from the isolated cellulose was 72%**,** indicating minimal material loss during the carboxymethylation process.

### 3.2. Organoleptic properties of groundnut shell CMC

The carboxymethyl cellulose obtained from the groundnut shell was observed to be an odourless, tasteless, light brownish powder containing very fine small to coarse particles. (Table 1)

**Table 1** Organoleptic properties of GS- CMC

| Parameters | Organoleptic properties |
|---|---|
| Colour | Dark brown |
| Odour | Characteristic |
| Texture | Coarse |

### 3.3. Physiochemical properties of groundnut shell CMC

*3.3.1. Identification test for cellulose*

The identification test carried out on groundnut shell alpha cellulose showed a slight violet blue colour to confirm the presence of cellulose in the sample.

*3.3.2. Solubility test*

The modified GS-CMC showed solubility in water which is similar to standard carboxymethyl cellulose that dissolves rapidly in both cold and hot water. In addition, the modified groundnut shell CMC was completely insoluble in ethanol which is also similar to standard carboxymethyl cellulose that doesn't dissolves in organic solvents.

*3.3.3. Swelling index*

The value for the swelling index obtained for GS-CMC was about 46% which is generally poor compared to standard carboxymethyl cellulose. This indicates that the CMC produced from groundnut shell has low water intake capacity.

*3.3.4. pH of groundnut shell CMC*

The pH level which indicates the acidic and alkaline nature of the GS-CMC was observed as 6.43 indicates that the sample is slightly acidic and low pH readings of GS-CMC may suggest diminished purity of the product with the unreacted chemicals used such as Monochloroacetic acid (MCA) and reaction residues (by-products).

*3.3.5. Total Ash value*

The total Ash value obtained from groundnut shell CMC was 60%, indicating a high level of inorganic content (e.g sands, metal ion or reaction by-products) in the sample. This suggests that only 40% of the sample contained organic materials including the GS-CMC

*3.3.6. Moisture content*

The moisture content (%) of GS-CMC was obtained as 7% indicating favourable conditions for monitoring and control processes.

**Table 2** Physiochemical properties of groundnut shell CMC

| **Parameters** | **Results** |
|---|---|
| Solubility | Sparingly soluble in water and completely insoluble in ethanol |
| Swelling index | 46.7% |
| Test for Cellulose | Positive |
| pH | 6 43 |
| Loss on drying (%) | 7% |
| Total ash value | 60% |

### 3.4. Micrometric properties

*3.4.1. Bulk and tapped densities*

The GS-CMC were investigated for their bulk and Tapped Densities. The average bulk density obtained for GS-CMC was recorded as 0.3759g/ml while the average Tapped density was recorded as 0.4132g/ml.

*3.4.2. Flow rate, angle of repose, Hausner ratio and Carr's index*

The results of the flow rate, angle of repose in addition with other derived parameters like Hausner ratio and Carr's index are presented in Table 3. Considering this result. The GS-CMC flowed freely through the funnel when investigated for their flow rate and hence have an excellent flow with an angle of repose of 28.07°.

**Table 3** Micrometric properties of GS-CMC.

| **Micrometric properties** | **Average readings** |
|---|---|
| Bulk density (g/ml) | 0.376 |
| Tapped density (g/ml) | 0.413 |

| | |
|---|---|
| Carr's index (%) | 9.027 |
| Hausner ratio | 1.099 |
| Angle of repose | 28.04 |
| True density | 1.632 |

### 3.5. Degree of substitution determination

Potentiometric titration was used to determine the degree of substitution of CMC derived from groundnut shell α-cellulose. In this study, the degree of substitution obtained for GS-CMC is 2.2 which indicates high degree of substitution. Hence, they are not swellable but are soluble in water.

### 3.6. Fourier transform infrared spectroscopy.

The Fourier Transform infrared spectroscopy analysis of GS-CMC presents distinctive absorption bands that provide insights into its functional groups. Figure 1 shows the absorption peak at 3336.0 cm corresponds to the stretching of -OH groups and hydrogen bonding, whereas the bands at 2899.9 cm indicate C-H stretching vibrations. The robust absorption band at 1587 cm serves as confirmation for the presence of the COO group, signifying the successful carboxymethylation process. Similarly, the peak at 1416.4 cm relates to the C-O bond, highlighting the carboxymethyl group substitution. The bands at 1457.4 cm are tied to -CH2 scissoring and -OH bonding.

Lastly, the 894.6 cm band pertains to the asymmetric bridge stretching (C-O-C) within cellulose, including the beta-4 glycosidic bonds in its structure.

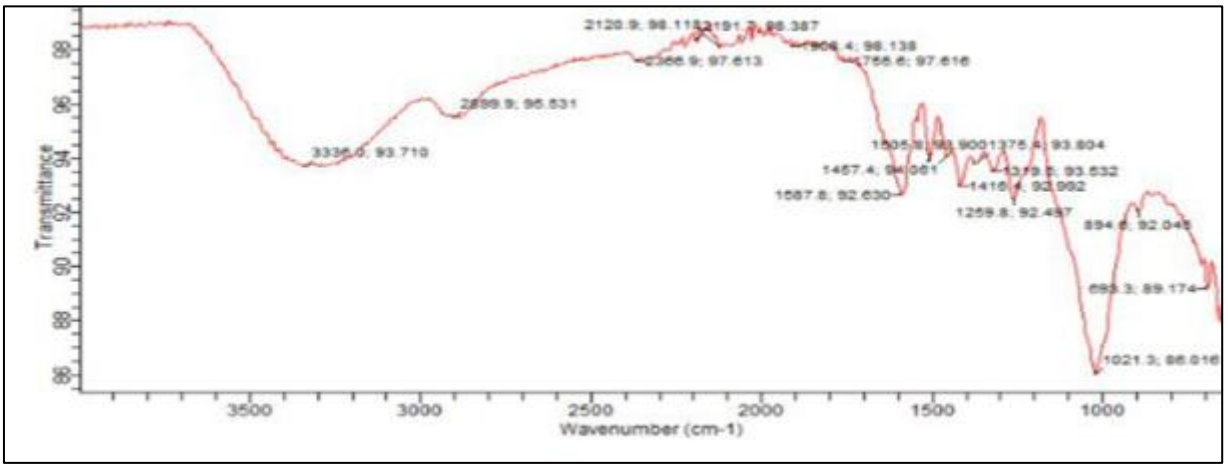


**Figure 1** FT- IR spectra of GS- CMC

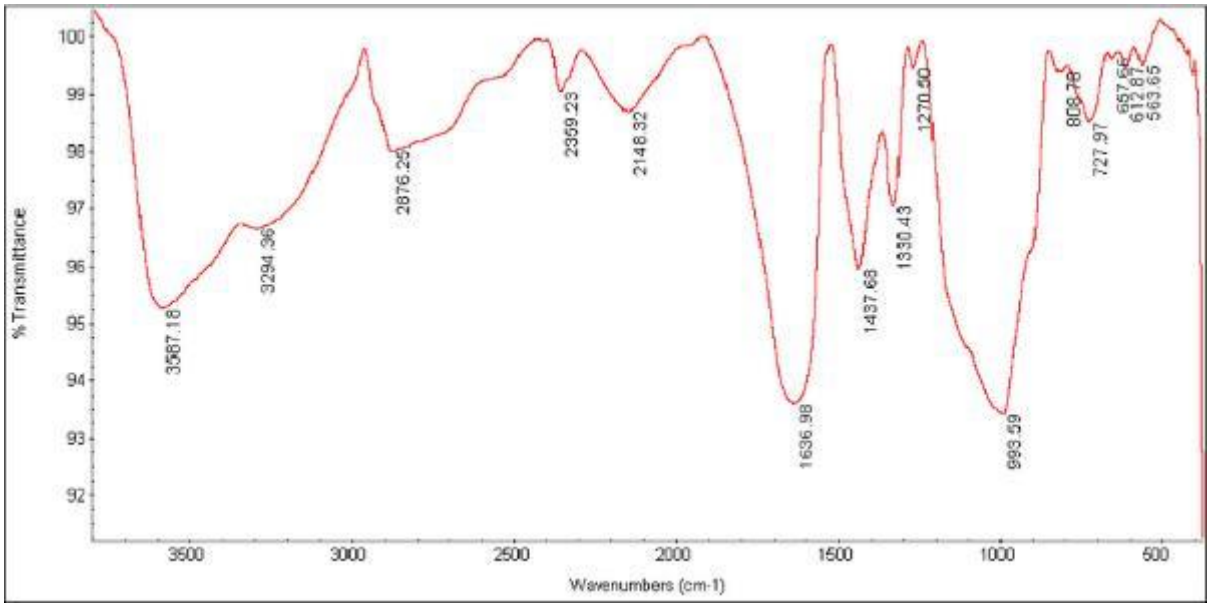


**Figure 2** FT- IR spectra of CMC reference (Aldrich)

The peak patterns of the pure CMC differ from those of the synthesized GS-CMC. This variation may be due to the incomplete purification of the GS-CMC, which could have contributed to the observed changes. Additionally, the processing conditions used during synthesis might have influenced the differences in the peaks.

### 3.7 X-ray diffraction

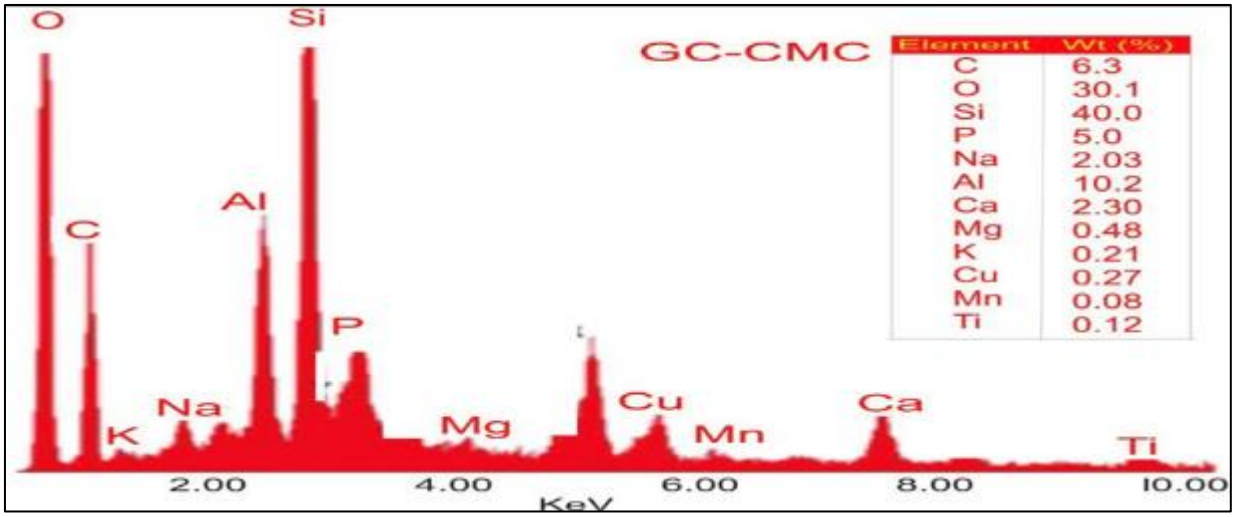


**Figure 3** X -ray diffractograms of groundnut shell CMC

The X-ray diffraction of the modified cellulose obtained from groundnut shell is presented in figure 3. The intensities of the diffraction bands were used to establish the crystalline and the amorphous phase of the GS-CMC. It can be observed that the CMC obtained have a low crystallinity (amorphous) due to its broadened peak, this result can be interpreted by the fact that this amorphous nature of the CMC may be as a result of high temperature used during its synthesis.

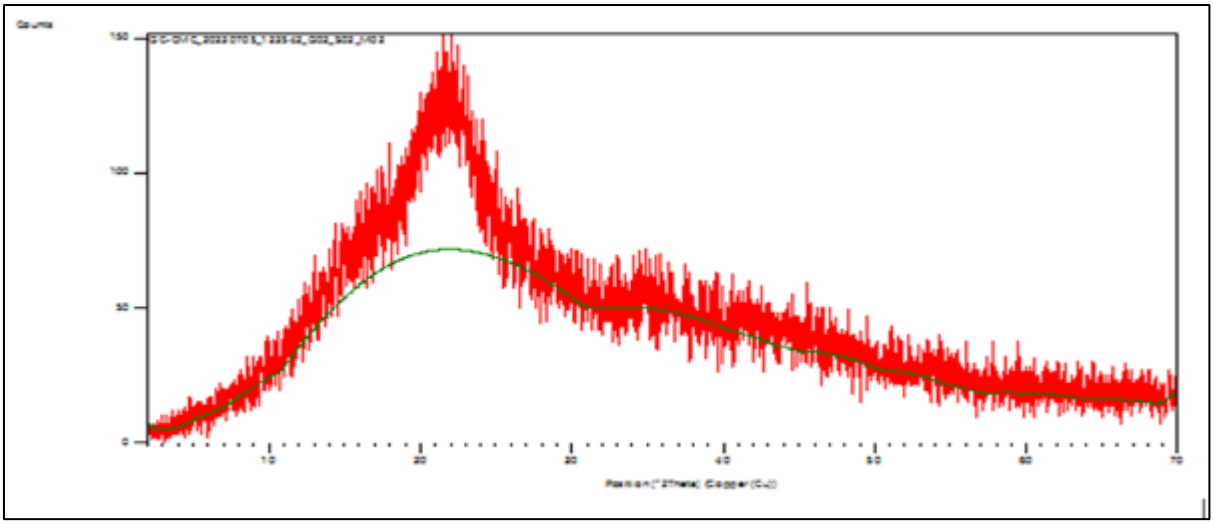

**Figure 4** SEM EDX image of GS- CMC

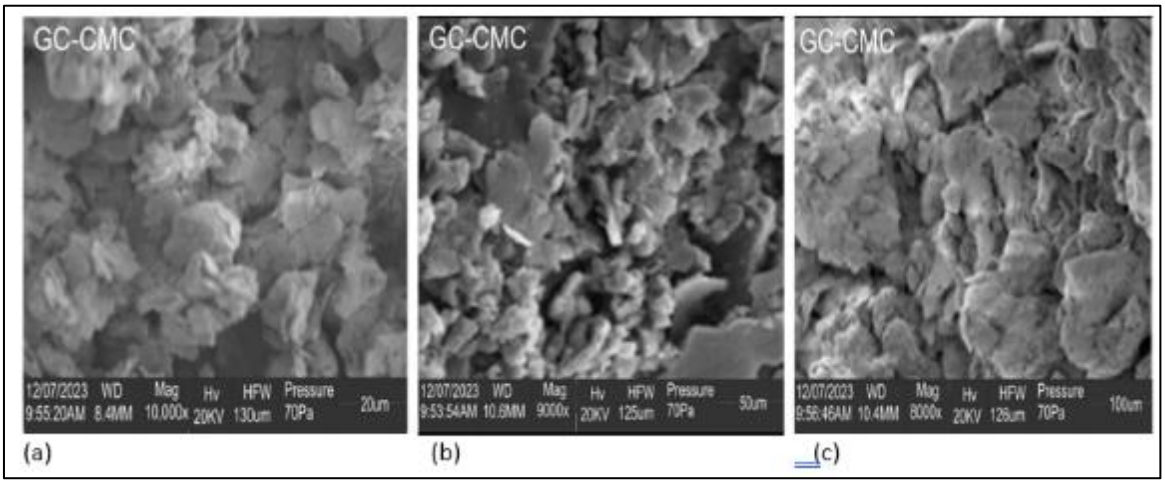


**Figure 5** SEM images of GS-CMC at magnifications of 10000x (a), 9000x (b) and 8000x (c)

### 3.7. Scanning electron microscope

The Scanning electron micrographs EDX Image shown above (figure 4) simply displays the various elements present in the CMC synthesized and their percentage weight respectively. The keV on the X-axis means Kiloelectron volt which describes energy of X-rays and Gamma rays, while the y axis is the count. The Scanning Electron micrographs (SEM) images for groundnut shell CMC (figure 5) at different sizes (50 um, 100 um, 200 um) reveals the CMC as a 3- granular dimensional morphology.

## 4. Discussion

The yield (%) of alpha-cellulose and carboxymethyl cellulose (CMC) extracted from groundnut shells in this study was 76.8% and 72%, respectively. Yield is a critical parameter reflecting the efficiency of the extraction process, and is often influenced by determinants such as raw material constituent, processing setting, and losses during purification. The alpha-cellulose yield obtained here compares favourably with those reported by Hadiza *et al.* [18], who achieved 78.4% from peanut shells and 77.1% from corn stalks. These similarities suggest that groundnut shells are a promising alternative lignocellulosic source for cellulose extraction.

The groundnut shell-derived CMC exhibited typical physical characteristics expected of crude CMC products. It was an odourless, tasteless, light brown powder with a heterogeneous mix of fine and coarse particles. The brown coloration

may be attributed to residual lignin or other impurities not fully removed during processing, a common feature in agro-waste-derived cellulose products [19].

Identification test confirmed the presence of cellulose in the sample, evidenced by a violet-blue coloration an expected result in iodine-zinc chloride cellulose detection tests [20]. Also, the CMC derived from groundnut shells demonstrated good solubility in water and insolubility in ethanol, consistent with the known properties of standard commercial CMC. These characteristics are indicative of successful etherification, where polar carboxymethyl groups enhance hydrophilicity [21]. In addition, the swelling index of 46.7% was lower than typical commercial CMC standards, indicating a reduced water uptake capacity. Such low values can stem from incomplete substitution of hydroxyl groups or the presence of impurities which limit the polymer's water absorption potential [22].

The pH value of 6.43 suggests a mildly acidic CMC sample, potentially due to residual monochloroacetic acid or sodium glycolate formed during synthesis. Lower pH values in CMC often reflect incomplete neutralization or purification [23]. Also, a total ash content of 60% is considerably high, implying the presence of inorganic materials and possible processing inefficiencies. This level of ash content is far above recommended values and could negatively impact the functional quality of the CMC, especially in pharmaceutical or food-grade applications [24].

The moisture content of 7% falls within the acceptable limit of less than 12% as set by FAO/WHO standards, suggesting the sample has good stability and is less prone to microbial growth or degradation during storage. The bulk and tapped densities obtained reads 0.376 g/mL and 0.413 g/mL, respectively. These values are within the acceptable range for powdered excipients and suggest moderate packing ability [25]. The angle of repose (28.04°), Carr's Index (9.03%), and Hausner ratio (1.099) indicate excellent flowability of the groundnut shell CMC. Typically, a Carr's Index < 15% and Hausner ratio under 1.2 are indicative of powders with good flow properties [26]. These properties are crucial in ensuring efficient handling and formulation in solid dosage manufacturing.

The degree of saturation (DS) value of 2.2 obtained in this study is notably higher than the typical commercial range (0.4–1.4) reported by Karatas *et al*. [22]. A higher DS enhances the solubility of CMC and suggests a more complete substitution of hydroxyl groups with carboxymethyl groups. However, excessive substitution can reduce swelling ability, as observed in the low swelling index [27].

Fourier Transform Infrared (FTIR) spectroscopy analysis (Figure 1) confirmed the successful synthesis of CMC derived from groundnut shells. The broad O-H stretching band at 3336 $cm^{-1}$ and C-H stretch at 2899 $cm^{-1}$ are characteristic of cellulose-based materials. The prominent $COO^-$ stretch at 1587 $cm^{-1}$ confirms the carboxymethylation process. These spectral features aligned with those reported by Joshi *et al.* [28] and Mondal *et al.* [29] for commercial CMC, validating the structural integrity of the modified product.

X-ray diffraction (XRD) analysis revealed a largely amorphous structure in the synthesized CMC, evident from broad diffraction peaks. This suggests successful disruption of the original crystalline cellulose structure during etherification, a known effect of alkaline treatment and high DS [30, 31]. Reduced crystallinity is associated with improved solubility, further confirming the CMC's functionality [32, 33].

Scanning Electron Microscopy (SEM) (figure 5) images demonstrated a granular morphology, typical of CMC materials. The disordered and porous structure may be linked to the substitution of hydroxyl groups with bulkier carboxymethyl groups, resulting in increased inter-particle distances. EDX analysis (figure 4) confirmed the elemental composition, supporting the structural modification. These observations align with findings by Najafpour *et al.* [34], who reported similar morphological transformations upon carboxymethylation.

## 5. Conclusion

The carboxymethyl cellulose was successfully isolated from the groundnut shell (*Arachis hypogea*). However, it revealed distinctive properties, including poor swelling behaviour, an amorphous nature and a high degree of substitution. These findings contribute to our understanding of carboxymethyl cellulose derived from groundnut shell an agricultural waste material and may have potential applications in the pharmaceutical Industry.

Further research can explore additional properties and applications to harness the full potential and applications of carboxymethyl cellulose from groundnut shell.

## Compliance with ethical standards

*Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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