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RESEARCH ARTICLE

PHYSICOCHEMICAL CHARACTERIZATION AND EVALUATION OF THE SUSPENDING PROPERTIES OF *CITRULLUS LANATUS* SEED WASTE COMPOSITE

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ABSTRACT

Background and aim: Biomaterial composite waste can be processed for application as pharmaceutical excipient. This study was aimed at assessing the suspending properties of *Citrullus lanatus* seed composite waste, after defatting, in the formulation of metformin suspension.

Methods: Defatted dried *C. lanatus* seed powder was subjected to micromeritics, water-holding and oil-holding, viscosity, pH, and microscopy pre-formulation studies. Eleven batches of metformin suspensions (100 ml) were formulated using 1, 2, 4, 6 and 8% $^{w}/_{v}$ of the composite powder, similar concentration ranges of xanthan gum, and a control batch. The pH, sedimentation volume, and re-dispersion number of the suspensions were determined.

Results: *Citrullus lanatus* seed yielded 56.31% composite powder having Carrs' index < 11.32, and angle of repose < 39.05. Pre-formulation studies revealed 3.81 g H_2O/ g water-holding capacity, and 2.53 g oil/ g oil-holding capacity. While pH of the aqueous composite decreased with storage, viscosity increased with concentration ($p < 0.05$) and remains relatively stable at < 40ºC. The TEM and SEM analyses of the composite-metformin blend revealed unique mesh-like and closely packed continuous sheaths. The composite suspension did not thicken on storage, and was not easily re-dispersed especially at higher concentration.

Conclusion: *Citrullus lanatus* seed composite showed good processing qualities, water-holding capacity and oil-holding capacity, passable thermal stability, and limited suspending properties. It demonstrated potential for optimization and for further research as emulsifier, and in combination with pharmaceutical gums as suspending agents.

Key words: *Citrullus lanatus*, re-dispersion number, water-holding capacity, oil-holding capacity, thermal stability

INTRODUCTION

Watermelon (*Citrullus lanatus*, family Cucurbitaceae), is native to tropical Africa, and is extensively cultivated in dry and warm regions worldwide for its bright coloured, pleasantly flavoured, and high water content fruit [1,2,3,4]. Watermelon fruit juice has been used in ethnomedicine, as diluent in dosage formulation for delivering drug active, and for quenching thirst [1, 3, 4, 5]. While the fruit juice is consumed for nutritive or medicinal value, the seeds are mainly discarded as agro-industrial waste [6]. The seed has low toxicity and is widely available [7]. The seed oil has shown potential for use in food, cosmetics, and pharmaceutical dosage design [4]. Composite of watermelon seed, after defatting, has been investigated for use in baking and in making medicinal biscuits to handle chronic diseases and gluten intolerance [3, 8, 9]. The seed composite has been found to have coagulation properties [10]

Watermelon seed gum has been investigated for suspending and emulsifying properties in pharmaceutical dosage design [11]. Metformin is an antihyperglycaemic agent used in management of type-2 diabetes mellitus. It is present in different formulations, but mainly as extended release dosage. The tablet form may cause taste and gastric disturbances. To reduce these side effects, and improve compliance and drug release, different formulations of metformin has been investigated, such as co-processing in dry suspension with guar gum excipient [12]. Suspensions are known to have a milder effect of the stomach, mask taste, and reduce nausea, diarrhoea, and stomach upset.

In the formulation of pharmaceutical suspensions, the selection of appropriate suspending agent from clays, natural gums, and synthetic gums or any of their combinations is critical. Suspending agents are crucial in maintaining uniform distribution of solid particles in liquid dispersion medium, preventing sedimentation, and ensuring consistent dosing. The cost effectiveness, flow properties, water-holding capacity, oil-holding capacity, viscosity, pH and chemical stability, compatibility with other excipients and main drug active, re-dispersion ability, and other formulation properties determine the suitability of selected suspending agent [13]. Biomaterials are abundant and a cheap source of pharmaceutical excipients. Good flow properties of excipients are necessary for technical operations like conveying, and discharging raw material during formulation. Water-holding and oil-holding capacities of excipients can predict the sensorial, textural, rheological and some other functional properties of powders that are linked with interaction between water/ oil and powder [13, 14]. Tragacanth, and xanthan gum, are reported to have higher water-holding capacities than guar gum, acacia gum and some other suspension excipients [14, 15, 16]. Guar gum and acacia have higher oil-holding capacities than xanthan and tragacanth [7]. As a result, while acacia gum has been used for its emulsifying ability, tragacanth and xanthan gum are used for their suspending and thickening properties in suspension. Works on the combination of acacia and xanthan gum in pharmaceutical emulsion formulation has been done with positive results [17]. Watermelon seed gum have been reported to show good rheological properties, and comparable suspending properties with tragacanth gum [11, 18]. It has been investigated as a sustained release excipient, and at low concentration as an emulsifying agent, and has shown better results than acacia gum [11].

In this study, metformin was blended with watermelon seed composite, in order to investigate the formulation and suspending properties of the blend.

MATERIALS AND METHODS

Materials: Air-dried seeds of *C. lanatus* (watermelon) were procured from the Muda Lawal Fruits Market in Bauchi, Bauchi State in 2023, authenticated by Mr. Owolabi Tunde of the Department of Pharmacognosy at Igbinedion University, Okada, Edo State, Nigeria (IUO/18/211).

Metformin Hydrochloride (Harman Finochem, Maharashtra, India) was gifted by Ulticare-Lyka Pharmaceuticals (Nigeria). All other chemicals were of analytical grade.

Isolation and generation of watermelon seed composite (WMSC): Adapting the methods of Saeed *et al.* [14] and Chaudhari *et al.* [11], air dried watermelon seeds were powdered using a multi-mill grinder (Chitra Machineries Pvt Ltd, Model SS304, Gjarat, India) and passed through a 1.5 mm stainless steel sieve to obtain fines. Using the method of Keke *et* al. [4], 500 g fine powder was defatted by Soxhlet extraction using 1:10 *N*-hexane at 60 – 70℃. The composite solid waste was washed with hot water. Isopropyl alcohol in water (2:1) added to the solid, stirred to disperse thoroughly for 30 min., and left to stand for 120 min at room temperature. The dispersion was filtered using a Whatmann No.1 filter paper, and dried in a hot-air oven (Kottermanns Company, Germany) at 80℃ until a constant mass was obtained. Dried powder was milled to fine powder, passed through a 1.20 mm stainless steel sieve, packed, labelled as WMSC powder, and stored for further analysis. The percentage yield was calculated and recorded.

Characterization of WMSC:

Organoleptic properties: The taste, colour, smell and surface of the powdered WMSC was noted. The powder was viewed under a binocular microscope (OLYMPUS CH, Model CHA, Japan) and the granules shape, size and fracture properties of the WMSC was observed and recorded.

Physicochemical properties

Micromeritics properties*:* Modifying the methods of Shalaby *et al.* [21] and Sharma *et al.* [22], the compressibility and flow properties of the dried WMSC powder was determined from their densities and angle of repose. For density determination, a 5 g sample was placed in a measuring cylinder. The cylinder was fixed on the bulk density apparatus and the volume occupied by the powder was noted at 37±2°C. Bulk density was calculated in the Equation 1 below and Tapped density was done using equation 2. Powder Compressibility (Carr's Compressibility Index) was calculated using equations 3. This test was repeated thrice, average calculated and recorded.

$$\text{Bulk Density} = \frac{\text{Weight of Powder}}{\text{Apparent Volume of Powder}} \quad \text{- - -eq 1}$$

$$\text{Bulk Density} = \frac{\text{Weight of Powder}}{\text{Tapped Volume of Powder}} \quad \text{- - -- eq 2}$$

$$\text{Carr's Index} = \frac{\text{Tapped density} - \text{bulk density}}{\text{Tapped density}} \text{-----eq 3}$$

To determine the angle of repose of the WMSC powder, 5 g was poured from a funnel which was kept at a distance of 5 cm from the surface. The radius (r) and height (h) of the heap formed on the surface were calculated and used to determine the angle of repose of the powder using equation 4.

$$\text{Tan } \Theta = \frac{h}{r} \quad \text{- - - - - ----------------------eq 4}$$

Water-holding Capacity: Applying the methods of Nguyen *et al.* [13] and Saeed *et al.* [14], 1 g dried WMSC powder was mixed thoroughly with 10 ml deionized water in a

30 ml centrifuge tube using a lab-scale vortex, and left to stand at room temperature of 37±2 °C for 10 min. Mixture was then centrifuged at 4000 rpm using a centrifuge machine (Model 3K 15, SIGMA, Germany) for 10 min., and excess water removed by filtering with a Whatman filter paper. The hydrated residue was weighed. The water-holding capacity was calculated as the weight of retained water divided by the weight of the dried powder. This test was repeated thrice, average calculated and recorded.

***Oil-holding Capacity* (OHC)**: Adopting the method Saeed *et al.* [14], dried sample (M_{dry}, 2 g) was mixed thoroughly with 20 ml refined sunflower vegetable oil in a pre-weighed 30 ml centrifuge tube, using a vortex mixer. The sample was then allowed to stand for 30 min at room temperature 37±2 °C. The mixture was then centrifuged at 4000 rpm using a centrifuge machine (Model 3K 15, SIGMA, Germany) for 10 min at room temperature 37±2 °C. The supernatant oil was removed with a syringe, and the new mass of the powder (M_{oiled}) recorded. Oil-holding capacity (g oil/ g dry powder) was calculated using equation 5. This test was repeated thrice, average calculated and recorded.

$$OHC = \frac{Moiled - Mdry}{Mdry} \quad \text{……………………eq 5}$$

***pH*:** The pH of 2% $^{w}/_{v}$ aqueous dispersion of WMSC was determined using pH temperature meter (pH-S25 EC/ORD, China). The WMSC aqueous dispersion (10 ml) was placed in a calibrated tube, and an electrode was dipped into the tube, and pH was read after 2 min. The pH was re-check after every week for 5 weeks.

***Viscosity*:** Using the method of Yahaya *et al.* [23] and a Brookfield viscometer (LvDv 1+, Brookfield Engineering Laboratories Inc.) with the shaft of the three-blade marine impeller set at 60^{o} and mixer speed of 100±10 rpm, the viscosities at 25±2°C of stirred 5, 10, 15, 20, 30 and 40% WMSC, acacia and xanthan gum dispersions were taken. The viscosities of 0.20, 0.40, 0.60, 0.80, and 1% $^{w}/_{v}$ xanthan gum was also taken for emphasis. This test was repeated thrice, the average calculated, and recorded. The temperature of the 40 % WMSC dispersion was increased from 25, 30, 45, 60 and 80^{o}C, and their respective viscosities recorded. This test was repeated thrice, average calculated and recorded.

Interactive properties of WMSC and metformin: The study of interaction between the WMSC powder and metformin was conducted by Scanning Electron Microscopy and Transmission Electron Microscopy.

Scanning Electron Microscopy (SEM): WMSC powder was sprinkled onto a double-sided adhesive carbon tape, sputter-coated with gold, and mounted on a JEOL JSM-65 10LV scanning electron microscope stub copper. The SEM images of the sample were then captured at acceleration voltage of 20 kv and x2000 magnification.

Energy dispersive X-ray (EDX): Using the EDAX DX-4 eDXi System, version 2.11 of the SEM apparatus (JEOL JSM-65 10LV type), the energy-dispersive X-ray of the WMSC and metformin-WMSC blend were analysed between 0 and 20 keV. A for 120 seconds and their spectra recorded.

Transmission electron microscopy (TEM): TEM images of water and alcohol pre-dispersed and air dried dispersions of the WMSC were obtained using a Tecnai G2 20 S-TWIN transmission electron microscope (FEI, USA) captured at various magnification levels (20 – 200 nm), and their diffraction pattern were captured at 101 nm to identify the nature of the specimen. The TEM of the metformin-WMSC blend was also obtained using the same procedure.

Formulation of metformin-WMSC blend for reconstitution: Modifying the methods of Yahaya *et al*. [23] and Woldu *et al*. [24] for preparation of pharmaceutical suspension, 0.25 g metformin powder was poured into a dry mortar and blended thoroughly with 1, 2, 4, 6, or 8 g of WMSC or xanthan gum and other constituents in Table 1, using a pestle for 5 min to get batches containing 1% $^{w}/_{v}$ (WA), 2% $^{w}/_{v}$ (WB), 4% $^{w}/_{v}$ (WC), 6% $^{w}/_{v}$ (WD), 8% $^{w}/_{v}$ (WE) WMSC, or 1% $^{w}/_{v}$ (XA), 2% $^{w}/_{v}$ (XB), X% $^{w}/_{v}$ (XC), 6% $^{w}/_{v}$ (XD), 8% $^{w}/_{v}$ (XE) xanthan gum respectively. The control batch was blended without WMSC nor xanthan gum. The formulation was stored in a clean dry glass container for analysis. The metformin-WMSC was constituted to 100 ml with deionized water, and well shaken to prepare a well reconstituted dispersion

Determination of suspending properties of reconstituted metformin-WMSC blend

Viscosity readings: The method of Woldu *et al*. [24] was used to determine the viscosities of the different batches of freshly reconstituted suspension and reconstituted suspensions after 5 days' storage was taken at 37±2^{o}C using the Brookfield viscometer (LvDv 1+, Brookfield Engineering Laboratories Inc.) with the shaft of the three-blade marine impeller set at 60^{o} and mixer speed of 100±10rpm.

Sedimentation indices: Using the method of Yahaya *et al.* [23] for sedimentation volume determination, 50 ml of the well shaken reconstituted dispersion was poured into a 50 ml - measuring cylinder on a stable flat table. The initial cloudy sediment portion was noted and recorded as original volume V_O. The cylinder was then left to stand at room temperature. At weekly intervals, for seven weeks, the volume of clouded sediment was measured and recorded as sedimentation volume V_u. The sedimentation indices, F (%), were then calculated using equation 6. The sedimentation indices were plotted against time to generate sedimentation profiles of the dry suspensions.

$F = 100*(V_u/V_o)$ ……………………….eq 6

***Re-dispersion number and aspect*:** Following the method of Yahaya *et al*. [23], 10 ml reconstituted dispersion was placed in seven different 10 ml cylinders. The cylinder openings were closed firmly with glass cork, fitted into a rack, labelled 1 – 7, and placed on a flat table. After standing stationary for 1 day, cylinder 1 was turned from standing the position down 90^{o} and returned back, recorded as one full-turn, and observed for degree of re-dispersion. The number of full-turns needed for complete dispersion was checked daily for 7 days. The test was repeated three times, and the average re-dispersion number was calculated.

Statistical analysis

The results were all subjected to mean and standard deviation (mean±SD) and Student's t-test used to determine their significant differences. Differences were considered significant at P values <0.05 or not significant n.s.

RESULTS

Organoleptic and phytochemical properties of WMSC: The WMSC had a yield of 56.31 %, glassy white to golden brown appearance with characteristic odour, and bland taste. The powder particles were about 4 -5 nm long, and 1.50 nm wide, and had a somewhat smooth surface, round to ovoid short tears, and fracture easily.

Physicochemical Properties of WMSC

***Micromeritics properties*:** The micromeritics properties of the dried WMSC powder showed Carr's index and angle of repose of 11.32±0.32, and 39.05±0.51^{o} respectively.

Table 1: Formula (g) for preparation of 100 ml reconstitutable metformin suspension

Batch code ⇒ Componts ⇓	N	WA	WB	WC	WD	WE	XA	XB	XC	XD	XE
Indomethacin	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Citric acid	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sodium benzoate	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Sodium citrate	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
WMSC	0	1	2	4	6	8	0	0	0	0	0
Xanthan gum	0	0	0	0	0	0	1	2	4	6	8
Corn starch	9.25	8.25	7.25	5.25	3.25	1.25	8.25	7.25	5.25	3.25	1.25
Total	10	10	10	10	10	10	10	10	10	10	10

WA, WB, WB, WC, WD, WE = 1, 2, 4, 6, 8% $^w/_v$ WMSC respectively.
XA, XB, XC, XD, XE = 1, 2, 4, 6, 8% $^w/_v$ xanthan gum respectively

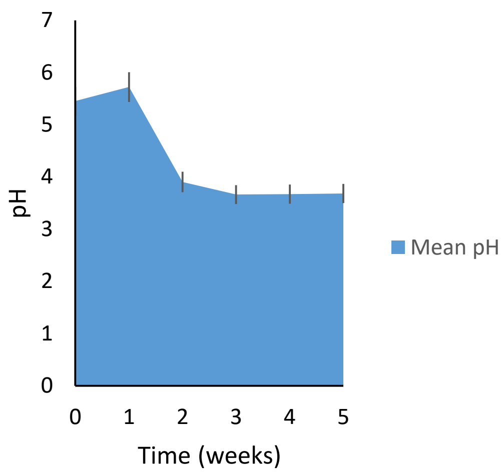

Figure 1: Effect of storage on pH of aqueous of watermelon Seed Composite

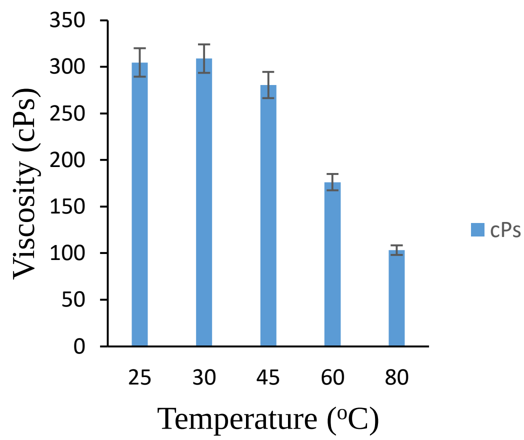

Figure 2: Effect of temperature on viscosity seed composite

Table 2. Effect of concentration on viscosity of powdered dispersion

Gum concentration % $^w/_v$	Viscosity (cPs)		
	WMSC	Control gum (acacia gum)	Xanthan gum
5	20.40	54.30	> 2765
10	55.30	165.00	> 2765
15	88.70	288.40	> 2765
20	125.34	306.30	> 2765
30	212.90	414.10	> 2765
40	305.59	764.30	> 2765

WMSC = Watermelon seed composite

pH, Water-holding capacity and oil-holding capacity: The effect of storage on pH of aqueous dispersion of WMSC is presented in Figure 1. On storage, the pH of aqueous dispersion of WMSC increased after the first week, and decreased over the next five weeks. The powder showed water-holding and oil-holding capacities of 3.81±0.18 g H_2O/ g and 2.53±0.13 g oil / g respectively.

Viscosity and temperature relationship: Increase in temperature of 40 % WMSC from 25 to 30 °C increased its viscosity from 304.60 to 308.80 cPs. Above 40 °C temperature, the viscosity subsequently decreased as presented in Figure 2.

Interactive properties of WMSC and metformin

TEM analysis**:** TEM analysis of the WMSC is presented in Figure 3, and showed mesh-like structures that cross-linked into closely packed, continuous sheaths with metformin with diffusion rings.

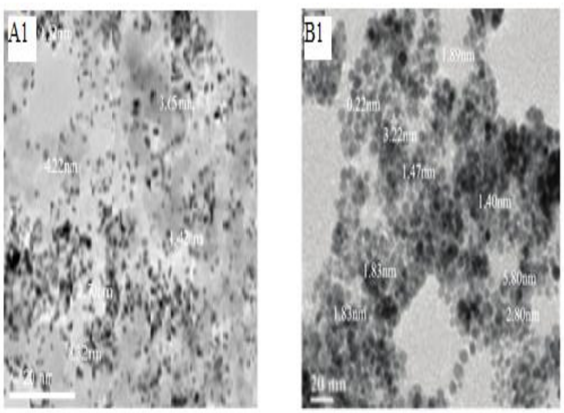

Figure 3. Transmission electron microscopy of watermelon seed composite (A1) and watermelon seed composite / metformin (BI) at 20 nm.

SEM **analysis:** The SEM images of the WMSC are presented in Figure 4, and revealed smaller-sized and larger-sized particles with irregular shapes and smooth surfaces. The particle sizes ranged from 2.52 – 4.22 nm. The metformin-WMSC blend appeared as a web-like interlink.

Energy dispersive X-ray (EDX): The SEM-EDX imaging of the WMSC and metformin-WMSC blend is presented in Figure 5. The EDX of metformin-WMSC blend showed additional trace element on the EDX of WMSC.

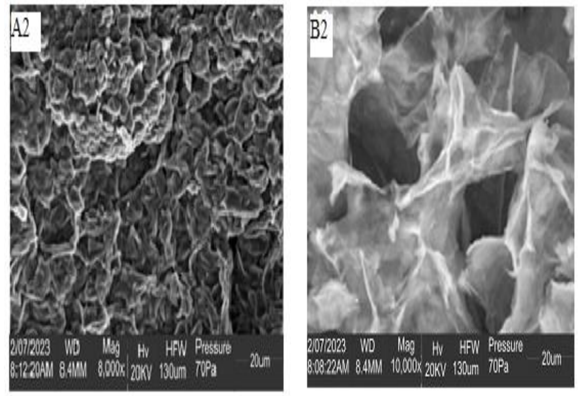

Figure 4. Scanning electron microscopy of watermelon seed composite (A2) and watermelon seed composite / metformin (B2) at 10,000× magnification.

Suspension properties of reconstituted metformin-WMSC blend

Viscosity**:** The effect of storage on the viscosities of plain metformin (N) and on the different batches of metformin suspension is presented in Figure 6. After storage, xanthan gum suspensions showed a marked increase viscosity over time. In contrast, WMSC suspensions showed little change in viscosity after storage.

Sedimentation indices: Figure 7 indicates the sedimentation indices of the suspensions. While the sedimentation volume of suspensions with WMSC remained relatively unchanged, the sedimentation volume of suspensions with xanthan gum increased with storage. The sedimentation volume of both materials decreased over 6 h as WMSC concentration increased, but xanthan gum exhibited slower sedimentation but higher sediment volumes than watermelon seed WMSC.

Re-dispersion number and aspect: The ease of re-dispersion of the reconstituted metformin suspensions are indicated in Figure 8. The re-dispersion numbers of suspensions with the WMSC remained > 18, while suspensions with xanthan gum had re-dispersion numbers < 18.

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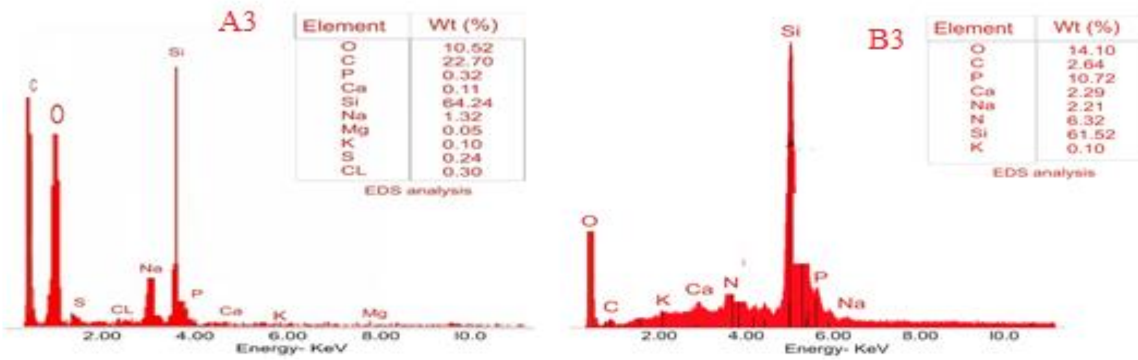
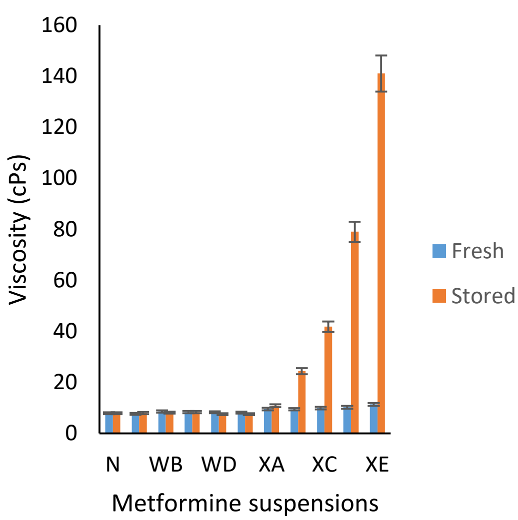
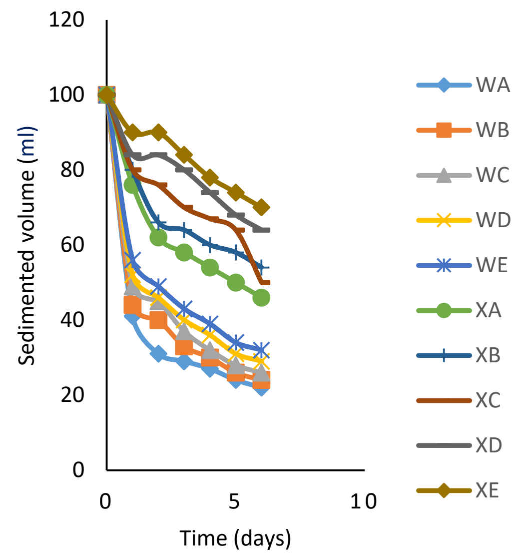


Figure 5. Scanning electron microscopy - energy dispersive X-ray of watermelon seed composite (A3) and watermelon seed composite / metformin (B3)

Also, suspensions with xanthan gum had re-dispersion numbers < 18. The WMSC suspensions were easily re-dispersed at concentrations between 0.10 and 2% w/v, but higher concentrations posed challenges. Xanthan gum suspensions, on the other hand, were easily re-dispersed even at higher concentrations.

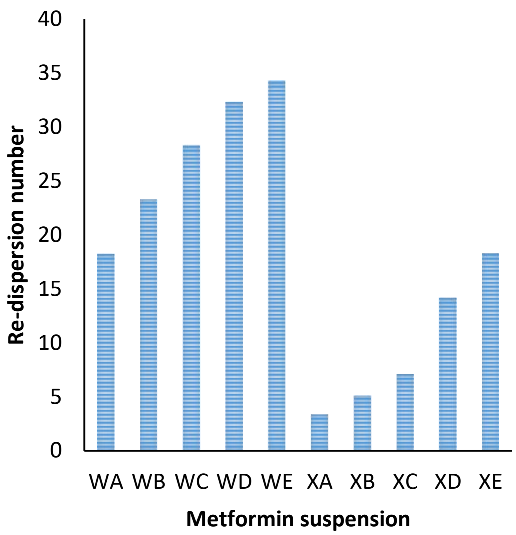


WA, WB, WB, WC, WD, WE = 1, 2, 4, 6, 8 % $^{w}/_{v}$ WMSC respectively.
XA, XB, XC, XD, XE = 1, 2, 4, 6, 8 % $^{w}/_{v}$ xanthan gum respectively.
Figure 6: Effect of watermelon seed composite concentration and storage on viscosity of metformin suspension.



WA, WB, WB, WC, WD, WE = 1, 2, 4, 6, 8% $^{w}/_{v}$ WMSC respectively.
XA, XB, XC, XD, XE = 1, 2, 4, 6, 8% $^{w}/_{v}$ xanthan gum respectively.

Figure 7: Sedimentation indices profile of metformin suspension



WA, WB, WB, WC, WD, WE = 1, 2, 4, 6, 8% $^{w}/_{v}$ WMSC respectively.
XA, XB, XC, XD, XE = 1, 2, 4, 6, 8% $^{w}/_{v}$ xanthan gum respectively.

Figure 8. Re-dispersion of metformin suspension after 7 days

DISCUSSION

The angle of repose of < 39.05^{o} of the WMSC is comparable with that of xanthan gum. The compressibility of <11.32 is less than those of xanthan. WMSC exhibited similar flow but lesser compressibility to xanthan gum. Sarkar *et al*. [7] had reported similar angle of repose and poorer compressibility for tragacanth gum compared to this WMSC results. Using the powder properties interpretation of Castellanos [20], the WMSC can be said to have good flowing powder necessary for conveying, and discharging during formulation.

The acidic nature of pH of aqueous sample (2 %) could be attributed to the presence of the acidic functional group of sugar units in the gum of the WMSC from researches such as Andrade *et al* [25]. The gum being acidic can easily partition into aqueous or oily phases, thus acting as an emulsifying agent. The increasing acidity of the mucilage over the six weeks' storage period may be as a result of this conversion. Suspensions are often formulated with buffering excipients to prevent these pH changes. The intermediate water-holding capacity of 3.81 g H_2O/ g WMSC is close to the 2.78 g H_2O/ g extract water-holding capacity of watermelon seed extract from previous research of Saeed *et al.* [14], and is greater than reports by Shalaby *et al.* [21]. This parameter is less than the reported water-holding capacity of tragacanth, and xanthan gum, but higher than the values reported for guar, and acacia gum [14, 15, 17]. Oil-holding capacity of WMSC powder (2.53 g oil/g) was higher than values reported for tragacanth, acacia and xanthan gums by Sarkar et al [7]. This may be interpreted as indication of looser and larger interstitial microstructure of the WMSC [16, 18].

According to Saeed *et al*. [14], Gadalkar and Rathod [26], and Nasirzadeh *et al*. [27] who stated that water-holding and oil-holding capacities enhance technological, rheological and functional properties of formulation, and improve stability and activity index of emulsion, WMSC may be suited for emulsification.

The 20.40 – 305.59 cPs viscosities of 5 – 40% $^{w}/_{v}$ of WMSC dispersion compared with those reported for acacia and viscosities of xanthan gum dispersion by Layek *et al*. [28] could infer a less thickening and release-retardant matrix at higher formulation concentration of the WMSC as against xanthan. The viscosities of the WMSC mucilage increased with concentrations, and reduced with temperature increase after 40^{o}C. This behavior aligns with the findings of Gyedu-Akoto *et al*. [29] on properties of natural gum, where the gum mucilage exhibits thinning with temperature rise. The steady viscosity of WMSC at ambient temperature of 30 - 40^{o}C and reduced thickening on storage, will offer stabilizing effect on suspension shelved within room temperature.

The presence of a diffused ring mesh-like structure in the TEM diffraction pattern infers the amorphous nature of the metformin-WMSC blend. These mesh-like structures further formed and cross-linked into closely packed continuous sheaths. These gel-forming properties of the WMSC, indicate that it may be suitable for use in hydrogel formulations. The SEM analysis report of smooth particle surfaces with some irregularities and size range of 2.52 – 4.22 nm is consistent with observations by Malsawmtluangi *et al*. [30] on particle characters that contribute to functional properties in pharmaceutical applications. Energy-Dispersive X-ray (EDX) of the metformin-WMSC particles showed detectable trace elements of metformin from the EDX of the WMSC in the web-like blend and is consistent with interpretation of Rusli *et al.* [31].

The suspending ability of WMSC was inferior to that of xanthan gum, as evidenced by assessments of sedimentation rate, and ease of re-dispersion. The viscosities of WMSC suspensions were not significantly affected by change in concentration of WMSC nor time of storage. This is characteristic of powder that does not hydrate nor expand, and is in contrast with xanthan gum suspension that increases in viscosity over concentration and time, a characteristic of gums that hydrate and enhance suspending ability with time.

CONCLUSION

In comparison with xanthan gum, watermelon seed composite, in this study, has demonstrated good processing properties, water and oil holding capacities, and thermal stability but limited suspending properties particularly at higher concentrations where sediment caking occurred. Application of *C. lanatus* seed composite as a suspending agent may require further research for optimization studies or combination with other excipients to enhance its quality. The water and oil-holding capacities of the composite suggests that they may have potential to improve stability and activity index of emulsion. The mesh-like closely packed continuous sheaths of the composite mucilage may be investigated for its potential as structural support matrix in pharmaceutical applications such as drug delivery systems or in the formulation of hydrogels for drug delivery systems. This study is limited in stability, safety and optimization studies.

Conflict of interest
Authors declare no conflict of interest.

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