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Original Article

PRELIMINARY INVESTIGATIONS INTO THE PHYSICOCHEMICAL AND COMPACTION CHARACTERISTICS OF MODIFIED STARCH OF *DISCOREA ALATA* USING DICLOFENAC SODIUM TABLET

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ABSTRACT

Objective: This work focused on evaluating the micromeritic and compressional properties of pregelatinized African water yam (*Discorea alata*) starch and its modified forms with comparison to pregelatinized corn starch and microcrystalline cellulose.

Methods: Two modifications of the water yam starch were prepared; acetone dehydrated pregelatinized form (DSA) and an admixture of DSA and pregelatinized corn starch (CDSA). A third form of starch is the acetone dehydrated pregelatinized corn starch (CSA). These were used to form batches compacted as tablets using diclofenac sodium as the active moiety. Physicochemical and flow characteristics of the starch powders were elucidated, and the drug starch compatibility studies done using the Fourier transform Infra-red (FTIR) technique. Compaction studies were investigated on tablets formed at different compression pressures and Heckel plots were prepared.

Results: The slope of the straight line (K) of 0.8959 was greatest for F_1 while yield pressure (Py) value of 10.965 was highest for F_3. These values from the Heckel plot suggest that while the tablets of control batch of microcrystalline cellulose (F_4) and a batch of pregelatinized corn starch (F_2) formed harder compacts, less likely deformed plastically, the *Discorea alata* batch (F_1) and the admixed batch (F_3) were likely to deform plastically. Also, the binding efficiency of the compact was significantly high (47.81%Kgscm^{-1}) for F_4 at 56.5Kpas compaction pressure, higher than that obtainable for any of the other formulations at the compaction pressures under consideration. All starches formed had similar moisture content (of 10%) despite the different sources but the interaction between the water molecule and pregelatinized water yam starch improved as revealed by viscosity(7.18mPas), hydration capacity(3.27%) and swelling index (250%) of CDSA.

Conclusion: It could be concluded that pregelatinized water yam starch could be used as a substitute for corn starch or microcrystalline cellulose as a pharmaceutical excipient (binder/filler) in tablets formulation.

Keywords: Pregelatinization, Compaction, *Disccorea alata,* Heckel plots

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INTRODUCTION

Research questions prompting innovative thinking are constantly on the minds of researchers and manufacturers of excipients. Such questions as; what is likely the next ideal excipient with greater degree of functionality to go for? Will the approval of such adjuvant by the relevant regulatory authorities be a very tall order? How can an existing excipient be improved upon to achieve better dosage forms? No doubt, the search for excipients having improved properties is in no way meagre since the desires and convenience of patients are intended to be achieved in dosage form design, while not compromising therapeutic efficacy.

Starch is widely used as drug excipients, owing to its properties, avalanche and availability. Starches obtained from different sources vary in their respective constitution. Using equations such as Kawakita's and Heckel's and their interpretations, pharmaceutical excipients could be studied and differentiated into plastic or brittle materials. Specifically, the yield pressure in Heckel plot is used as the determining factor [1]. Such knowledge is essential to achieve compacts having the good tensile strength and binding efficiency. Native starch has desirable disintegration properties but its crystalline characteristics give it its poor water solubility [2].

Excipient modification has reportedly knocked off certain undesirable properties inherent in some polymers while introducing newer improved ones [3]. Synthetic, semi-synthetic and natural products have been modified, with derivatives having better flow properties, improved binding properties, emulsification features and even hydrophilic characteristics. Starch, gums, and mucilage have been reportedly modified; chemically by acetylation, carboxymethylation, oxidation; thermally by pregelatinization and even physically by admixture of excipients with different properties [2, 4, 5].

Diclofenac sodium, a Non-Steroidal Anti-inflammatory Drug (NSAID) is employed clinically for the management of several pain and inflammatory-related conditions such as osteo-and rheumatic arthritis, dysmenorrhoea, and lower back pain.

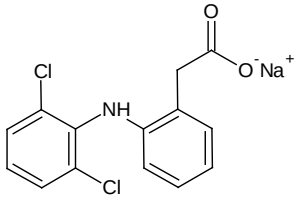

Fig. 1: Chemical structure of diclofenac sodium

In recent times many researchers have modified starch with amazing outcomes. One noteworthy advantage reported in their works is the better binding characteristics, reduced crystalinity and improved solubility of the modified starch [2, 3, 6]. Particularly, ethanol and acetone dehydrated pregelatinization have been used to circumvent the main challenge of prolong drying and high energy consumption associated with pregelatinization of starch [5, 7]. A useful question worth asking therefore is do starches of different sources give similar characteristics on pregelatinization? This original work investigates *Discorea alata* (African water yam) starch, comparing the peculiar

properties and compaction potentials of the acetone dehydrated pregelatinized forms of the starch (DSA) with that of similarly modified corn starch (CSA), and when the two are admixed (CDSA) using powder of diclofenac sodium as the active pharmaceutical ingredient (API). Microcrystalline cellulose was used as a reference.

MATERIALS AND METHODS

Materials

Acetone (BDH Chemicals, UK), cornstarch, water yam starch (obtained from *Discorea alata* sourced in Uyo metropolis, Nigeria), distilled water, all other chemicals being of analytical grade.

Methods

Preparation of acetone treated pregelatinized starch

To a 3.3L of distilled water at room temperature, 500g of water yam starch was suspended to form a slurry which was then heated to 90 °C forming a mucilage. The mucilage was precipitated with acetone 5 L. The precipitated rubber-like products were cut into small lumps and allowed to cool and dried. The dried products were diminuted using the laboratory blender (Sonic, Japan) and sieved to obtain powder size fraction of≤1. 0 mm which was used for determination of powder characteristics. Cornstarch sample was also subjected to similar treatment to obtain its pregelatinized form.

Physical characterization

True density

The true density of powder sample was carried out using the liquid displacement method. Xylene was used as the inert displacement liquid as reported in literature [8]. The numerical value of the parameter was calculated from the equation

$$Dt = \frac{w}{(a+w)-b} \times SG \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where D_t is true density, w is the weight of powder sample, SG is the specific gravity of the xylene, a is the weight of the density bottle+xylene, and b is the weight of bottle+solvent+powder sample. This was done in triplicates.

Bulk and tapped density

A quantity of 10g of powder was placed in a 25 ml clean dry measuring cylinder and the volume, V_0, occupied by each of the samples without tapping was obtained. After 100 taps at regular intervals, the volume, V_{100} was also determined. The bulk (D_b) and tapped (D_{tp}) densities were then computed as the ratio of the mass of powder to the volume (V_0 and V_{100}) respectively.

Carr's index and hausner's ratio

These were calculated to assess the propensity of the powder samples to be compressed. Carr's index was derived from the formula

$$CI = \frac{D_{tp}-D_b}{D_{tp}} \times 100 \ldots. (2)$$

Where CI is the Carr's index as a percentage, D_{tp} is the Tapped density and D_b is the Bulk density

For Hausner's ratio, this was calculated as the ratio of the tapped density to the bulk density of the powder samples *i.e.* tapped density/bulk density

Angle of repose

The angle of repose was measured using the fixed funnel and free-standing cone method [9]. The tangent of the angle of the powder heap was calculated from the equation

$$\text{Tan} \propto = \frac{2h}{D} \ldots\ldots\ldots\ldots (3)$$

Powder porosity

Porosity of the powders was derived from the values of bulk and true densities as shown in the equation below;

$$e = 1-\frac{D_b}{D_t} \times 100 \ldots\ldots\ldots\ldots (4)$$

Where D_b and D_t are the bulk and true densities respectively

Moisture sorption profiles

Specifically 2g of the powder sample was accurately weighed and evenly distributed over the surface of a 70 mm petri dish. The samples were then placed in a large desiccator containing distilled water in its reservoir (100%) at room temperature and the weight gained by the exposed samples over a seven–day period was recorded and amount of water absorbed calculated from the weight difference [10].

Loss on drying

A 5g quantity of the powder sample was transferred each to a petri dish and then dried in an oven at 105 °C until a constant weight was obtained. The percentage (%) moisture content was then determined as the ratio of weight of moisture loss to weight of sample expressed as percentage [11]

$$LOD = \frac{Wi-Wf}{Wi} \times 100 \ldots\ldots (5)$$

Where LOD =Loss on drying, $\boldsymbol{Wi}$ is the initial weight of the sample and Wf is the final weight

Swelling index

The swelling index of the powder was carried out is described as follows: A quantity (1g) of the powder sample was placed in 15 ml calibrated centrifuge tubes and the volume occupied was noted as V_1. Specifically 10 ml of distilled water was added and stoppered. The contents were mixed on a vortex mixer (XH-Stuart, UK) for 2 min. The mixture was allowed to stand for 10 min and centrifuged immediately at 1000 revolutions per minute (rpm) for 10 min on a bench top centrifuge (Model 80-2). The supernatant was carefully decanted and the volume of sediment recorded as V_2 [10]. The swelling index was computed using equation 6 below;

$$S = \frac{V_2-V_1}{V_1} \times 100 \ldots\ldots\ldots (6)$$

Where S is the swelling capacity, V_2 is the volume of the hydrated powder, and V_1 is the volume of powder before hydration.

Hydration capacity

The method for determination of the hydration capacity was patterned after that used by Kornblum and Stoopak and described by Owhoavworhua [5]. It was carried out during the same time the swelling capacity was done but instead of the volume of sediment, the weight was determined. The hydration capacity was calculated as the ratio of the weight of sediment to the dry sample weight as shown in the equation below:

$$HC = \frac{W_2-W_1}{W_1} \times 100 \ldots\ldots\ldots (7)$$

Where HC is the Hydration capacity, W_2 the sediment weight and W_1, the sample weight

Fourier–transform infrared spectra

The surface of the starch (*Discorea alata*) sample was characterized using Perkin Elmer spectrum 100 Fourier transform Infrared spectrophotometer. Each starch sample was scanned at a wavelength of between 4000 cm^{-1} and 400 cm^{-1}. The diclofenac sodium powder was equally scanned using the same device. An admixture of the each starch sample with diclofenac sodium powder was prepared and equally scanned respectively.

Compaction properties

Preparation and analysis of tablets

Tablets weighing 400 mg each made up of diclofenac sodium and pregelatinized water yam starch was produced using a single punch Carver Hydraulic press (Model C, USA) at compression pressures from 0.25 to 1.25 tonnes corresponding to the compression pressures 27.3KPa–163.5KPa respectively. Fifteen tablets were compacted at each pressure and retention time being 30s. Prior to compression, the die and the flat-faced punches were lubricated with 1% magnesium stearate in acetone. The tablets were stored in air-tight container for

24 h (to allow for elastic recovery) before evaluation. Parameters of the tablets such as thickness (t), diameter (D), and weight uniformity of the tablets were determined. Also, the crushing strength (Cs) was ascertained using the Monsanto hardness tester (MHT-20, UK). The relative density D was calculated as the ratio of the density of the tablet to the true density of the starch samples, from which Heckel plots were carried out over a compression range of 136.2KPa and the parameters from Heckel plots deduced. The density of the tablet is a ratio of the weight of tablet to its volume. The area under the Heckel curve (AUHC) was calculated by the Trapezoidal method and used to express the extent of volume reduction that the material had undergone during the entire compression pressure range.

$$D = \frac{Wt}{VtDt} \ldots (7)$$

Where Vt is the volume of the tablet in ml, and Dt is the true density, g/ml, of the starch powder.

The compaction potential of the powders was studied using the Heckel equation

$$ln\left(\frac{1}{1-D}\right) = K.P + A \ldots\ldots\ldots (8)$$

D is the relative density of the compact with reference to the material being compacted, P is the applied pressure, and K (the slope of the straight line portion) is the reciprocal of the yield pressure, Py, of the starch material. The yield pressure is inversely related to the ability of the material to deform plastically under pressure and A is a function of the original tablet volume. It is a constant representing particle rearrangement [1]. The relative density D was obtained from a ratio of the density of compact to the true density also derivable from

$$D_1 = 1 - e^{-A} \ldots\ldots\ldots\ldots (9)$$

The relative density becomes D_0 when the applied pressure is equal to zero (D_0= loose density/true density), is used for the description of initial particle rearrangement and densification due to die filling. A high value would indicate very dense packing.

The tensile strength (Ts) was calculated from:

$$Ts = \frac{2Cs}{nDt} \ldots\ldots\ldots\ldots (10)$$

Where 1metric ton =9.8N. The degree of compatibility of the material (that is the strength of the material) was deduced from the plot of the tensile strength, against the respective compression pressures.

Hardness, friability and disintegration time

The crushing strength (hardness) of the compacts was carried by diametrical compression using Monsanto hardness tester (MHT-20, UK). Each tablet was placed between the plates of the tester and the knobs screwed until enough pressure caused breakage and the force noted.

The Veego Friability apparatus (BT-2D) was used for determining friability, wherein 5 tablets were pre-weighed and placed in the friabilator allowed to operate at 25 revolutions per minute for 4 min. After the test, tablets were recovered, dusted re-weighed. The percentage friability was calculated as;

$$\text{Friability} = \frac{\text{loss in weight}}{\text{initial weight}} \times 100 \ldots\ldots\ldots\ldots (11)$$

The time it takes the tablet to disintegrate into particles that can diffuse through the mesh was determined in 0.1NHCl using the BP disintegration apparatus.

The values of the parameters were used to calculate the binding efficiency.

Binding efficiency

To ascertain the potency of the pregelatinized starch as a binder, the binding capacity of the tablets was calculated for from the following equation.

$$\textit{Binding efficiency} = \frac{\text{Hardness}}{\text{Friability}} \times \frac{1}{\text{disintegration time}} \ldots\ldots\ldots\ldots (12)$$

RESULTS

Table 1: Micromeritic properties of the starch powders

Starch powders	Bulk density (g/ml)	Tapped density (g/ml)	True density (g/ml)	Angle of repose(°)	Hausner's ratio	Compressibility Index (%)	Porosity (%)
CSA	0.42±0.01	0.67±0.05	1.67±0.09	25.28±0.10	1.59±0.1	37.12±3.12	75±2.90
DSA	0.41±0.02	0.56±0.01	1.64±0.13	36.25±0.41	1.36±0.04	26.74±4.72	74±1.82
CDSA	0.44±0.03	0.63±0.12	1.65±0.22	12.53±0.35	1.45±0.05	30.90±2.13	73±2.16

Key*:* CSA, Pregelatinized Corn Starch; DSA, Pregelatinized Water yam starch; CDSA, a mixture of pregelatinized corn starch and water yam starch. Values are presented as mean±standard deviation (SD). Where the number of the experiment (n) is =3

Table 2*:* Physicochemical properties of the starch

Starch powders	pH	Moisture Content (%)	Viscosity (mPas)	Hydration capacity (%)	Swelling capacity (%)	Loss on drying (%)
CSA	6.28±0.07	10±1.73	8.56±0.52	3.47±0.14	330±14	2.0±0.00
DSA	5.64±0.38	10±1.00	6.28±0.22	3.04±0.15	210±14	2.0±0.01
CDSA	6.13±0.69	10±1.73	7.18±0.45	3.27±0.23	250±14	2.0±0.01

Key: values are presented as mean±standard deviation and number of the experiment (n) is 3

Table 3*:* Composition of the diclofenac compact

Ingredients*	F1	F2	F3	F4(control)
Diclofenac	200	200	200	200
DSA	136	-	-	-
CSA	-	136	-	-
CDSA	-	-	136	-
MCC	64	64	64	200
Total weight(mg)	400	400	400	400

*Lubricant used was magnesium stearate in 1% acetone during compression.

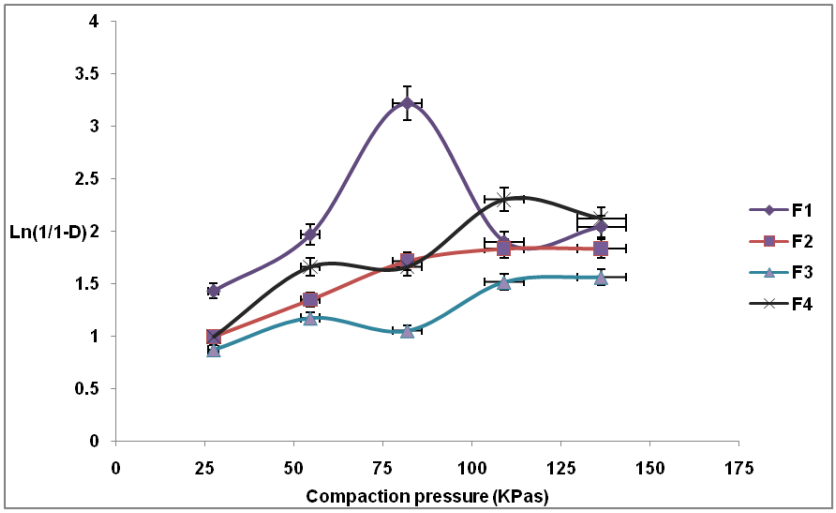

Fig. 2: Heckel plots of compacts of the different powder samples

Table 4: Values from heckel plot

Batch code	R^2	AUHC(Kpas)	K	A	Py(KPas)
F1	0.9498	238.025	0.8959	0.4123	1.1162
F2	0.999	166.775	0.3603	0.6315	2.7755
F3	0.3557	129.55	0.0912	0.8472	10.965
F4	0.75	188.75	0.3332	0.7421	3.0012

Key: linearity of the curve was taken at 3 points between 25 and 80KPas of the compaction pressure

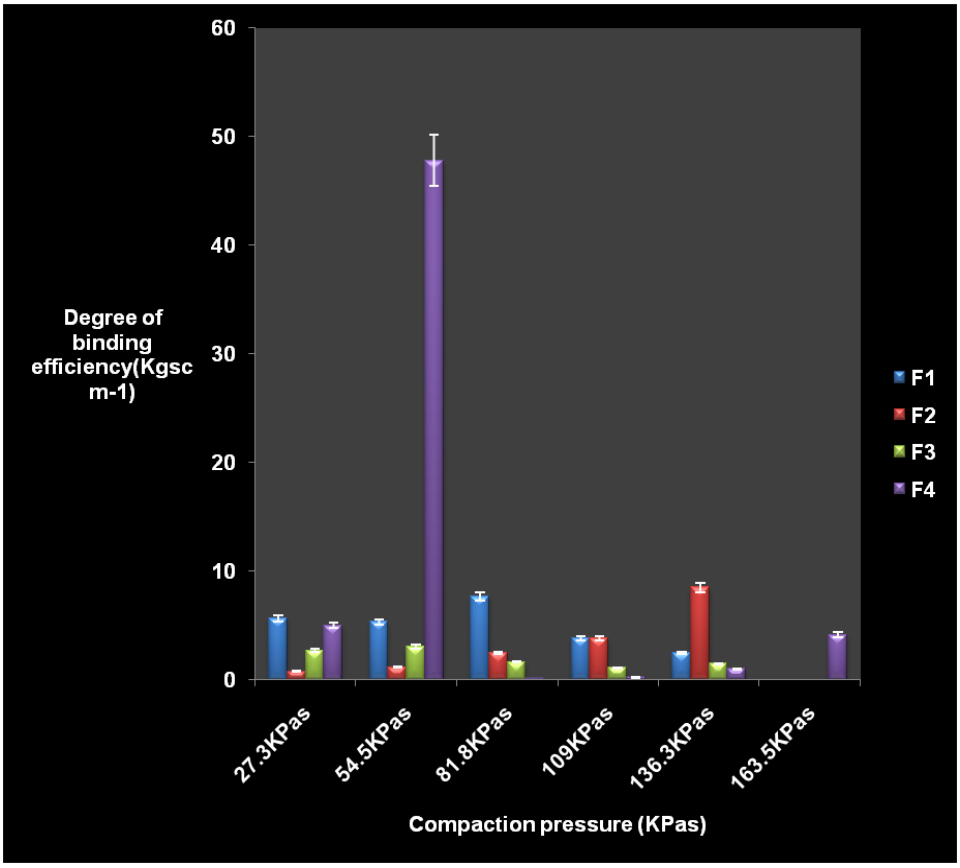

Fig. 3: Plot showing binding efficiency of compacts at different compaction pressures, three tablets were randomly selected and used for the determination for each batch at the respective pressure

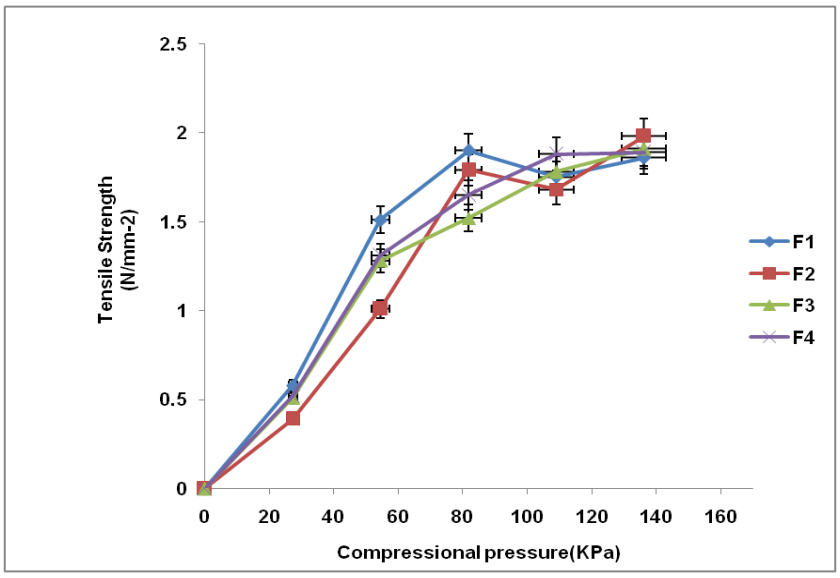

Fig. 4: Tensile strength–compressional pressure relationship, 3 tablets were used for the determination at the respective pressures

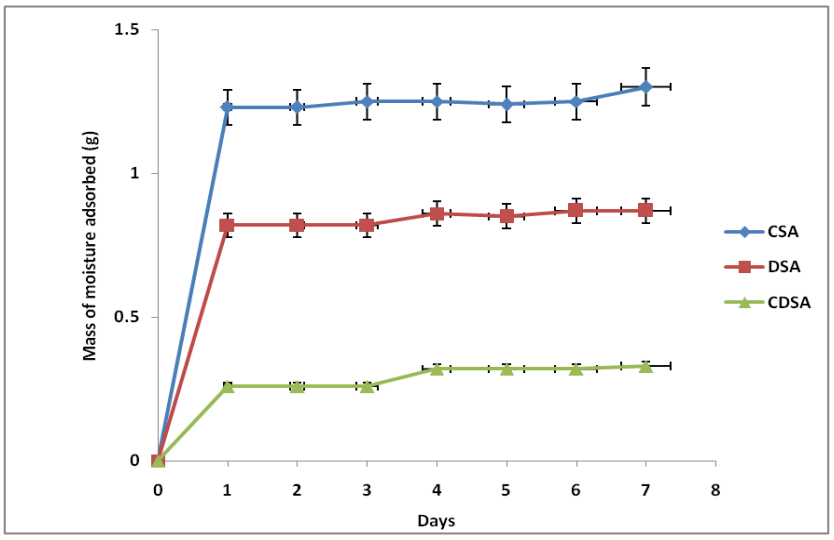

Fig. 5: Sorption profile of pregelatinized Starches, a sample size of 2g each was used and experiment done in triplicate for each sample

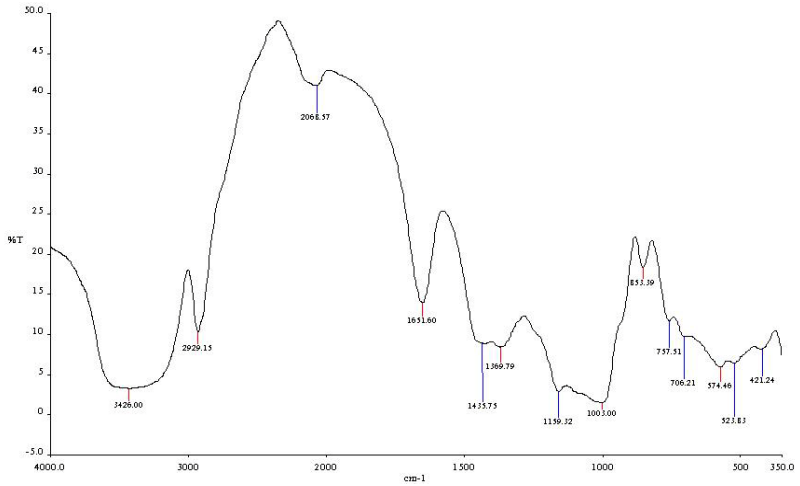

Fig. 6: FTIR for pregelatinized *Discorea alata* (DSA)

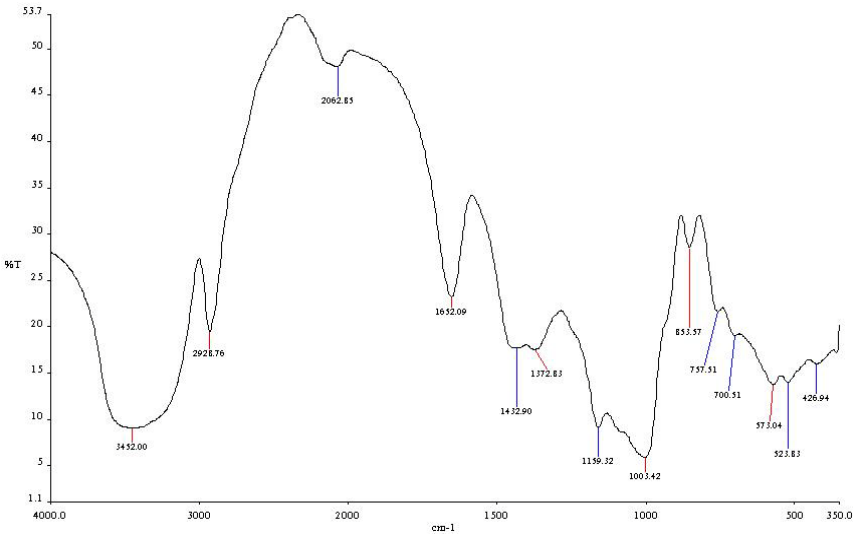

Fig. 7: FTIR for pregelatinized corn starch (CSA)

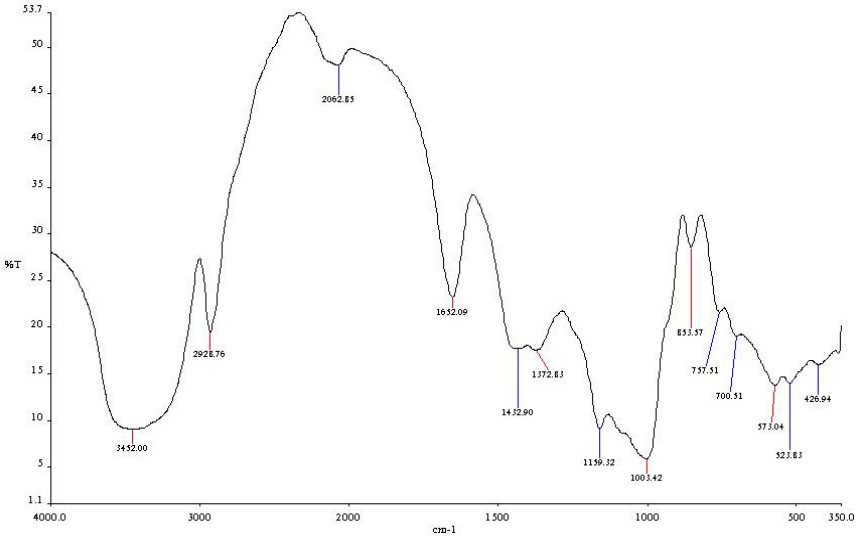

Fig. 8: FTIR for admixed pregelatinized starches (CDSA)

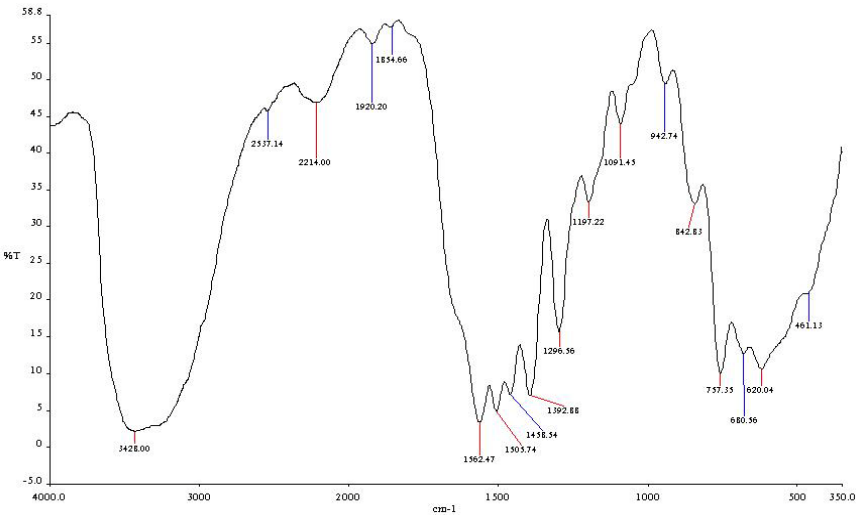

Fig. 9: FTIR for pure Diclofenac sodium

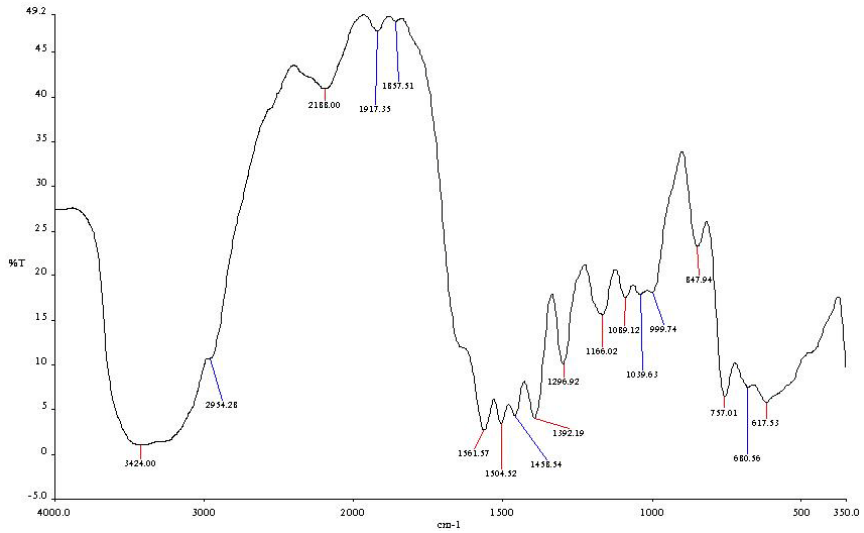

Fig. 10: FTIR for Discorea pregelatinized *Discorea alata*+Diclofenac

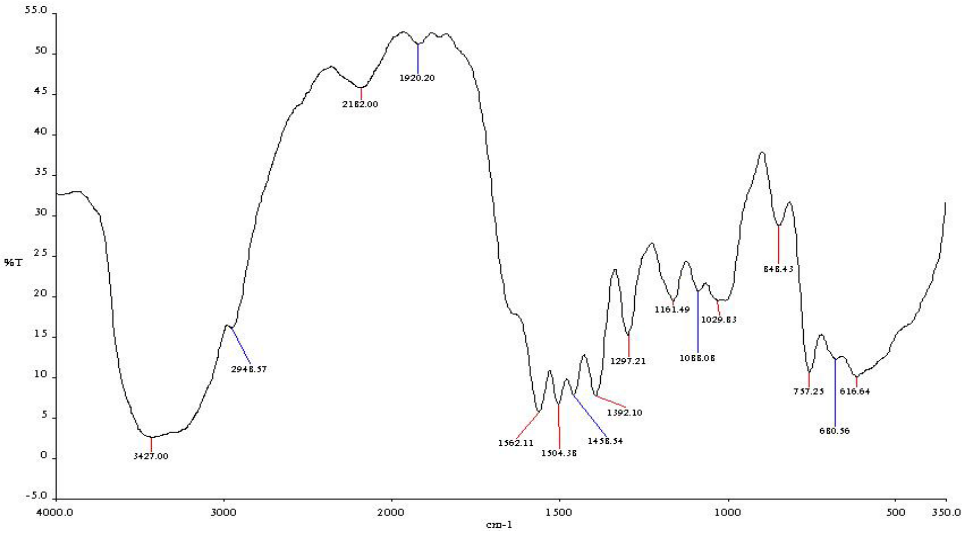

Fig. 11: FTIR for pregelatinized corn starch (CSA)+diclofenac

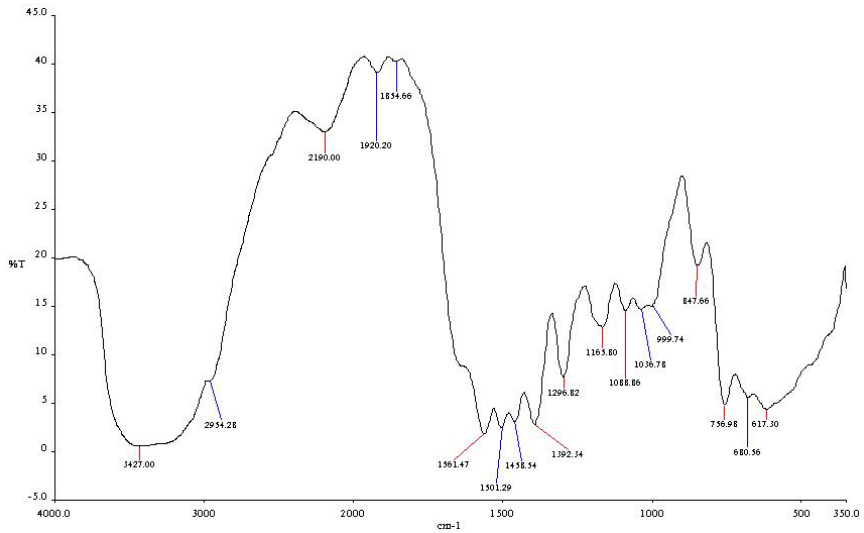

Fig. 12: FTIR for admixed pregelatinized starches (CDSA) and diclofenac

Table 5: Main peaks observable in the FTIR spectra of the modified starches and diclofenac

S. No.	Wave numbers (cm^{-1})	Possible functional groups present
1	3426-3457 broad smooth	-OH of the starches
2	2928 Sharp peaks	CH2-CH2
3	1692	C=O stretch of an aldehyde group in the starches
4	3452 peak	-OH of Carboxylic group
5	757, 680 peaks	-Cl atoms of diclofenac
6	1562, 1505	C=C stretch in aniline of diclofenac

DISCUSSION

The ease and proper filling of the die cavity of the tabletting machine during direct compression is related to the flow property of the powdered material [12]. Powders with Hausner's ratio (HR) of value<1.2 show good flow. Those with values in the range 1.25–1.5 require the use of glidants to improve the flow while those with values>1.5 as seen in powders with flakes indicate poor flow. Values of Carr's index of range 1-10% indicate powders with the excellent flow; 11-15% describes a good flow and higher values such as 16-20% means flow that is fair while powders with extremely poor flow have greater than 40% Carr's index [9]. The indirect indicators of flowability (angle of repose, Carr's index and Hausner's ratio) from table 2 show the powders have poor flow with the pregelatinized corn starch exhibiting lowest values. Hausner's ratios for all the powders were greater than 1.25 and the values for Carr's index are higher than 20%, these reflect poor flowability. The order is as follows DSA>CDSA>CSA. Admixed powder (CDSA) showed only slightly improved flow over the pregelatinized corn starch (CSA). One possible reason for this observation could be that the particles of the DSA are well interspersed between those of the CSA thus enhancing the flow property slightly**.**

The FTIR was employed for determining the compatibility of the pregelatinized starches with the diclofenac sodium powder as well as the functional groups present in the pregelatinized starches. The broad smooth intense peak found at 3426 cm^{-1} (for water yam) and 3452 cm^{-1}(for corn starch) are attributable to the diagnostic–OH groups whereas the sharp peaks attached laterally to the OH peaks found at 2928 cm^{-1} for both spectra characteristic for water yam and cornstarch represents the CH_2-CH_2 chains of the starch [13, 14]. Peak seen at 1692 cm^{-1} on all the pregelatinized starch spectra is attributable to C=O stretch of an aldehyde. It is no surprise as starches are aldehyde compounds. The functional groups present in the pregelatinized starch are similar to that in the native starch as reported in literature[5]. It could be inferred then that pre-gelatinization did not introduce any new functional group nor knock off any pre-existing one, hence it is not a chemical modification method but only affected the rearrangement of the powder particle. The key peaks of the pure diclofenac reveal the presence of–OH group of the carboxylic functional group (3452 cm^{-1} peak), the–Cl groups (757 cm^{-1}, 680 cm^{-1}) and the aromatic C=C stretch in the aniline rings (1562 cm^{-1},1505 cm^{-1}) present [14]. The admixed diclofenac sodium powder with the respective starches did not shift or cancel out the prominent diagnostic peaks of the starches or that of the diclofenac. This implies that the pregelatinized starch was compatible with the diclofenac.

The Heckel plot (fig. 2) graphically represents how the powders behave in the presence of compressional force applied to form compact. It is developed on the assumption that powder compression follows a first order of reaction with the powder voids acting as 'reactants' and the compacts(having reduced porosity) being the products [15]. Values obtained at appropriate points on the plots classify the sample powders based on their behaviour under pressure. For example, larger K values (slope of the linear part of the plot) indicate harder compacts [5]. K also relates the minimum pressure necessary to cause a permanent deformation in the sample powder [17]. From table 4, F_2 and F_4 values are similar; while F_1 is highest, F_3 is lowest. This implies that F_2 and F_4 (composing of DSA and MCC respectively) would form compacts that are harder than those of F_3. The F_1, however, will form the hardest compacts of the four samples. This explains the tensile strength-compression force plot (fig. 4) which reflects such higher value in hardness as force of compression increased. This obvious trend is further corroborated (in fig. 3) where the binding efficiency has a steady rise with increasing compression pressure for F_2. The binding efficiency of F_1 on the other hand was consistently higher than others. One reason could be that higher compressional force favoured close-knit consolidation of the molecules of F_2 and F_1 possibly by fusion bonding.

The mean yield pressure (Py) in the Heckel equation is a descriptive term inversely related to the ease of plastic deformation of a powdered material to form a compact under pressure. A lower value will indicate a faster onset and degree of plastic deformation and vice-versa [18]. It is derived from the inverse of K value and has to be obtained from the linear portion of the curve since the Heckel plots are not completely linear. It is worthy of note that the deviation from linearity of Heckel plot, at low compaction pressure, is due to particle reorganization/repositioning but, at higher pressure, the linearity drift is because of elastic deformation of compact (9). Yield pressure is dependent on the material and as such can be used to classify pharmaceutical materials. Thus the higher the Py value, the lesser the tendency for plastic deformation to occur under pressure and vice-versa [18, 9]. Table 3 reveals that the Py is highest for F_3 formulation and follows the order F_3>F_4>F_2>F_1. Thus pregelatinized water yam starch will more readily deform plastically than pregelatinized corn starch, but the ease of the former to undergo plastic deformation under pressure is significantly reduced on admixture with the latter. However the Py value is influenced by R^2 values which is also a significant predictor of extent of compressibility via plastic deformation. The closer the R^2 is to unity, the likely for plastic deformation but the lesser, the likely conclusion for fragmentation propensity [17] and with F_3 so distant from unity it goes to suggest that its mechanism for deformation is possibly due to particle fragmentation. The AUHC obtained from Heckel plot is a useful estimate of compressibility. The greater the AUHC value the more compatible the powder [17]. From table 4, F_1 has the highest value of AUHC and the order is F_1>F_4>F_2>F_3.

As shown in fig. 4, the increase in compression pressure, the greater the tensile strength for all the four compacts. F_1 measured similarly as F_2 and F_4 at the same compression pressure. From compressional force of 0-100KPas, F_1 showed the highest tensile strength but F_2 was lowest. Above the 100KPas where the F_1 became the lowest and tensile strength for F_2 became highest at increased compression pressure. How compacted a tablet is has been linked to the amount of loading pressure which brings about close proximity of the particles being tableted so that they are held together by cold welding or fusion bonding [20]. Generally higher tensile strength reflects strong interparticulate bond formation, harder compacts and is proportional to the compression force [9]. Thus to form harder tablets of F_2, compression pressure will be optimized at above 100KPas.

Although having the same moisture content and loss on drying, the different pre-gelatinized starches possess separate interactions with water molecules as revealed by the viscosity, hydration capacity and the swelling index. Similar moisture content implies that the class of drugs that pregelatinized corn starch (CSA) has been used for as a pharmaceutical aid can also be used with pregelatinized water yam starch (DSA) with no fears of consequent incompatibility occurring from drug-excipient interaction possibly due to hydrolysis. CSA has the highest interaction with water whereas DSA possess the lowest. As expected, an admixture of the two gave an intermediary value. High moisture content is no far distant from that reported in literature that pregelatinized starch undergoes 'starch granule de-

structuralisation' which in turn allows for good water penetration and retention [5]. That a tablet will readily disintegrate could be seen in its index of swelling. The physicochemical properties of hydration capacity and swelling capacity are inter-related and are good indicators reflecting the swelling of the tablets and thus its subsequent ease of disintegration [21]. Each of those indicators describes the different relationships of water molecules with the pharmaceutical aid. For example the swelling index reflects the increase in volume of sample, after water absorption, while the hydration capacity is the amount of water molecule that can be absorbed and held in the excipient after exposure to water. Table 3 shows that for the powders, the swelling index and the hydration capacities follow the same trend, CSA having the highest value while CDSA had improved properties. Such modification mainly could be due to 'proximal intermolecular association' of particles of the different powders. It goes with reason that such association 'opens up' the molecules of DSA for improved water penetration; a good property looked for in disintegrants.

However, it is noteworthy that although all powders had a same moisture content, moisture sorption profile reveals that the CSA possessed higher sensitivity to atmospheric moisture over the DSA and its admixture (fig. 5). Unlike the relative improvement of the admixed powders in other moisture-related indicators, (swelling index and hydration capacities), the 'proximal interparticle association' reduced the effective surface area of the CSA thereby reducing its effective attraction of water moisture. Higher moisture content in a pharmaceutical powder can influence its flow properties, containers for storage and affect negatively any incorporated drug that can hydrolyse in the presence of moisture.

CONCLUSION

Pregelatinized water yam starch would be a good pharmaceutical excipient as a binder/filler for immediate release or delayed tablet just like the standard is known as cornstarch and microcrystalline cellulose. However physical admixture of the two improved the physicochemical and compaction properties of the former and would provide an alternative to employing only corn starch as an adjuvant to tablet manufacture.

CONFLICT OF INTERESTS

We declare no conflict of interests

AUTHORS CONTRIBUTIONS

Timma O and Jacob G designed the work, collected assemebled the data. Daniel E wrote the manuscript and analysed the data. All the authors critically revised and approved the final manuscript.

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