ORIGINAL ARTICLE

Processing pharmaceutical grade microcrystalline cellulose from groundnut husk: Extraction methods and characterization

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Microcrystalline cellulose (MCC) is an important ingredient in pharmaceutical, food, cosmetic and other industries. In this work, MCC was prepared from the *alpha* cellulose content of groundnut husk, a renewable natural resource that has no industrial utilization yet. The effects of pulping methods (sodium hydroxide and multistage pulping) and varying bleaching time on yield and amorphous properties of obtained *alpha* cellulose were examined. The prepared MCC (groundnut husk-MCC) was characterized using scanning electron microscopy (SEM), infrared spectroscopy (FTIR), X-ray powder diffractometer (X-RPD), differential scanning calorimetry (DSC) and compared with commercial-grade MCC. The results showed that complete pulping was achieved only by the use of the multistage pulping method and its yield was 15%. It was also found that the duration of bleaching affected the polymeric form of the processed *alpha* cellulose and hence, it is suggested that X-ray diffraction analysis should form an in-process check in the production of cellulose to ensure batch-to-batch consistency and performance. It was concluded that GH-MCC compared favourably with the commercial-grade MCC as well as conform to official specifications for MCC in the British Pharmacopoeia.

Key words: Extraction and characterization, groundnut husk, microcrystalline cellulose

INTRODUCTION

The preparation of tablets by direct compression has steadily increased since the advantages of direct compression technology in tabletting are numerous. These include economy, elimination of granulation process, and uniformity of particle size and greater stability of tablets on aging.[1] Currently, microcrystalline cellulose (MCC) is the most commonly used direct compression excipients. MCC is produced by reacting cellulose with an aqueous solution of a strong mineral acid at boiling temperature for a period until the level-off degree of polymerization (level-off DP) of cellulose is obtained. MCC is not only highly compressible it increases compressibility of other excipients when added in small quantities. It is an effective dry binder in low concentration. It has sufficient fluidity to be directly compressed and to exhibit disintegrating properties.[2]

Commercially available MCC is derived from both gymnosperms (generally conifers) and other softwoods, and from hardwood dicotyledons. These woods differ considerably in chemical composition (proportions of cellulose, hemicelluloses, and lignin) and structural organization which affect the composition of the α-cellulose extracted and the composition and crystallinity of MCC finally produced.[3] Besides the wood pulp as a source of cellulose and its derivatives, the purified cotton linters obtained from *Gossypium* species are also a common source.[4]

The use of alternative non-wood sources of fiber in preparation of pulp for industrial applications has received substantial attention. There are two important reasons for the continuous increase in this area. Firstly, there is a decrease in wood availability with the increasing demand for market pulp in some rapidly developing countries in Asia, Africa, and Latin America. Secondly, agricultural residues are excellent alternative materials to substitute wood because they are plentiful, widespread, and easily accessible. Aside from their abundance and renewability, utilization of agricultural residues has advantages for economy, environment, and technology. Traditionally, farmers harvest grain and burn or otherwise dispose the residues (stalks, husk, etc.), but heightened interest in industrial utilization of agricultural wastes can mean second income for farmers from grain plantings. Burning agricultural residues also causes environmental problems such as air pollution, soil erosion, and a decrease in soil biological activity. Therefore, utilizing agricultural residues not only prevents air pollution due to residual burn which

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adversely affect air quality and human and environmental health, but also economically profitable for farmers. It is against this background that we investigate groundnut husk, an agricultural waste, as a source for production of pharmaceutical-grade MCC.

Groundnut *(Arachis hypogaea)* is domesticated in most parts of the world. It is a variable annual herb whose chief and remarkable characteristic is the production of fruits underground.[5] In Nigeria, it is a very important legume for food and cash and its husk exist as huge waste in Northern Nigeria where its cultivation is highest. This paper reports on the preparation of MCC from groundnut husk (GH-MCC) and its characterization in comparison with commercial-grade MCC, Avicel PH 101. The effects of pulping methods (sodium hydroxide and multistage pulping) and varying bleaching time on yield and amorphous properties of obtained *alpha* cellulose were also examined.

MATERIALS AND METHODS

Materials

These include nitric acid, sodium nitrite, sodium sulphite, sodium hydroxide (BDH, England), sodium hypochlorite as JIK® (Reckitt and Colman Ltd., Nigeria), Avicel PH 101 (particle size, ~50 μm) (FMC Corporation, USA), and xylene (Vicker laboratories Ltd., England). All other chemicals used were of analytical reagent grade and water was double distilled.

Groundnut husk was obtained from a local mill, Abuja, Nigeria.

Extraction of *Alpha* Cellulose

Pre-treatment of groundnut husk sample

The groundnut husk was washed, dried at 60°C for 24 hr and milled. The fraction passing through sieve 1.18 mm aperture size was first extracted with toluene-ethanol (2:1 v/v) in a Soxhlet extractor for 6 hr. The defatted sample was dried at room temperature in a dust free air and used for the pulping procedures.

(a) Sodium hydroxide pulping

The extractive free powder (300 g) was delignified with aqueous sodium hydroxide at 80°C in a stainless steel container.[6]

(b) Multistage pulping

The method of Okhamafe and Azubuike with slight modification was used.[7] A 300 g extractive-free powder was treated with 4L of 3.5% nitric acid containing 40 mg of sodium nitrite for 2 hr in a stainless steel container immersed in a water bath (FGL 1083 Karl Kolb Scientific) set at 90°C to remove lignin in the form of soluble nitrolignins. Following thorough washing and filtration, it was digested with a 3L solution containing 2% w/v each of sodium hydroxide and sodium sulphite at a temperature of 50°C for 1 hr. Again, it was washed, filtered, and bleached with a 2L 1:1 aqueous dilution of 3.5% w/v sodium hypochlorite at boiling temperature for 10 min. The washed and filtered material (i.e., holocellulose) was next treated with 2 L of 17.5% w/v sodium hydroxide at 80°C for 0.5 hr. The resulting *alpha* cellulose was washed thoroughly with water. The extraction process was then completed by whitening with a 1:1 aqueous dilution of 3.5% w/v sodium hypochlorite for 5 min at 100°C and subsequent washing with water until filtrate was clear. The cellulose material was filtered, and the water manually squeezed out to obtain small lumps, which were dried at 60°C in fluidized bed dryer.

Preparation of Microcrystalline Cellulose (GH-MCC)

The procedure reported earlier with slight modification was used.[6] A 50 g quantity of the *alpha* cellulose obtained was placed in a pyrex glass beaker and hydrolyzed with 2.5 N hydrochloric acid (1.2 L) at boiling temperature for 15 min. The hot acid mixture was poured into cold tap water that was followed by vigorous stirring with a spatula and allowed to stand overnight. The microcrystalline cellulose obtained by this process was washed with water until neutral, pressed, and dried in a fluidized bed dryer at an inlet air temperature of 57-60°C for 60 min. Following further milling and sieving, the fraction passing through 0.710 mm sieve was obtained and stored at room temperature in a desiccator.

Physicochemical and Powder Properties of GH-MCC

The organoleptic characteristic, identification, organic impurities, starch and dextrin, solubility, total ash, and water-soluble substances were carried out in accordance with BP 2004 specifications.

pH determination

This was done by shaking 2 g of the powder material with 100 ml of distilled water for 5 min and the pH of the supernatant liquid was determined using a pH meter (Corning, model 10 England).[6]

Scanning electron microscopy

Scanning electron microscopy (gold coating, Edwards Sputter Coater, UK) was performed using a Joel 6310 (Joel Instrument, Tokyo, Japan) system running at 10 KeV.

Fourier-transform infrared spectra

The surface of each sample was characterized using Perkin-Elmer Spectrum 1000 Fourier transform infrared (FTIR) Spectrophotometer. Each sample was scanned 64 times at a resolution of 4 cm^{-1} between 4000 and 650 cm^{-1}.

X-ray powder diffractometer studies

Diffraction patterns were obtained using Phillips X-ray diffractometer. The diffraction patterns were recorded using Cu-Kα radiation at 40 kV and 25 Ma. The samples were pressed into pellets (25 mm in diameter) by compression of 0.25 g in a mold under a pressure of 50 MPa. The crystallinity index (CrI) calculated as follows:[8]

$$CrI = [(I_{002} - I_{am})]/I_{002}$$

where I_{002} is the intensity of the peak (at about $2\theta = 22$) and I_{am} is the intensity corresponds to the peak at about $2\theta = 18$.

Differential scanning calorimetry

Differential scanning calorimetry (DSC) scans of the powdered samples were recorded using the DSC 204 F1 (Netzsch Geratebau, GmbH, Selb, Germany), a heat-influx DSC equipped with Netzsch Thermokinetic Analysis Software. The thermal traces were obtained by heating from 26°C to 500°C at a heating rate of 10°C under inert nitrogen dynamic atmosphere (70 ml/min) in close aluminum pan with lid pierced and an empty pan was used as the reference. The parameters evaluated were: (a) transition temperatures: MCC water loss (T_{wl}), MCC thermal decomposition (T_{MCC}) and (b) heats of fusion or thermal decomposition: MCC thermal decomposition (ΔH_{MCC}).

Particle size analysis

An Endicott's sieves shaker (Endicott's Ltd UK) was used for this. Test sieves ranging from 1.18 mm to 75 μm were arranged in a descending order. A 40 g quantity of GS-MCC powder was placed on the top sieve and was shaken for 5 min and the weight of material retained on each sieve was determined. The average diameter was calculated using the equation:[9]

$$\text{Average diameter} = [\sum (\% \text{ retained}) \times (\text{mean aperture})] /100 \quad (1)$$

True Density

The true densities, D_t, of cellulose powders were determined by the liquid displacement method using xylene as the immersion fluid and computed according to the following equation:[6]

$$D_t = w/[(a + w)\text{-}b] \times SG \quad (2)$$

where *w* is the weight of powder, SG is specific gravity of xylene, *a* is weight of bottle + solvent and *b* is weight of bottle + solvent + powder.

Angle of Repose

The static angle of repose, *a*, was measured according to the fixed funnel and free standing cone method.[10] A funnel was clamped with its tip 2 cm above a graph paper placed on a flat horizontal surface. The powders were carefully poured through the funnel until the apex of the cone thus formed just reached the tip of the funnel. The mean diameters of the base of the powder cones were determined and the tangent of the angle of repose calculated using the equation:

$$\text{Tan } a = 2h/D \quad (3)$$

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

Bulk and Tapping Densities

A 30 g quantity of each powder samples were placed into 250 ml clean, dry measuring cylinder and the volume, V_0, occupied by each of the samples without tapping was determined. After 500 taps using Stampfvolumeter (Model STAV 2003 JEF, Germany), occupied volumes, V_{500} were determined. The bulk and tap densities were determined from these volumes (V_0 and V_{500}) using the equation:

$$\text{Density} = \text{Weight of cellulose/Volume of cellulose} \quad (4)$$

Carr's Index and Hausner Ratio

The Carr's index and the Hausner ratio were calculated using the equation:
[Tap density – bulk density)/Tap density × 100%] and Tap density/ bulk density, respectively.

Powder Porosity

This was derived from the values of true and bulk densities when fitted into the equation:

$$e = 1\text{-}\ B_b/D_t \times 100 \quad (5)$$

where B_b is the bulk density, D_t is the true density and *e* is the porosity

Hydration Capacity

The method of Kornblum and Stoopak was used.[11] A 1.0 g of each samples was placed in four 15 ml plastic centrifuge tubes and 10 ml distilled water was added from a 10 ml measuring cylinder and then stoppered. The contents were mixed on a vortex mixer (Vortex-Gennie Scientific Industry, USA) for 2 min. The mixture was allowed to stand for 10 min and immediately centrifuged at 1000 rpm for 10 min on a Gallenkamp bench centrifuge (Gallenkamp, England). The supernatant was carefully decanted and the sediment weighed. The hydration capacity was taken as the ratio of the weight of the sediment to the dry sample weight.

Swelling Capacity

This was measured at the same time as the hydration capacity and calculated as follows:

$$S = (V_2 - V_1) / V_1 \times 100 \quad (6)$$

where S is the % swelling capacity, V_2 is the volume of the hydrated or swollen material and V_1 is the tapped volume of the material prior to hydration.[7]

Moisture Sorption Capacity

Two grams of the cellulose materials were accurately weighed and evenly distributed over the surface of a 70 mm tarred Petri dish. The samples were then placed in a large desiccator containing distilled water in its reservoir (RH = 100%) at room temperature and at the end of a five-day period, the weight gained by the exposed samples were recorded. The amount of water sorbed was calculated from the weight difference.[12]

Loss on Drying

Five grams of powder samples were transferred, each, into a Petri dish and then dried in an oven at 105°C until a constant weight was obtained. The percentage moisture loss was then determined as the ratio of weight of moisture to weight of sample expressed as percentage.[6]

RESULTS AND DISCUSSION

Pulping Methods

Two methods, namely: Sodium hydroxide and multistage pulping were used to delignify the groundnut husk sample. While complete pulping could not be achieved using sodium hydroxide pulp method as the resulting pulp was inhomogeneous and contained unhydrolyzed materials, hence the yield could not be calculated; the multistage method resulted in a homogeneous white pulp (*alpha* cellulose) with a yield of 15%. This was further hydrolyzed in aqueous hydrochloric acid to obtain GH-MCC.

Effect of Varying Bleaching Time

The effect of different bleaching time on the yield and amorphous properties of obtained *alpha* cellulose was achieved by varying the duration of the first bleaching cycle between 10 and 30 min while the second bleaching duration was kept constant at 5 min. The result obtained is as shown in Table 1 and [Figure 1]. The diversity of polymeric forms induced by the variation in the duration of bleaching are reflected in the X-ray diffractograms of the processed *alpha* cellulose. [Figure 1a and b] showed diffractogram patterns where only halos were observed while [Figure 1c] shows the appearance of peaks in pattern that are a measure for crystalline content. Comparison of these diffractograms with published diffractograms for the different polymeric form[13,14] indicate that the processed *alpha* cellulose at 10 and 20 min are essentially in the cellulose 1 form and that at 30 min, becoming more crystalline (evidenced by the appearance of peak) is clearly a cellulose II form, evidenced by the presence of doublet in the peak intensity. It is explained that the appearance of peaks could have resulted from hydrolysis of *alpha* cellulose by the action of hydrochloric acid formed *in-situ*, during prolong bleaching. The mechanism of hydrochloric acid formation could have been by the abstraction of a hydrogen atom from an organic substrate by chlorine as shown in the chemical equation:[15]

$$Cl_2 + RH \rightarrow Cl\cdot + R\cdot + HCl$$

where R is an organic residue.

It should perhaps be noted that although the primary determinant of polymeric form appears to be the temperature of regeneration,[16] the duration of the bleaching process is also an important factor. Since the form type can

Table 1: The effects of varying bleaching time (first cycle) on the percent yield of the alpha cellulose

Duration (min)	% yield
10	15.2
20	11.6
30	6.4

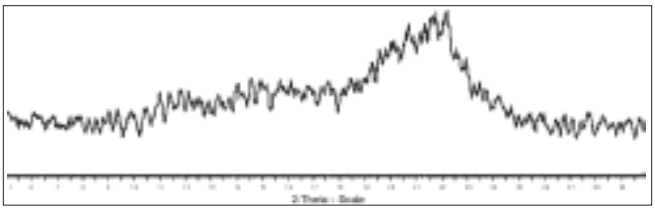

Figure 1a: X-ray diffraction patterns of *alpha* cellulose from groundnut husk processed for 10 min bleaching time

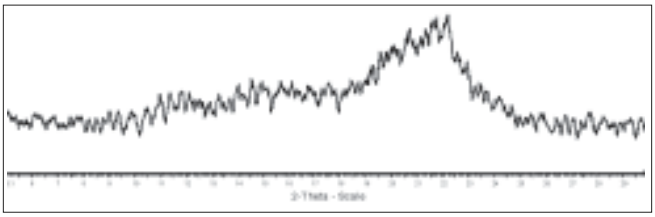

Figure 1b: X-ray diffraction patterns of *alpha* cellulose from groundnut husk processed for 20 min bleaching time

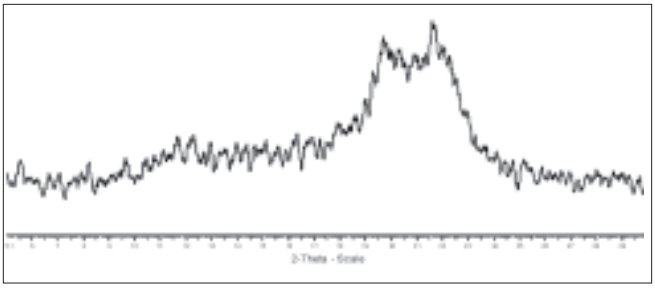

Figure 1c: X-ray diffraction patterns of *alpha* cellulose from groundnut husk processed for 30 min bleaching time

affect pharmaceutical properties, chemical stability, and reactivity,[17] it becomes imperative to suggest that X-ray diffraction analysis should form an in-process check in production of cellulose to ensure batch-to-batch consistency and performance.

It was also observed that when the final (second) bleaching cycle, after treatment with 17.5% w/v sodium hydroxide, was prolonged (10 min as compared to the usual 5 min) the yield of *alpha* cellulose was very small (4.8%), possibly due to excessive degradation of the pulp causing it to go into solution with the accompanying washing process.

Physicochemical Properties

The results of the physicochemical properties of GH-MCC are shown in Table 2. The organoleptic qualities of the GH-MCC produced were good as the material was odorless, tasteless, white, and granular in texture. The value obtained for the total ash was very low possibly because cellulosic materials are almost free of inorganic compounds. The total ash figure is of importance and indicates to some extent the amount of care taken in the preparation of the substance.[4] The pH value is within the official value of 5-7.5 (British Pharmacoepiea, 2004).

Powder Properties Characterization

[Figure 2] compares the SEM photographs of GH-MCC and Avicel PH 101. Both are consisted of non-aggregated fibers. There is no difference between them except for short fibers seen in GH-MCC. This could be attributed to different processing conditions employed.

The FT-IR spectra of GH-MCC and Avicel PH 101 are compared in [Figure 3]. The two spectra are similar. The analysis of the spectra with reference to published data[18] showed several typical features of the cellulose which include: (i) the characteristic intermolecular and intramolecular O—H stretching vibration band in the spectra which occur at 3327 and 3330, respectively, for GH-MCC and Avicel PH 101; (ii) the peak at 1429, 1426, and 1315/cm which are associated with intermolecular hydrogen bonds at the C group and the O—H in plane bending vibration, respectively. It is noted that the band at 1426 for the GH-MCC is less strong when compared to that for Avicel PH 101; (iii) the absorption band at 895/cm in the spectra that is due to antisymmetric out-of-phase stretching vibration. However, this intensity for the GH-MCC spectra is stronger than that for Avicel PH 101. Krassig has

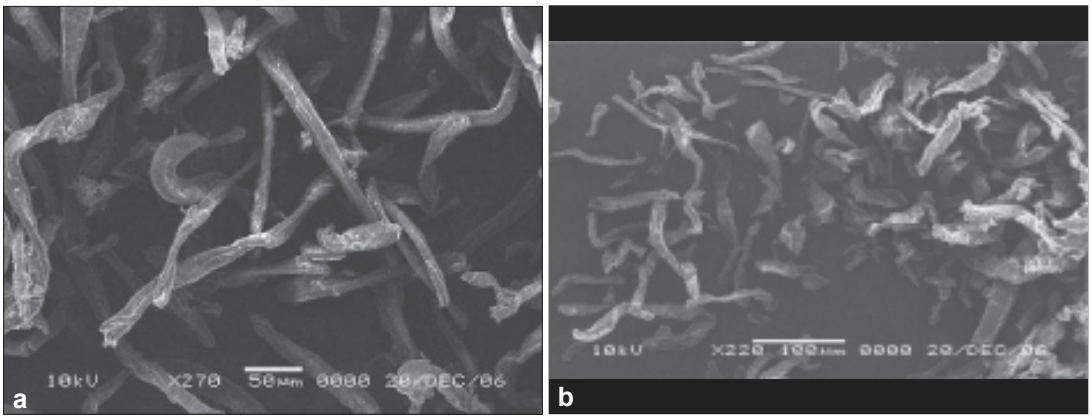

Figure 2: SEM graphs of commercial Avicel (a) and GH-MCC (b)

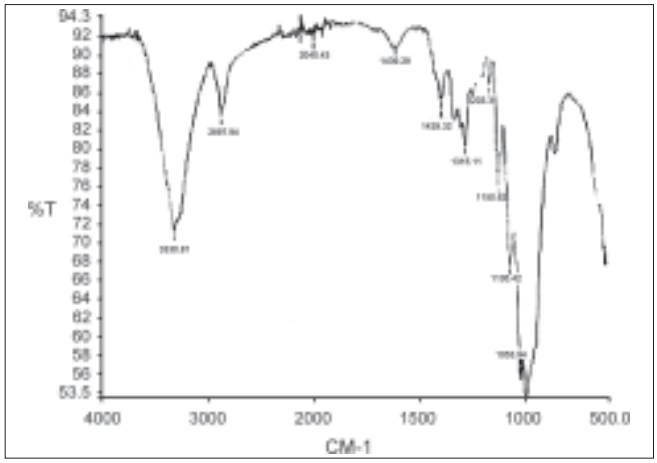

Figure 3a: Infrared spectroscopy spectra of Avicel PH 101

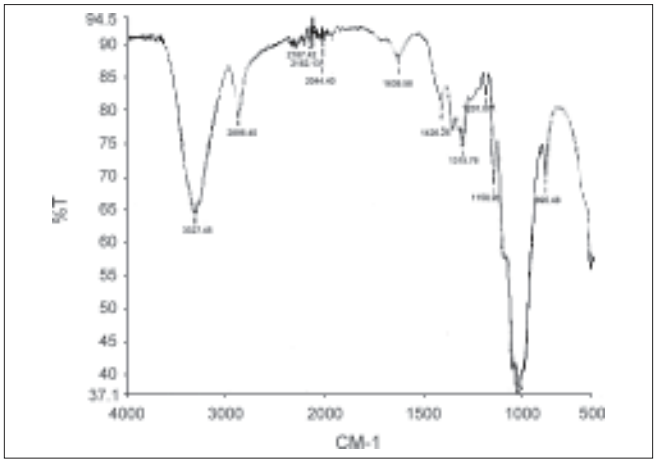

Figure 3b: Infrared spectroscopy spectra of GH-MCC

pointed out that the intensity of this peak increases with decrease in crystallinity of the cellulose material and a change in the crystal lattice from cellulose I to cellulose II.[19] Consequently, the higher intensity of this peak seen for GH-MCC compared to that of Avicel PH 101 indicates that the former would have lower crystallinity index.

The X-ray diffraction pattern of prepared GH-MCC along with that of commercial Avicel PH 101 is shown in [Figure 4]. The diffractograms are similar, with the diffraction peaks appearing at about 15.5 and 22°C 2θ (due to 101 and 002 reflections, respectively) and the pattern is characteristics of cellulose I.[20] The calculated crystallinity indices are 0.67 and 0.64 for Avicel PH 101 and GH-MCC, respectively. These values are within the crystallinity index range of 0.58-0.69 reported for 11 brand-name MCCs as measured by powder X-ray diffraction patterns and infra-red absorption spectra.[21]

Thermal analysis is convenient and reproducible, and is a useful method for characterizing heterogeneous organic material. In particular, it is a valuable analytical method to investigate the physico-chemical properties of macromolecules such as cellulose. [Figure 5] shows the DSC thermograph for Avicel PH 101 and GH-MCC. The similarity of the thermograms indicates that the prepared GH-MCC and Avicel PH 101 had equal thermal stability. The major features in these thermograms are presence of two endothermal peaks. Results obtained from the thermogram are summarized in Table 3. T_{MCC} (for the melting or thermal decomposition) for GH-MCC and Avicel PH 101 are practically the same with values at 341.6 and 335.8°C, respectively. T_{wl} (of water loss) shows no significant dislocations. However, it should be noted that the first endotherm peak, which indicate de-sorption of water from the cellulose materials, is broader for Avicel PH101, indicating it has more water than the GH-MCC. This observation is in agreement with the results of amount of moisture loss [Table 4] as determined by loss on drying. This endotherm is present on the thermograms of cellulosic materials due to the interaction of the water and the hydroxyl groups of the cellulose.

Area of endothermal peak 2 (melting or thermal decomposition of MCC), ΔH_{MCC}, correlates with proportion of crystallinity; higher value implies higher crystallinity.

Table 2: Some physicochemical properties of GH-MCC

Identification	Turns violet-blue with iodinated $ZnCl_2$
Organic impurities	Nil
Starch and dextrins	Nil
pH	6.4
Solubility (in ammoniacal solution of copper tetrammine)	Complete and no residue
Water soluble substance	<0.2%
Total ash (%)	0.38 (0.06)

Values in parenthesis represents standard deviations with *n* = 3

Table 3: Heat of the thermal decomposition reaction (ΔHMCC), temperatures at the minimum of the water loss (TWI) and thermal decomposition (TMCC) differential scanning calorimetry (DSC) peaks, for prepared GH-MCC and Avicel PH 101

	TWI (°C)	TMCC (°C)	ΔHMCC (J/g)
GH-MCC	58.7	341.6	322.3
Avicel PH 101	59.7	335.8	328.7

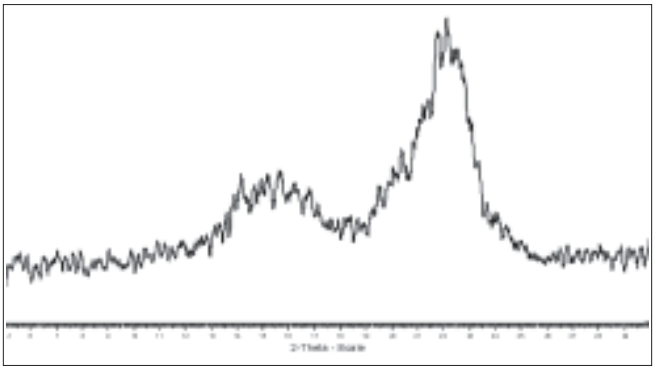

Figure 4a: X-ray diffraction patterns of prepared GH-MCC

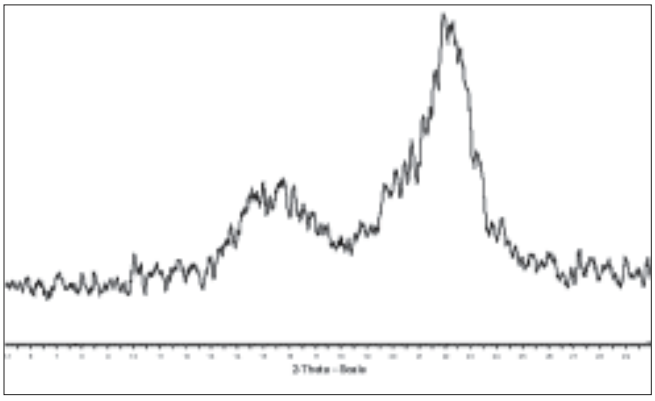

Figure 4b: X-ray diffraction patterns of prepared Avicel PH 101

Table 4: Powder properties of GH-MCC and Avicel PH 101

Parameters	GH-MCC	Avicel PH 101
True density (g/ml)	1.47 (0.05)	1.40 (0.12)
Bulk density (g/ml)	0.26 (0.01)	0.31 (0.04)
Tapped density (g/ml)	0.38(0.01)	0.42 (0.12)
Flow properties:		
Angle of repose	44.23(0.8)	41.20 (0.46)
Hausner index	1.47	1.35
Compressibility index (%)	31.72	26.00
Hydration capacity	4.22. (0.65)	2.17 (0.31)
Swelling capacity (%)	45.22(1.06)	21.40 (0.24)
Loss on drying (%)	6.20(0.22)	7.40 (0.4)
Moisture sorption capacity (%)	28.40 (0.46)	16.60 (0.28)

Values in parenthesis represents standard deviations with *n* = 3

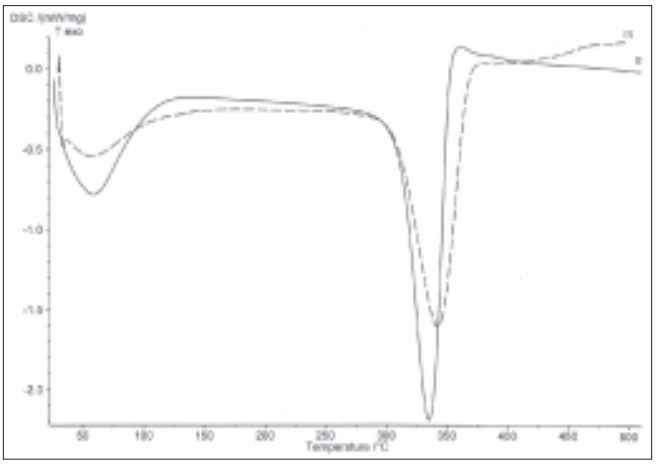

Figure 5: Differential scanning calorimetry (DSC) curves for Avicel PH 101 (1) and GH-MCC (2)

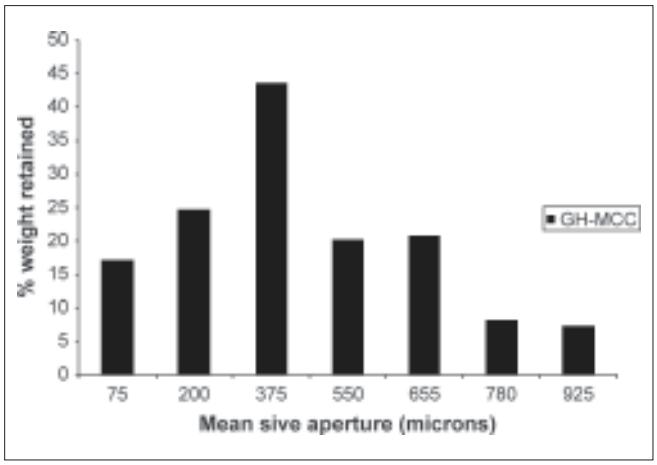

Figure 6: Particle size distribution of GH-MCC powder

Consequently, this results indicate that the order of crystallinity is Avicel PH 101 > GH-MCC - the same trend as measured by powder X-ray diffraction method.

The powder properties of GH-MCC and Avicel PH 101 are presented in Table 4 while the result of particle size distribution for GH-MCC is as shown in [Figure 6]. The figure represents a unimodal frequency distribution that is slightly positively skewed. The particle size is in the range of 70-1000 microns, as such GH-MCC powder belongs to the classification conventional powder.[22] Over 90 percent of the particle population is less than 375 micron, and the calculated average diameter was 206 μm.

The loss on drying of GH-MCC was about 6.2% that is slightly below the official limit of 6.5% (BP, 2004). This low value is indicative of the suitability of GH-MCC as a diluent in the formulation of hydrolysable drugs such as aspirin.

The flow properties of a powder are essential in determining the suitability of it as a direct compression excipent. The angle of repose, Hausner index, and Carr's percent compressibility are considered as indirect measurements of powder flowability.[23] The angle of repose of GH-MCC is high [Table 4], which is indicative of very poor flow.[24] While the Hausner index is indicative of interparticle friction, the Carr's index shows the aptitude of a material to diminish in volume.[23] As the values of these indices increase, the flow of the powder decreases. In general, however, Hausner ratio greater than 1.25 indicates poor flow and Carr's compressibility index below 16% indicate good flowability while values above 35% indicate cohesiveness.[23] Thus, the flow indices [Table 4] showed that both GH-MCC and Avicel PH 101 flowed poorly. As such, a glidant will be needed when these materials are to be used in solid dosage formulation.

Swelling which is generally accepted as an indication of tablet disintegration ability can be assessed by the determination of hydration capacity, swelling capacity, and moisture sorption profile.[25] The hydration capacity value [Table 4] indicates that GH-MCC is capable of absorbing more than four times its own weight of water. The swellability, which reflects the increase in volume of cellulose following water uptake was 45.22% [Table 4]. It seems therefore, that only a small portion of absorbed water actually penetrated the individual cellulose particles causing them to swell. Consequently, if the cellulose was incorporated in tablet formulation as a disintegrant it would probably produce tablet disintegration by two mechanisms: Capillary or wicking due to interparticulate water and swelling.

The moisture sorption capacity is a measure of moisture sensitivity of materials and the value for GH-MCC is rather high when compared to Avicel PH 101. Stamm has reported that the crystallite portion of cellulose does not adsorb water and that the extent of water adsorption by cellulose should thus be proportional to the amount of amorphous cellulose present.[26] Thus, the result is suggestive that GH-MCC would have higher proportion of amorphous cellulose than Avicel PH 101. Also, measurement of water sorption is of importance since it reflects the relative physical stability of tablets made from cellulose when stored under humid condition. Consequently, tablets made from GH-MCC powder would be less stable when compared to those from Avicel PH 101. Furthermore, this property showed that the cellulose powders are sensitive to atmospheric moisture and should therefore be stored in airtight container.

CONCLUSION

The results indicated that the production of

pharmaceutical grade cellulose from groundnut husk waste is technically feasible. It was found that the duration of bleaching affected the polymeric form of the processed *alpha* cellulose and hence, it is suggested that X-ray diffraction analysis should form an in-process check in the production of cellulose to ensure batch-to-batch consistency and performance. It was shown that the obtained microcystalline cellulose, GH-MCC, compared very well with the commercial grade MCC, Avicel PH 101, as well as conformed to the official specifications for MCC, in the British Pharmacopoeia (2004). Hence, GH-MCC is a potential tablet excipient.

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