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COMPARATIVE PHYSICOCHEMICAL AND RHEOLOGICAL EVALUATION OF EXTRACTED AND CARBOXYMETHYLATED *PARKIA BIGLOBOSA* MUCILAGE

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ABSTRACT

Parkia biglobosa gum and mucilage are versatile plant products which are mostly used in food as well as in pharmaceutical industries and can easily be carboxymethylated to modify their physicochemical characteristics. This work aimed to evaluate the physiochemical and rheological properties of the mucilage from *Parkia biglobosa* seeds. The mucilage was extracted from *Parkia biglobosa* seeds and modified by carboxymethylation via the Williamson´s synthesis using monochloroacetic acid as the etherifying agent. Physico-chemical characeterization was carried out on the modified mucilage via viscosity and swelling capacity investigation and for its degree of substitution via titrimetric, Fourier transform infra-red spectroscopy (FT-IR) and differential scanning calorimetry (DSC) techniques. Hydration capacity, moisture sorption, scanning electron microscopy, rheological and flow properties were used to characterize the mucilage. Both mucilages had desirable pleasant odours and bland taste. The extracted mucilage produced a derivative with higher hydration and moisture sorption capacity, a marked decrease in viscosity, and improved flow properties. Also, changes attributable to modification were observed from the FT-IR spectra and DSC thermograms. Both the extracted and modified mucilage possessed fundamental characteristics that would make them suitable as pharmaceutical excipients in the formulation of solid and liquid dosage forms.

KEYWORDS: ***Parkia biglobosa;* Mucilage; Carboxymethylation; Physicochemical; Rheology.**

INTRODUCTION

In recent years, plant-derived polymers appear to be more preferred over synthetic ones due to their accessibility, biocompatibility, low cost and low toxicity potential. Mucilage's and gums (both plants hydrocolloids) are most widely used as pharmaceutical excipients due to their binding, diluent, disintegrant, suspending, gelling, thickening, stabilizing and humidifying properties [1, 2]. Mucilage is a complex polymeric substance composed mainly of carbohydrates with highly branched structures, which include L-arabinose, D-galactose, L-rhamnose, D-xylose and galacturonic acid in various proportions [3]. It also contains glycoproteins [4] and other substances such as tannins, alkaloids and steroids [5].

Parkia biglobosa (Mimosoideae - Leguminosae) commonly called the African locust bean tree has long been widely recognized as an important indigenous fruit tree in anglophone and francophone West Africa. A mature *P. biglobosa* bean pod contains yellow, dry and powdery pulp in which dark brown or black seeds are embedded [6]. The seeds can be roasted for the production of tea, like infusion (called Sudan Coffee). Fermented seeds ('soumbala', 'dawadawa', 'netetu' 'Kula', 'Iru') serve primarily as condiments for seasoning sauces and

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soups served in various Nigerian meals among the various tribes of Nigeria. The sweet, yellow floury pulp is eaten fresh by rural dwellers, which indicates its edibility and non – toxicity [7]. The pulp can also be fermented into an alcoholic beverage. The leaves are sometimes eaten as a vegetable, usually after boiling and mixed with other foods such as cereal flour. Different parts of the plant are used in indigenous medicine [6].

The mucilage has been reported to be of acceptable shelf-life, biocompatible, biodegradable, non-teratogenic, non-mutagenic, and to possess degradation products that can easily be excreted [8]. It can be chemically modified to alter their physicochemical properties and to improve specific functional properties. Chemical modifications of polysaccharides by etherification, esterification, oxidation, and hydroxypropylation are generally done to prepare custom-made derivatives with desirable functionality attributes [9]. Carboxymethylation generally increases the hydrophilicity and solution clarity of the polysaccharide and makes it better soluble in aqueous systems [10]. This work aimed to extract the mucilage from *Parkia biglobosa* seeds, modify the extracted mucilage by carboxymethylation, evaluate the physicochemical and rheological properties, and determine their potential suitability as pharmaceutical excipients.

MATERIALS AND METHODS

Materials

Parkia biglobosa seeds were obtained from Kaura Local Government Area of Kaduna State.

Monochloroacetic acid (Sigma Chemical Co., Mo, USA), absolute ethanol, methanol, sodium hydroxide and hydrochloric acid were from BDH Chemicals Ltd. Poole - England.

Sample collection and extraction of *Parkia biglobosa* mucilage

Exactly 4 kg of the *Parkia biglobosa* seeds were thoroughly washed to remove all extraneous materials and then immersed in 10 L of boiling water at 100 ^{o}C for 6 h after which the resulting mucilage (a viscous solution) was filtered using a silk cloth and absolute ethanol was gradually added. Off-white amorphous precipitates were formed when ethanol was added; they were collected and washed with ethanol and air-dried for 24 h. The dried mucilage was milled into powder and stored in an airtight container at room temperature for further use [11]. The colour, taste, odour and flavour of the extracted *Parkia biglobosa* mucilage (PBM) were examined and the percentage yield determined using Equation 1.

$$\%\ yield\ of\ mucilage = \frac{Weight\ of\ extracted\ mucilage}{Weight\ of\ Parkia\ Biglobosa\ seeds}\ x\ 100 \quad \ldots\ldots 1$$

Carboxymethylation of *Parkia biglobosa* mucilage

Nine batches each containing 10 g of *Parkia biglobosa* mucilage were separately kneaded with a variable amount (as shown in Table 1) of ice-cold 10 M NaOH solution for 45 min forming mixtures with dough-like consistencies. Then different amounts of monochloroacetic acid (MCA) were dissolved in 10 mL of water and added slowly to the mixtures which were then kept at 15 ^{o}C on a water bath for 1 h, after which they were heated to 65 ^{o}C and stirred for 1 h. The wet, semi-solid mass was then washed with 80 %$^{v}/_{v}$ methanol solution and neutralized with glacial acetic acid. The modified polymer was then dried at 45 ^{o}C in an oven. The dried modified *Parkia biglobosa* mucilage (MPBM) was milled, sifted with 125 µm sieve and stored in an airtight amber colored glass bottle at room temperature for further investigation [12]. The colour, odour, taste and flavour of the different batches of the modified *Parkia biglobosa* mucilage were examined and its percentage yield was also calculated using Equation 2.

$$\%\ \text{yield of MPBM} = \frac{Weight\ of\ MPBM}{Weight\ of\ PBM}\ \text{x}\ 100 \quad \ldots. 2$$

Determination of degree of substitution

Titration method

Five hundred milligrams (500 mg) of the extracted and modified mucilage was dispersed in 5 mL of 80% ($^{v}/_{v}$) methanol solution, thereafter, concentrated hydrochloric acid was added and stirred for 2 - 3 h. The mixtures were filtered through a Whatman filter paper with a pore diameter of 11 µm and the residues washed successively with 5 mL of methanol until the washing gave a neutrality pH. The residues were dried to a constant weight, then accurately weighed 200 mg of the dried samples were taken into a beaker and 1.5 mL of methanol solution (70% $^{v}/_{v}$) was added and allowed to stand for a few minutes. Then 20 mL of distilled water and 5 mL of 0.5 N NaOH were added. The mixtures were shaken until the samples dissolved completely. The solutions were then back titrated with 0.4 N HCl using phenolphthalein indicator to denote the endpoint. The degree of substitution (DS) of O-

carboxymethyl group was calculated using Equation 3 [8].

$$DS = \frac{0.162A}{(1-0.058A)} \quad \text{..... 3}$$

Where '*A*' is milliequivalents of NaOH required per gram of sample.

FT-IR spectroscopy method

The *Parkia biglobosa* mucilage (PBM) and each of the different batches of the modified *Parkia biglobosa* mucilages (MPBM) (5 mg) were blended with solid KBr, (100 mg) and about 40 mg of the blend was used to prepare a pellet. The spectra were scanned from 4000 to 400 cm^{-1} in a FT-IR spectrometer (Agilent technologies Cary 630) under dry air at room temperature. From the obtained spectra, the degree of substitution was determined quantitatively by calculating the ratio between the intensity of carbonyl frequency at 1600 - 1500 cm^{-1} and the intensity of hydroxyl vibration at 3500 – 3000 cm^{-1} [10].

Differential Scanning Calorimetry (DSC) method

DSC thermogram of the extracted and modified mucilage was obtained by using a DSC (DSC3, Mettler Toledo). Each sample (3 - 7 mg) was accurately weighed into a 40 μL aluminum pan in a hermetically sealed condition. The measurements were performed in an atmosphere of nitrogen between 20 and 250 °C at a heating rate of 10 °C/min.

Viscosity determination

The viscosities of 1.0% aqueous dispersions of the extracted and modified mucilage was determined at room temperature (27.0 ± 2°C) at 100 rpm using programmable Brookfield viscometer (DV-I Prime, USA), spindle no. 62.

Swelling capacity determination

The swelling capacity of the extracted and modified mucilage was determined using the method described by Noma *et al* [13]. The tapped volume occupied by 2 g of the powder (V_1) was noted. The powder was then dispersed in 8.5 mL of distilled water and the volume made up to10 mL with more water. After 24 h of standing, the volume of the sediment, V_2, was estimated and the swelling capacity was computed using Equation 4.

$$\text{Swelling capacity} = \frac{V1}{V2} \times 100 \quad \text{..... 4}$$

Batch MPBM-4 was selected as the optimal batch of the modified *Parkia biglobosa* mucilage based on possession of the lowest viscosity.

Physicochemical characterization of the extracted and modified *Parkia biglobosa* mucilage

Determination of the Solubility of PBM and MPBM

In each case, 1% $^{w}/_{v}$ dispersions of the extracted and optimal modified (batch M4) mucilage were prepared in distilled water, ethanol, acetone and chloroform respectively at ambient temperature and mixed at high speed for 2 min.

Hydration capacity

This was determined according to the method of Kornblum and Stoopak [14]. One gram (1 g) of each of the mucilage (Y) was placed in a centrifuge tube and covered with 10 mL of distilled water. The tube was shaken for 2 h and left to stand for 30 min before centrifuging at 3000 rpm for 10 min. The supernatant was drained and the weight of the powder after water uptake and centrifugation (X) was determined. Hydration capacity was calculated.

$$\text{Hydration capacity} = \frac{Y}{X} \quad \text{..... 5}$$

Moisture sorption

Two grams (2 g) of the mucilage (W) was separately weighed and transferred into a tarred Petri dish. The samples were placed in a desiccator containing distilled water at room temperature and the weight gained (Wg) by the exposed samples at the end of five days was recorded. The amount of water absorbed (Wa) was calculated from the weight difference [15].

$$Wa = Wg - W \quad \text{..... 6}$$

pH determination

This was done by shaking a 1% $^{w}/_{v}$ dispersion of the samples in water for 5 min and the pH determined using a pH meter (Milwaukee pH55, Europe).

The angle of repose determination

The angle of repose was determined using the method described by Ohwoavworhua and Adelakun [16]. The heights (h), of the powder cones and the mean diameters (D), of the base of the powder cones, were determined and the tangent of the angle of repose calculated as below.

$$\text{Tan } \theta = \frac{2h}{D} \quad \text{..... 7}$$

Bulk and tapped densities determination

The bulk and tapped densities of the samples were determined using the method described by Emeje *et al*., [17]. Two (2.0) grams quantity of each sample was placed in a 10 mL measuring cylinder and the volume, V_o, occupied by each of the samples without tapping was noted. After 100 taps on the table, the occupied volume V_{100} was read. The bulk and tap densities were calculated as the ratio of weight to volume (V_O and V_{100} respectively).

Hausner's ratio

This was calculated using the equation

$$\text{Hausner ratio} = \frac{\text{Tapped density}}{\text{Bulk density}} \quad \ldots\ldots\ldots\ldots\ldots 8$$

Carr's index

This was calculated using the equation.

$$\text{Carr's index} = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}} \times 100 \quad \ldots 9$$

Flow rate determination

Thirty grams (30 g) (w) of the samples were placed in the Erweka flow apparatus (Erweka apparatebau-G.m.b.H, Germany) and allowed to flow through the funnel orifice. The time (t) taken for the powder to flow through the orifice was noted and the flow rate was computed using the equation.

$$\text{Flow rate} = \frac{w}{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 10$$

Surface morphology

The surface morphology of the samples was examined using a scanning electron microscope. The samples were mounted on aluminum stubs and coated with gold by sputtering at 1200 V, 20 Ma for 105 s using a vacuum coater and observed to check any possible modification.

Rheological characterization of the extracted and modified *Parkia biglobosa* mucilage

The viscosities of 1% aqueous dispersion of the samples were determined at varying temperatures (30, 40, 50, 60 and 70 ^oC) using a Brookfield viscometer (DV-I Prime, USA) at a shear rate of 100 rpm using spindle number 62. It was repeated by varying concentrations (0.5, 0.75, 1.0, 1.25 and 1.5%) of the aqueous dispersions at room temperature (28 ± 2 ^oC).

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) windows version 23 (SPSS Inc., CA, USA). The results were presented descriptively in tables and charts. The differences between the data sets were determined using *t*-test and $p < 0.05$ was considered statistically significant.

RESULTS

The extracted and modified mucilage gave brown and light brown colour respectively, both exhibited desirable odour and bland taste (Table 2).

The swelling capacity and viscosity of the extracted mucilage were higher than those of the modified mucilage (Table 3). The FTIR spectrum of PBM showed broadband between 3000-3500 cm^{-1}, characteristic of –OH stretching, this was broadened in the different batches of the modified mucilage (M1 to M9). The modified mucilages MPBM-1 and MPBM-2 showed bands at 1736.9, 1401.5 cm^{-1} and 1595.3 cm^{-1} while MPBM-3 to MPBM-9 showed bands at 1600 cm^{-1} which represents -C=O stretching for acids and -C-O stretching for ethers (Figure 1). The DSC thermogram of both the extracted and modified mucilages (Figure 2, Table 3) showed a broad endothermic peak with the different thermal dissociating peaks as presented in Table 3. The thermal dissociation peak increased as signified by the increased melting point with an increase in the concentration of reaction variables like NaOH, MCA, or a rise in temperature.

While 1 g of PBM mixed with 100 mL of water (1% $^w/_v$) formed a viscous dispersion, MPBM-4 formed a clear solution. Both PBM and MPBM-4 were however insoluble in ethanol, acetone and chloroform forming precipitates that sediment when allowed to stand for 10 min.

There was a significant ($p < 0.05$) increase in the hydration capacity ($p = 0.021$) and moisture sorption ($p = 0.01$) of the modified mucilage compared to the extracted mucilage. There was however, a decreased in the values of the flow properties, that is, lower Carr's index, flow rate, and angle of repose. The modified mucilage also had a lower pH compared to the extracted mucilage (Table 4). The viscosity of both PBM and MPBM-4 increased with increasing mucilage concentration at room temperature (Figure 3). MPBM-4 was also observed to be significantly ($p < 0.05$) less viscous than PBM across the different concentrations [0.5% ($p = 0.034$), 0.75% ($p = 0.01$), 1.0% ($p = 0.016$), 1.25% ($p = 0.000$) and 1.5% ($p = 0.042$)].

The results showed that the modification produced larger particles with spherical shape and rough surfaces (Figure 4).

Table 1: Different batches of modified (carboxymethylated) *Parkia biglobosa* mucilage and the conditions of preparation.

Batch	Vol of 10 M NaOH (mL)	Monochloroacetic acid (MCA) (g)	Molar ratio NaOH/MCA/PBM	Tempt (°C)
MPBM-1	2.8	2.64	1:1:1	65
MPBM-2	5.6	2.64	2:1:1	65
MPBM-3	8.4	2.64	3:1:1	65
MPBM-4	11.2	2.64	4:1:1	65
MPBM-5	14.0	2.64	5:1:1	65
MPBM-6	11.2	5.28	4:2:1	65
MPBM-7	11.2	7.92	4:3:1	65
MPBM-8	11.2	5.28	4:2:1	95
MPBM-9	11.2	5.28	4:2:1	35

Table 2: Organoleptic properties and the percentage yield of the extracted and modified *Parkia Biglobosa* mucilages.

Properties	Extracted *Parkia Biglobosa* mucilage	Modified *Parkia Biglobosa* mucilage
Colour	Brown	Light brown
Taste	Bland	Bland
Odour	Desirable	desirable
Percentage yield	11.130 ± 0.40	81.0 ± 2.765

Table 3: Swelling capacity and viscosity of both the *Parkia biglobosa* mucilage (PBM) and the different batches of the modified mucilage (MPBM-1 TO MPBM-9) in distilled water and the degree of substitution of O-carboxymethyl group following modification in the different batches of the modified mucilage (N=9).

Batch	Swelling capacity (%)	Viscosity (mPa s)	Degree of substitution (Titrimetric)	Degree of substitution (FTIR)	DSC (melting point shift)
PBM	88.7 ± 0.23	4.4 ± 0.28	0.00	0.00	75.88
MPBM-1	76.3 ± 1.06	4.3 ± 0.07	0.34	1.06	76.40
MPBM-2	65.3 ± 0.00	3.6 ± 0.28	0.36	0.90	79.34
MPBM-3	55.8 ± 0.32	3.2 ± 0.41	0.41	0.83	72.70
MPBM-4	41.0 ± 1.41	3.1 ± 0.41	0.41	0.85	78.21
MPBM-5	41.0 ± 1.41	3.3 ± 0.42	0.42	0.77	80.40
MPBM-6	51 ± 1.41	3.7 ± 0.42	0.41	0.84	82.33
MPBM-7	70.0 ± 0.00	3.3 ± 0.41	0.41	0.84	81.69
MPBM-8	62.8 ± 0.35	3.8 ± 0.43	0.43	0.67	87.01
MPBM-9	44.5 ± 0.01	3.5 ± 0.42	0.42	1.01	88.51

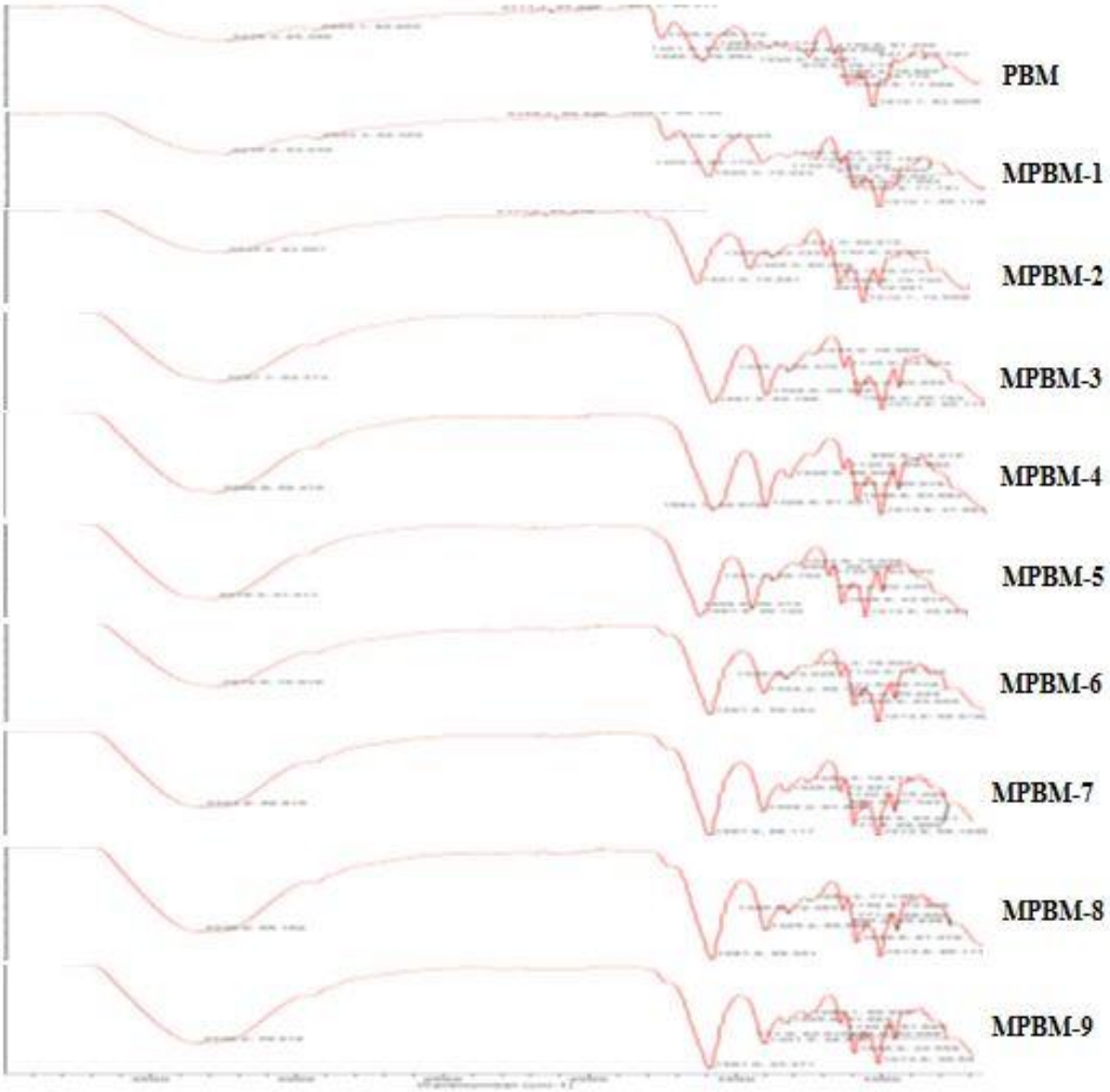

Figure 1: FTIR spectra of *Parkia biglobosa* mucilage (PBM) and the different batches of the modified mucilage (MPBM-1 to MPBM-9).

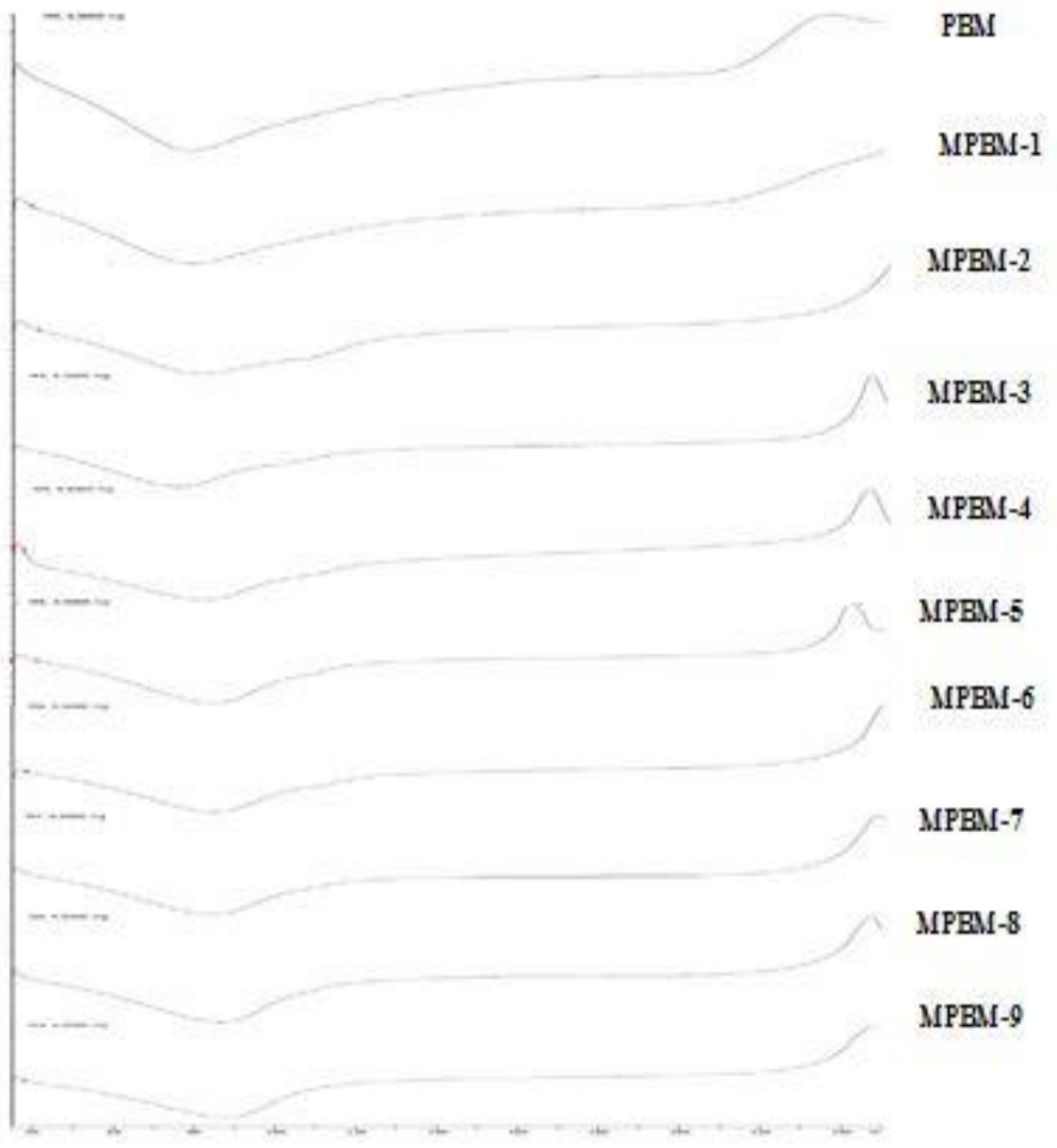

Figure 2: DSC thermograms of *Parkia biglobosa* mucilage (PBM) and the different batches of the modified mucilage (MPBM-1 to MPBM-9).

Table 4: Physicochemical characteristics of the extracted (PBM) and the optimal batch of the modified *Parkia biglobosa* mucilage (MPBM-4).

Properties	PBM	MPBM-4
Hydration Capacity*[a]	1.82 ± 0.219	2.07 ± 3.536
Moisture Sorption*[b]	1.55 ± 0.710	2.52 ± 0.710
pH	7.20 ± 0.071	6.70 ± 0.000
Angle of repose (degree)	35.50 ± 0.710	29.90 ± 3.048
Bulk density (g/cm^3)	0.67 ± 0.022	0.57 ± 0.001
Tapped density (g/cm^3)	0.85 ± 0.026	0.71 ± 0.001
Hausner's ratio	1.27 ± 0.003	1.25 ± 0.001
Carr's Index (%)	21.20± 0.226	19.71 ± 0.339
Flow rate (g/sec)	2.30 ± 0.099	2.03 ± 0.042

*[a] p = 0.021, *[b] p = 0.01,

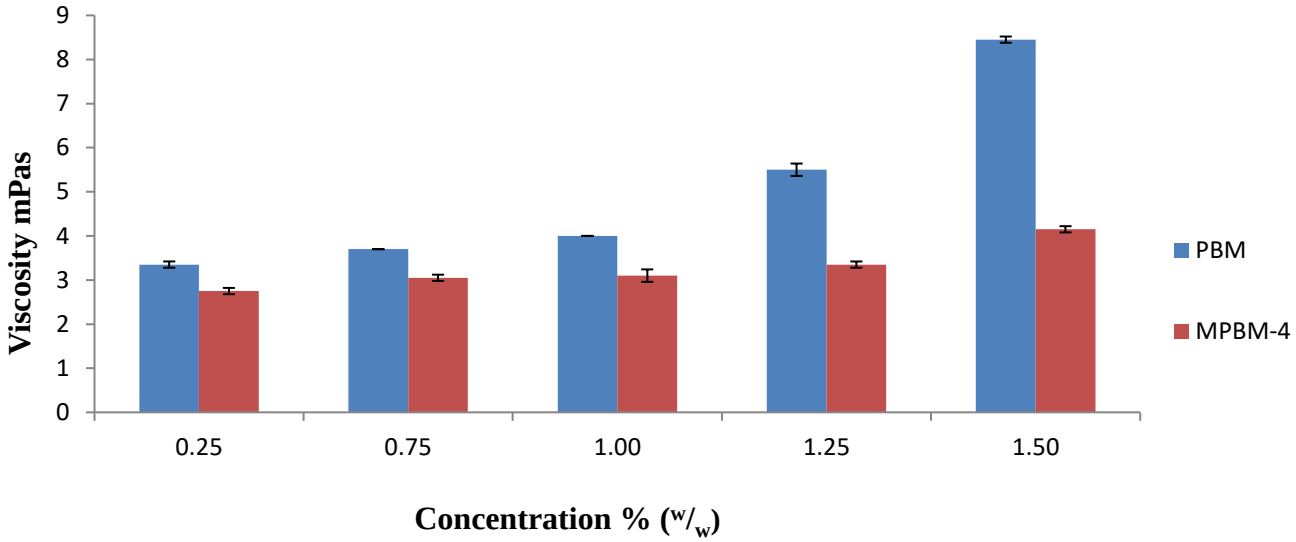

Figure 3: Effect of concentration on the viscosity profile of *Parkia biglobosa* mucilage (PBM) and the optimal batch of the modified *Parkia biglobosa* mucilage (MPBM-4).

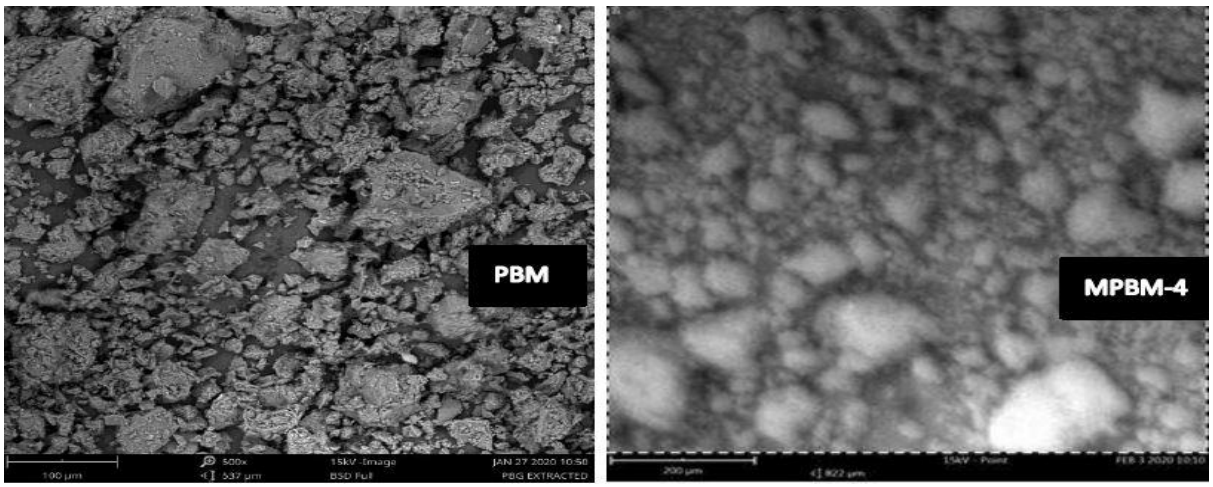

Figure 4: Scanning electron micrograph of *Parkia biglobosa* mucilage (PBM) and the optimal batch of the modified *Parkia biglobosa* mucilage (MPBM) (x 500 magnifications).

DISCUSSION

Carboxymethylation is the most commonly used chemical derivatization method to transform water-insoluble polymeric materials into a water-soluble form [10]. Carboxymethylation reaction is highly dependent on several factors including the ratio of base catalyst, MCA, reaction medium, time, and temperature. Processing variables optimization is therefore highly required to get the highest possible carboxymethylated *Parkia biglobosa* mucilage. Decreased in viscosity may be due to the steric hindrance of carboxymethyl groups and decreased intermolecular forces, or there may be a reduction of the molecular weight due to polymer chain degradation during the alkali kneading of the carboxymethylation process [12]. The mucilage viscosity was observed to increase with increasing MCA, temperature and NaOH concentration beyond 11.2 mL

The extent of carboxymethylation of carbohydrates is expressed in terms of the degree of substitution, which is the average number of substituted carboxymethyl groups per anhydrous sugar unit. Generally, the degree of carboxymethyl substitution as determined by the titrimetric, FTIR and DSC method was found to increase with increased NaOH concentration and rise in temperature. The broadening of the band between 3000-3500 cm^{-1} and the appearance of new bands at 1736.9 $^{-1}$, 1401.5 cm^{-1}, 1595.3 cm^{-1} and 1600 cm^{-1} in the different batches of the modified mucilage are changes which could be due to modification [18]. The changes in the thermal dissociation of the modified mucilages could be attributed to structural changes due to modification. Chemical modifications of polysaccharide are carried out to produce derivatives having desirable functional attribute such as increasing the aqueous solubility of the polysaccharide [8]. Except on a few occasions, a high drug dissolution rate is usually associated with high drug solubility [19]. For a drug to be absorbed it must first be dissolved in the fluid at the site of absorption and at least, limited aqueous solubility is required for therapeutic efficiency [20]. The rate of dissolution of a drug particle will be decreased as the viscosity of the dissolution medium is increased [21, 22]. Batch MPBM-4 was selected as the optimal batch of the modified *Parkia biglobosa* mucilage on the basis of possession of the lowest viscosity.

Water hydration capacity (water absorption, water uptake, or water holding or binding) is the amount of water that 1 g of material will imbibe and retain under low-speed centrifugation. It is the optimal amount of water you can add to a dough before it becomes too sticky to process. It gives an insight into the capillary effect of the powder which corresponds to its absorption ability [23]. Moisture sorption capacity, on the other hand, is a parameter for indicating how sensitive a powder material is to atmospheric moisture which also indicates its physical stability when formulated into a tablet. The optimized modified *Parkia biglobosa* mucilage (MPBM-4) had higher hydration and moisture sorption capacity than the extracted *Parkia biglobosa* mucilage (PBM). This shows that MPBM-4 absorbs more water than PBM, which can be attributed to an improvement in the hydrophilicity of the mucilage following Carboxymethylation. This suggests that, when use as a disintegrant, MPBM-4 may have a faster disintegration time than PBM. Disintegrants for orally disintegrating tablets are required to be highly moisture sensitive, thus the higher the value the better [13]. The high value of the moisture sorption capacity of MPBM-4 is however an indication that it is sensitive to atmospheric moisture which may undermine the stability of hydrolyzable constituents of a solid dosage form if used as an excipient in that formulation. The modified mucilage should, therefore, be stored in airtight containers since they are susceptible to moisture sorption at atmospheric conditions. Knowledge of the pH of an excipient is an important parameter in determining its suitability in formulations since the stability and physiological activity of most preparations depends on pH [24]. A pH of 6.70 suggests that MPBM-4 will not be irritating to the gastrointestinal tract.

Powder flowability refers to the ease with which a powder will flow under a specified set of conditions [25]. The angle of repose, bulk density, tapped density, Hausner's ratio, Carr's Index, and flow rate are some of the techniques that have been developed to characterize powder flowability. The determination of powder flow via angle of repose is often affected by the methodology of the test and may not be highly reproducible. As observed from the results of the physicochemical evaluation, both PBM and MPBM-4 had fair flow according to the Carr's scale, which could be improved by the inclusion of flow aids (lubricant and/or anti-adherent) [26]. MPBM-4 however exhibited a better angle of repose, Hausner's ratio and Carr's Index, hence, showed improved flow compared to PBM. This may be associated with the increased in size and change in shape (to spherical, see Figure 4) of the MPBM-4 following the carboxymethylation process, which often results in a reduction in the influence of adhesive forces on powder flow properties [27, 28].

The viscosity of the extracted PBM was higher than that of MPBM-4. This corroborates the report of Kaity and Ghosh [12] that polysaccharides in alkaline

solution generate saccharinic acids which can reduce the viscosity of the system. Also, as earlier mentioned, this may be due to the steric hindrance of carboxymethyl groups and decreased intermolecular forces, or there may be a reduction of the molecular weight due to polymer chain degradation during the alkali kneading of the carboxymethylation process. The viscosity of both PBM and MPBM-4 increased with an increase in concentration at room temperature. This is expected because increased concentration increases intermolecular attraction arising from increasing molecular mass. This is of particular interest in the formulation of suspensions and semi-solid dosage forms, where resistance to shear of agitation may impair easy pouring from the container [28]. Hence, the optimum concentration of the gum is expected to be determined. An increase in temperature was accompanied by a corresponding decrease in viscosity, a trend that has been widely observed, generally, the viscosity of a liquid decreases with increasing temperature [29].

CONCLUSION

A brown mucilage with a bland taste and desirable odour was extracted from *Parkia biglobosa* seeds and successfully modified to its carboxymethylated derivative using a simple and cost-effective method. The carboxymethylation process was optimized and it was observed that at 65 °C and NaOH/monochloroacetic acid/*Parkia biglobosa* mucilage molar ratio of 4:1:1, the extracted mucilage produced a derivative with a marked decrease in viscosity and improved flow properties. Both the extracted and modified mucilage possessed fundamental characteristics that would make them suitable as pharmaceutical excipients in the formulation of solid and liquid dosage forms.

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