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PROCESSING AND EVALUATION OF MICROCRYSTALLINE CELLULOSE OBTAINED FROM THE TENDER SHOOT OF *Bambosa Vulgaris*

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ABSTRACT
Microcrystalline cellulose (MCC), a purified, partially depolymerized cellulose remains the most widely used direct compression excipient in pharmaceutical industry[1,2]. It is prepared by treating alpha-cellulose obtained as a pulp from tender shoot of *Bambosa Vulgaris* with 2.5N hydrochloric acid and subsequent bleaching with 0.1N sodium hypochlorite, heated to 50°C for 30mins[3]. Results obtained showed a yield of 64% microcrystalline cellulose. It is a whitish, odorless, tasteless crystalline powder. Its direct compression and binding properties were compared with those of fine grade microcrystalline cellulose (Avicel PH 101). At concentration ratios of 60:40(new MCC : Ascorbic acid), friability showed anconcentration ratio. Though Hausner quocient of 1.24 and percent compressibility of 20.02 indicates that this new MCC does have fairly good flow properties, it has been shown to possess a potentially good binding characteristics without addition of other excipients.

Keywords: *Microcrystalline cellulose (MCC); Bambosa vulgaris; compressibility*.

INTRODUCTION

Direct compression is the simple and most advanced tablet manufacturing technique that offers product stability and improved process reliability with the optimization of tablet disintegration[1]. Microcrystalline cellulose remains the best excipient for direct compression tabletting[2]. It is a purified, partially depolymerised non-fibrous form of cellulose that occurs as a white, odorless, tasteless, crystalline powder composed of porous particles. Its use in pharmaceutical industry as a strong dry binder, tablet disintegrant, absorbent, filler or diluent , lubricant and anti adherent are well documented[3-7].

Pharmaceutical grade microcrystalline cellulose obtained from natural sources such as Sorghum bicolor, sisal fibers, viscose rayon, waste paper, *Luffa cylindrica*, corncobs as well as from fast growing plants like *Crotolaria juncea*[3-10] have proven to be stable, safe and physiologically inert and has revolutionalised tabletting. Consideration of the properties of direct compression excipient which microcrystalline cellulose possesses and the high cost of commercially available product necessitated study of our local source of this material from the tender shoot of *Bambosa vulgaris*.

Bamboo group of woody, perennial, world's fastest growing evergreen plant in the true grass family Poaceae is available abundantly in India, other East Asian countries, Sub-saharan Africa, China and Australia. Bamboos are of notable economic and high cultural significance in those countries. Among its numerous uses such as scaffolding, houses, papers, toothpicks, particle boards, decorative artwork carvings, bamboo shoots are largely used as food in Asian dishes and broths; fermented sap of young stalks are used in making Chinese liquor. Medically, it is used in Chinese medicine for treating infections and healing. It is a good low-calorie source of protein. Pharmaceutically, microcrystalline cellulose has a good dilution potential, compressibility and flowability. It is a special form of cellulose fibril in which the individual crystals are held together by hydrogen bonding. Warr et al[11] noted that water penetration, disintegration and dissolution of tablets containing microcrystalline cellulose were low. In the course of this work, attempt was made to evaluate physicochemical properties of MCC prepared from tender shoot of *Bambosa vulgaris* and to evaluate its use as a direct compression excipient in ascorbic acid tablet formulation. This product was evaluated with reference to pioneer/standard product Avicel PH101.Tablet properties such as hardness (crushing strength), friability, and uniformity of weight, disintegration time as well as dissolution rates were evaluated for all the batches produced.

Chemicals

The following chemicals: Ethanol, Sodium hydroxide, Acetic acid, Sodium hypochlorites were obtained from BDH Chemical Ltd. Poole England; Hydrochloric acid, and distilled water obtained from M&B England and lion table water from university of Nigeria, Nsukka.

Materials

Chips of about 1-3months tender shoot of plant *Bambosa Vulgaris* were collected from around the

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University of Nigeria, Nsukka, Ascorbic acid powder(Sigma,USA), Avicel PH 101 powder(FMC Cooperation, USA).

METHODS

Preparation of microcrystalline cellulose from *Bambosa Vulgaris*

Its natural fiber contains appreciable quantity of lignin with â and ã-cellulose. To obtain pure microcrystalline cellulose from the plant, these constituents were removed following these methods.

De-lignification and bleaching of the fiber

The new MCC was prepared using Ohwoavworhua et al[3] method with slight modification. Two cm pieces of *Bambosa vulgaris* chip free of sand and other contaminants were dried in the oven at 60°C for 5 hours and milled. A 2.5 Kg quantity of this material was placed in 11.9N ethanol solution overnight to remove possible chlorophyll present.

The material was filtered and placed in 0.9N solution of sodium hydroxide and heated to 50°C for 8 hours. The filtered material was heated in 4.4N sodium hydroxide to 50°C for 8 hours for complete delignification and removal of â and ã-cellulose. The á-cellulose left was neutralized with 0.1N acetic acid and washed with water. This was bleached by heating severally with 0.1N Sodium hypochlorite solution to 50°C for 30 mins until white material was obtained. This was dried at 60°C for 3 hours and weighed.

Partial Depolymerisation

An 1.6 Kg bleached, dried material heated in 2.5N hydrochloric acid with vigorous stirring for 30 mins yielded a suspension which was cooled, filtered and the residue washed several times with water. The product was filtered under negative pressure, dried, weighed and stored in an air tight container.

Powder properties of microcrystalline cellulose

Angle of repose and flow rate

Free standing cone method was adopted. A weighed amount of new vehicle was carefully poured through the funnel of orifice diameter 1.1cm and base 5.5cm until the apex of the cone formed, reached the tip of the funnel. Mean diameters of the base of the powder cones were determined and tangent of the angle of repose calculated. With same funnel of closed orifice, a weighed amount of the vehicle was poured and as the orifice was opened, the time required for the powder to flow through the orifice was taken as flow rate. Average of three determinations was taken.

Bulk Density, Tapped Density, Hausner Quocient And Percent Compressibility

The bulk and tapped densities were measured in a 100ml measuring cylinder as a measure of packability of the MCC powders. A pre-weighted quantity of the powder material contained in the cylinder was tapped mechanically by means of a constant-velocity rotating cam until a change from its initial bulk density to a final tapped density was attained (unchanging arrangement). Three determinations were made.

$$D_b = M/V_0 \quad \text{——Eqn 1}$$

$$D_t = M/V_t \quad \text{——Eqn 2}$$

D_b and D_t= Bulk and tapped densities respectively

V_0 and V_t = Initial and final volumes respectively

M = Mass of powder.

Percent compressibility was calculated from the values of D_b and D_t using Carr's equation:

% compressibility = [(Tapped density - Bulk density)/ Tapped density] * 100—Eqn 3

Hausner quocient Q = Tapped density / Bulk density.

Direct compression excipient capacity

The ability of the new vehicle to successfully carry the active ingredient in direct compression technique was tested by tabletting with varying concentrations of the powder vehicle to that of ascorbic acid and evaluating the crushing strength and friability of tablets obtained in comparison with that of the Avicel PH 101.

Tablet formulation and evaluation

Tablets containing 100mg Ascorbic acid were prepared using corn starch as a disintegrant varying between 6% and 10% w/w and microcrystalline cellulose from *Bambosa vulgaris* used as the filler binder for batches A, B, and C whereas Avicel PH 101 used for the batches D, E, and F. The weighed ingredients were added using serial dilution method and then tumble-mixed in an air-tight container for 10 mins. Each batch of granule blend was lubricated with 1.0% w/w magnesium stearate prior to compression with Manesty F-3 single punch tabletting machine fitted with 9.5 mm biconcave punches to a target weight of 300mg±20mg.

Crushing strength

Twenty tablets were randomly selected from each batch. The crushing strength of each was determined using Erweka Crushing strength tester (Erweka, GmbH,Ottostrasse,Germany). The mean crushing strength and coefficient of variation were determined for each batch of tablet.

Friability test

A sample of twenty tablets was selected from each batch and dusted by directing a stream of air onto the tablets. The weighed sample of tablets was placed in the electronic friabilator tester (Roche Friabilator) programmed to revolve for 4 mins at 25 rpm after which the tablets were de-dusted and reweighed. Weight different before and after the test were used to calculate the friability.

Uniformity of weight

The BP 2009 method was adopted. Twenty tablets were weighed singly and then together. The deviation from the mean and the coefficient of variation were determined[12].

Disintegration time test

An Erweka disintegration unit (ModelZT-4) was used for the test. A 0.1N Hydrochloric acid maintained at 37±1°C constituted the disintegration medium. Five tests were performed with a single tablet at a time and the mean calculated for the five runs.

Dissolution test

The dissolution profile of Ascorbic acid tablets were determined using BP 2009 dissolution apparatus[12]. The dissolution medium was a standard solution of 0.1N Hydrochloric acid maintained at 37±1°C. Using one tablet from each batch, a basket containing test tablet was made to rotate at 100±2rpm. Triplicate determinations were carried out in each batch for 45 mins. Aliquot of the dissolution medium were withdrawn at predetermined time intervals while sample withdrawn was replaced with an equivalent volume of dissolution medium maintained at the same temperature. Absorbance was taken at 244 nm on spectrophotometer. Average of 3 dissolution data points were used for obtaining a dissolution profile.

Calibration curve

Absolute drug content of ascorbic acid tablet was obtained by weighing 100mg of the sample and dissolving in 100mg 0.1N hydrochloric acid. Dilutions were made from this stock solution to obtain concentrations of 0.2, 0.4, 0.6, 0.8, and 1.0 mg%. Absorbance values for each dilution was read at 244 nm using UV Spectrophotometer.

RESULTS AND DISCUSSION

Percentage yield of prepared microcrystalline cellulose

Original weight of material processed = 2500g
Weight of product obtained = 1600g

$$\% \text{ yield} = \frac{\text{final weight}}{\text{Original weight}} \times 100 = \frac{1600g}{2500g} \times 100 = 64\%$$

The percentage yield of the microcrystalline cellulose prepared is good and this is economically viable compared with avicel PH 101.

Physicochemical properties

Table 1: *Powder characteristics*

MATERIAL	Flow rate (g/sec±SD)	Angle of Repose (θ±SD)	Bulk density (g/ml±SD)	Tapped density (g/ml±SD)	Compressibility (%)	Hausner Quocient (Q)
MCC from *Bambosa vulgaris*	4.23±0.02	33.22±1.41	0.318±0.005	0.420±0.005	20.02	1.24
Avicel PH 101	3.85±0.10	43.10±0.54	0.415±0.023	0.661±0.001	37.22	1.60

Flow characteristics of pharmaceutical excipient are a major concern with respect to the handling and compaction of the powder material for direct compressible excipients[6]. From Table 1, the flow indices showed that new MCC has a fair flowability against Avicel PH 101 of 3.85g/secs. The poor flow property of avicel PH 101 is widely reported in literature[13, 14]. This could be attributed to particle shapes and sizes and/or moisture content. Smaller particles could cause blockage of the orifice resulting from cohesive forces. On the other hand, particle sizes beyond optimum could cause a drag on the container wall thus decreasing flowability[15]. Consequently, glidants would be employed to reduce both effects.

Angle of repose and Hausner quocient give qualitative assessment of interparticle friction. An angle of repose greater than 50° exhibit poor or absent flow, whereas angle up to 40° indicates reasonable flow and minimum angles close to 25^0 correspond to very good flow. From the values obtained (Table 1), new MCC (From *Bambosa vulgaris)* indicates a better flowability than the standard. Hausner quocient of 1.2 indicates good flowability while high values show interparticulate cohesion which reduces flowability[16]. According to Carr[17] whose index shows an aptitude of a material to diminish in volume, materials with percent compressibility value more than 35% indicate poor flow behavior and values below 16% indicate good flowability. Here, HQ and % compressibility values of new MCC indicate superiority in flow property over the standard filler binder. These values correlate with the observed angle of repose and flow rates. The resultant poor flow of Avicel also correlates with its high values for HQ and % compressibility. Bulk density of a powder is a measure of its packing behavior. An increase in consolidated bulk density is advantageous in tabletting[18]. This is because the fill volume of the die would be reduced. Moreover, good flow rate and fill ensure uniformity of weight and content. New MCC and Avicel showed low values for both bulk and tapped densities.

Direct compression excipient capacity

Direct compression capacity of an excipient is defined as the amount of active ingredient(s) which the excipient can successfully carry in the direct compression technique. Friability as shown in Table 2 increases as the concentration of both MCC decreases. This is expected since crushing strength decreases in the same order to loss of ability of MCC in binding the ascorbic acid particles at decreasing concentration. However at 60% concentration, MCC from *Bambosa vulgaris* showed an optimum direct compression capacity from its friability and mean crushing strength values.

Table 2: *friability and hardness with respect to excipient's capacity.*

Proportion of MCC in Ascorbic acid	MCC from *Bambosa Vulgaris*		Avicel PH 101	
(MCC or Avicel : Ascorbic Acid)	Hardness (kgf)	Friability (%)	Hardness (kgf)	Friability (%)
90:10	8.6±0.01	0.10±0.02	9.0±0.01	0.11±0.01
80:20	7.8±0.02	0.15±0.01	8.4±0.01	0.13±0.02
70:30	6.0±0.01	0.26±0.03	7.2±0.02	0.20±0.01
60:40	5.4±0.03	0.30±0.01	6.8±0.01	0.24±0.03
50:50	4.0±0.02	0.40±0.01	5.0±0.03	0.40±0.01

Friability and hardness

Friability measures the resistance of tablets or granules to abrasion owing to the type and concentration of excipients employed in tabletting. It is one of the physical properties of tablets which are very important for its packaging, transportation, handling and storage. As shown in Table 3, all batches except C passed this test. This failure could be attributed to the compressional force during tabletting.

The hardness of a tablet is very important in determining its ability to withstand mechanical shock and vibration. It is a function of the physical properties of granules[19]. Hardness is surely affected by the type and concentration of binder and lubricant used and also by compressional force. The values obtained above showed that Avicel as well as MCC from *Bambosa vulgaris* indicated varied hardness values and the factors listed could contribute to these values. However, the dissolution rate profile indicated that the drug was released though at varying times. From Table 2 it is observed that tablet hardness varies directly proportional to the concentration of MCC from *Bambosa vulgaris* and Avicel PH 101.

Table 3: *summary of physical characteristics of tablet batches (a-f) manufactured using 60:40 (mcc: ascorbic acid) at different concentrations of disintegrant.*

Batches	Starch used (%)	Hardness	Percent friability (%±SD)	Disintegration Time (min±SD)	Weight uniformity (mg±CV (%)
A	6.00	4.22±0.34	0.71±0.02	6.60±0.02	298.015±0.68
B	8.00	4.10±0.30	1.02±0.01	5.53±0.04	299.25±0.33
C	10.00	3.50±0.28	1.45±0.03	5.35±0.05	298.95±0.45
D	6.00	5.65±0.38	0.71±0.02	7.55±0.03	296.50±1.35
E	8.00	4.13±0.37	0.72±0.02	5.43±0.04	298.10±0.74
F	10.00	4.14±0.37	0.74±0.01	4.30±0.03	298.00±0.66

Weight uniformity

The weight uniformity test was carried out using 20 tablets and mean values obtained for each batch as shown in Table 3 revealed that all batches passed the BP specification.

Disintegration time test

This is a measure of the time it takes a tablet to disintegrate when immersed in the test fluid. Tablets are said to have disintegrated if no fragment remains on the screen or if particles remain, they are soft without an unwanted core[10]. For most normal release tablets, time permitted is 15mins. From Table 3, it is evident they all passed the disintegration tests, however it is seen that the disintegration time and crushing strength of each batch decreased with increase in the concentration of the disintegrant from 6% to 10% while friability increases with increase in the concentration of the disintegrant.

Dissolution rate profile

This shows from Fig 1 and 2 that increase in concentration of disintegrant leads to increase percentage drug released. It was also observed that tablets containing avicel (batches D, E and F) released faster than the formulations (A, B and C) containing new MCC at 45mins (t_{45}).

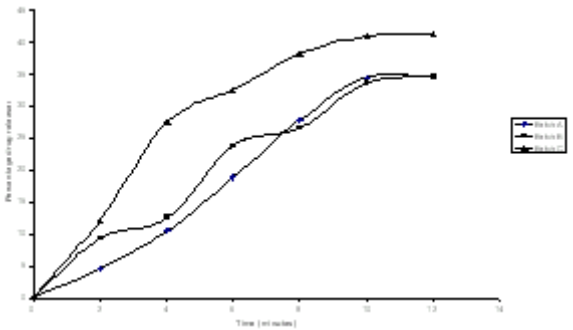

Fig. 1 : *Dissolution Rate Profile for Batches A, B, and C of ascorbic acid*

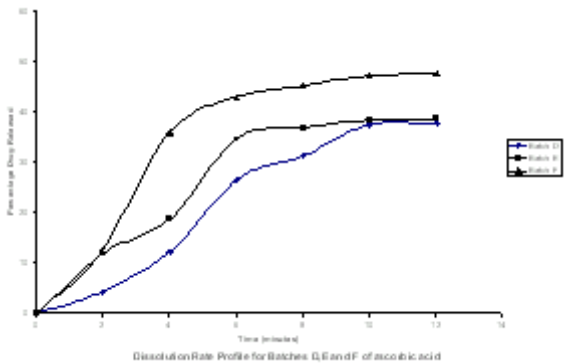

Fig. 2 : *Dissolution Rate Profile for Batches D, E, and F of ascorbic acid*

CONCLUSION

The microcrystalline cellulose obtained from *Bambosa vulgaris* could make available to pharmaceutical industry an extremely valuable excipient for tabletting. Preliminary toxicological tests indicated it is non-toxic to male and female albino mice. Even though much energy and skill may be involved in cultivating and

harvesting very tender shoots of Bambosa vulgaris, the results obtained may be rewarding. Its yield was appreciably high (64%), major tablet characteristics tested complied with B.P specification. It has shown to possess good direct compression property with fair flowability. The evidence that the material was able to carry ascorbic acid particle without addition of any other excipient is commendable.

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