SILICIFIED *SORGHUM BICOLOR* STARCH ENHANCED DISINTEGRATION OF DIRECTLY COMPRESSED IBUPROFEN TABLET FORMULATIONS

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ABSTRACT

Background: Often, excipients have to be modified to enhance their functionality. Co-processing is a method of excipient modification which provides a synergy of functionality improvements and requirements. Sorghum starch (Uss) was co-processed with colloidal silica (Cs) to obtain silicified sorghum starch (sSS) which was evaluated as a directly compressed disintegrant (DCD) in ibuprofen tablets in comparison with silicified microcrystalline cellulose BP (Prosolv®).

Method: The Uss was co-processed with Cs at different concentrations to obtain sSS containing Uss:Cs at ratios of 95:5, 97:3 and 98:2 respectively. The Uss and sSS powders were characterized using FTIR spectroscopy, density measurements, angle of repose, Carr's Index and Hausner's ratio. Different sSS batches (or Prosolv®) were incorporated as DCD at 10 – 25 %w/w in ibuprofen tablet formulations. Tablets were analyzed for tensile strength and friability, and also analyzed using disintegration test.

Results: The Use had characteristic FTIR peaks at 3416.87 cm^{-1} and 2930.98 cm^{-1}, while sSS had peaks at 1151.79 cm^{-1} and 1097.62 cm^{-1} and the highest particle density. Tapped densities were 0.69±0.08 gcm^{-3}, 0.57±0.11 gcm^{-3}, 0.68±0.01 gcm^{-3}, 0.64±0.06 gcm^{-3} and 0.69±0.02 gcm^{-3} for Uss, Prosolv®, sSS(95:5), sSS(97:3) and sSS(98:2) respectively. Hauner's ratio ranked Uss the highest. Tablets containing Uss and Sss had lower tensile strengths and were more friable than tablets containing Prosolv® and had comparable disintegration times at high concentrations.Conclusion: Silicification enhanced the powder and disintegrant properties of sorghum starch with better results achieved as the concentration of silicon dioxide was increased.

Keywords: Silicified sorghum starch, Co-processing, Enhanced functionality, Directly compressible disintegrant, Ibuprofen tablets.

INTRODUCTION

Drug delivery refers to approaches, formulations. technologies employed (those concerning drug preparation, route of administration, site targeting, metabolism, and toxicity), and systems for transporting a pharmaceutical compound in the body as desired to safely achieve its anticipated therapeutic effect[1]. Drug delivery technologies modify drug release profile, absorption, distribution and elimination for the benefit of improving product efficacy and safety as well as patient's compliance and convenience[2]. Oral drug delivery remains the preferred route for providing ambulatory drug delivery with improved performance, patient compliance, and enhanced quality. An ideal delivery system must be inert, biocompatible, mechanically strong, and convenient for the patient, capable of achieving high drug loading, safe from accidental release, easy to administer, remove, fabricate and sterilize[3].

It is rare to find tablets that do not incorporate excipients. The addition of these excipients is usually required to produce satisfactory drug release, to achieve acceptable physical and mechanical properties and to facilitate the bulk manufacture of tablets. Starch is one of the most abundant organic chemicals on earth[4] and widely used biomaterials in the pharmaceutical industries, premised on its availability, low cost, high caloric value, inherent excellent physicochemical properties and the ease of its modification to other derivatives. Sorghum (Sorghum bicolor, Family: Poaceae) is the fifth most important cereal globally in terms of acreage and production[5]. Several investigations on Sorghum bicolor starch (SBS) have been carried out. Boudries et al worked on the physicochemical and functional properties of SBS cultivated in the Sahara of Algeria[6], while Alebiowu and Itiola pregelatinized SBS and studied the mechanical properties of the tablets formulated using the starch[7]. Also, Ali and Hasnain studied the morphological, physicochemical, and pasting properties of modified white SBS[8]. Several challenges that limit the use of starch as excipients, especially as stand-alone entities when used in solid dosage drug formulations include poor flow properties, which has been attributed to particle size and shape. A major attempt towards eliminating this limitation is by coprocessing. Coprocessing is defined based on the concept of two or more excipients interacting at the sub-particle level, the objective of which is to provide a synergy of functionality improvements at the molecular, particulate and bulk levels, as well as masking the undesirable properties of individual excipients. These levels are closely linked to one another, with the changes in one level reflecting in another level.

The solid-state properties of particles such as particle size, shape, surface area, density influence the excipient properties such as flowability, compressibility, dilution potential. Hence, creation of new excipients must begin with particle design. Thus, in this study, SBS was co-processed with colloidal silica and the resulting silicified sorghum starch was evaluated as a directly-compressible disintegrant in ibuprofen tablet formulations at different concentrations in comparison with official silicified micro-crystalline cellulose (Prosolv®). Ibuprofen has been chosen for this study because of its poor compressibility and hence it requires a disintegrant among other excipients to form satisfactory tablets.

MATERIALS AND METHODS

Materials

The materials used include colloidal silica and Prosolv® obtained as gifts from Bentos Pharmaceutical Co., Ltd, Ibadan, Nigeria, ibuprofen powder (Shangqiu Kangmeida BioTechnology Co., Ltd Asia), corn starch BP (Mitushi BioPharma Ltd., Ahmedalad, India), lactose BP (Mitushi BioPharma Ltd., Ahmedalad, India) and magnesium stearate (Fooding Group Limited, Shanxi, China). Distilled water (DW) was obtained from the research laboratories of the department of Pharmaceutics and Industrial Pharmacy, University of Ibadan, Nigeria. Sorghum starch (from tubers of Sorghum bicolor), Family Poaceae was obtained from the Botanical Garden, University of Ibadan, Nigeria and authenticated at the Forest Research Institute of Nigeria with voucher specimen number FHI 376133.

Methods

Extraction and purification of sorghum starch

The extracted Sorghum bicolor starch (SBS) grains were washed and soaked in DW for 48 hours for softening. The softened grains were pulped and DW was added to dilute the slurry prior to sieving using a 100 µm mesh. The procedure was repeated thrice and the extracted starch was dried at 50°C in hot air oven for 96 hours. The dried mass was powdered in a laboratory mill at a speed of 1200 rpm using a screen size of 250 µm. This was carried out at ambient room temperature of an average of 30°C and the product was stored in an airtight clean container until needed[9].

Preparation of co-processed excipient

Exactly 150 g of a suspension containing 40 %w/v of SBS was prepared in a 500 ml beaker using 90 ml DW. Exactly 3.2 g of Colloidal silica (CS) was weighed and dispersed in the starch slurry with constant stirring for 5 minutes. The mixture was transferred to a thermostatic water bath set at 5°C with constant stirring for another 15 minutes, cooled before 100 ml ethanol was added. The co-precipitate was separated from the mixture and spread in a tray to dry in open air. It was then passed through a sieve (0.8 mm) and the drying was completed in the oven set at 40°C[10]. This process was carried out for five different combination ratios of SBS:CS namely: 95:5, 96:4, 97:3, 98:2, and 99:1.

Test for starch

A drop of N/50 iodine solution was added to 0.01 g of the SBS powder on

a microscope slide and examined under the optical microscope[11].

Fourier Transform Infrared (FTIR) Determination

Spectra were obtained for the powdered sample and the model drug (Ibuprofen) using a Magna-IR, 560 spectrometer (Perkin Elmer, USA). Exactly 5 mg of powdered samples was weighed and dispersed in 200 mg potassium bromide pellets[12]. Signal averages were obtained at a resolution of 4 cm^{-1}.

Particle size determination

The mean particle size of each powdered sample of unmodified sorghum (Uss), silicified sorghum (sSS) and Prosolv® were determined microscopically with the aid of a calibrated eyepiece. The particle size of each sample dispersed in glycerol was determined.

Angle of repose

About 10 g of each powdered sample of Uss, sSS and Prosolv® was poured through a funnel clamped on a retort stand onto a flat surface under the funnel. The hypotenuse and radius of the cone was calculated and the angle of repose was determined (in triplicates) from equation (i):

Angle of repose, $\theta = \tan^{-1} (h/r)$ Eqn (i)

Where h = hypotenuse of the conical powder heap

r = radius of circular base

Bulk density

Exactly 30 g of each powdered sample of Uss, sSS and Prosolv® was poured at an angle of 45^0 through a funnel into a 100 ml glass measuring cylinder. The volume and density were calculated (in triplicates) using equation (ii):

$$\text{Bulk Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{Eqn (ii)}$$

Tapped density

The tapped density was measured by applying 100 taps to 30 g of each powdered sample of Uss, sSS and Prosolv® in a measuring cylinder. The volume after tapping was measured and the density calculated (in triplicates) using equation (iii):

$$\text{Tapped Density} = \frac{\text{Mass}}{\text{Tapped Volume}} \quad \text{Eqn (iii)}$$

Carr's index

The Carr's compressibility index was calculated from the bulk and tapped densities and it is used to evaluate the compressibility of each powdered sample of Uss, sSS and Prosolv®. It was calculated using equation (iv):

$$\text{Carr's Index} = \frac{\text{Tapped Density} - \text{Bulk Density}}{\text{Tapped Density}} X100 \quad \text{Eqn (iv)}$$

Hausner's ratio

Hausner's ratio which is also used in evaluating a powder's compressibility property was calculated using equation (v):

$$\text{Hausner's ratio} = \frac{\text{Tapped Density}}{\text{Bulk Density}} \quad \text{Eqn (v)}$$

Determination of particle density

A 50 ml capacity pycnometer was weighed empty (W), filled with the non-solvent (xylene) and the excess wiped off. The weight of the pycnometer with the non-solvent was determined (W_1). The difference in weight was calculated as W_2. A 2 g quantity of the sample was weighed (W_3) and quantitatively transferred into the pycnometer bottle. The excess non-solvent was wiped off and the pycnometer was weighed again (W_4). The particle density (gcm^{-3}) was calculated from equation (vi).

$$\frac{(W_2 W_3)}{50\,(W_3 - W_4 + W_2 + W)} \quad \text{Eqn (vi)}$$

Preparation of powder mix

Exactly 50 g batches of the basic formulation (Table 1) comprising of ibuprofen (50% w/w), corn starch (20% w/w), magnesium stearate (0.5% w/w), lactose (19.5% w/w, 14.5% w/w, 9.5% w/w, 4.5% w/w) and silicified sorghum starch (10% w/w, 15% w/w, 20% w/w, 25% w/w) were weighed into a clean dry pestle and mortar and triturated for about 10 minutes until a good mix was obtained. Similar formulations containing Prosolv® (or Uss) as disintegrants were also made. The different batches were stored in air-tight containers.

Preparation of tablets

The Carver hydraulic hand press (model C Carver Inc., Menomonee Falls, Wisconsin, U.S.A), fitted with a pressure gauge reading up to 2.5 metric tons was used for tableting 400 mg ± 10 mg tablets using a 10.5 mm diameter in die combination with flat-faced upper and lower punches at a compression pressure of 1 metric ton for 30 seconds. Before each compression, the punches and die were lubricated with 1 %w/v dispersion of magnesium stearate in acetone. The compressed tablets were carefully ejected and stored in sealed containers for 24 hours before measuring their weights and dimensions to allow for hardening and elastic recovery.

Weight uniformity

Mean weights and standard deviation of twenty randomly picked tablets from each batch were determined using the weighing balance (Mettler PC 440 Delta RangeR, Griefennsee Zurich, Switzerland).

Thickness test

The tablets thicknesses were determined for all batches using a micrometer screw gauge (Mitutoyo micrometer screw gauge). The mean tablet thickness and standard deviation were calculated.

Crushing strength

The hardness or crushing strength of the tablets was determined using the Semiautomatic Hardness Tester, (Copley Scientific Industries, U.K. Serial no: 23571). The force at which the tablet cracked or broke into two halves was then recorded. Six random determinations were carried out for each of the batches. The mean and standard deviation was also calculated.

Table 4: Frequency of antiretroviral regimen with reported adverse drug reactions

Component	Ingredient	Batch 1 (w/w)	Batch 2 (w/w)	Batch 3 (w/w)	Batch 4 (w/w)
API	Ibuprofen	50%	50%	50%	50%
Binder	Corn starch	20%	20%	20%	20%
Disintegrant	Silicified Sorghum (or Prosolv® or unmodified sorghum)	10%	15%	20%	25%
Filler	Lactose	19.5%	14.5%	9.5%	4.5%
Lubricant	Magnesium stearate	0.5%	0.5%	0.5%	0.5%

API = Active Pharmaceutical Ingredient

Tensile strength

The tensile strength of the tablets was computed from the crushing strength and the thickness of the tablet using equation (vi):

$$\text{Tensile strength}v = \frac{2F}{\pi dH}$$

Where: F= crushing strength (N)
d = diameter of the tablet (mm)
H = thickness of the tablet (cm^3)

Friability

The friability of the tablets was determined using the Tablet Friability Tester FRV, (Copley Scientific Industries, U.K.). Ten tablets were randomly weighed and transferred into the friabilator drum, which was set at 25 rpm for 4 minutes. The tablets were dusted, reweighed and the percentage weight loss was calculated.

Disintegration time test

The disintegration time for 5 random tablets from each batch was determined in distilled water at 37 ± 0.5°C using the Tablet Disintegration Tester DTG 4000, (Copley Scientific Industries, U.K.). The time taken for all of the tablets to disintegrate and pass through the mesh was noted and recorded. The mean of the disintegration time of the tablets was calculated.

RESULTS

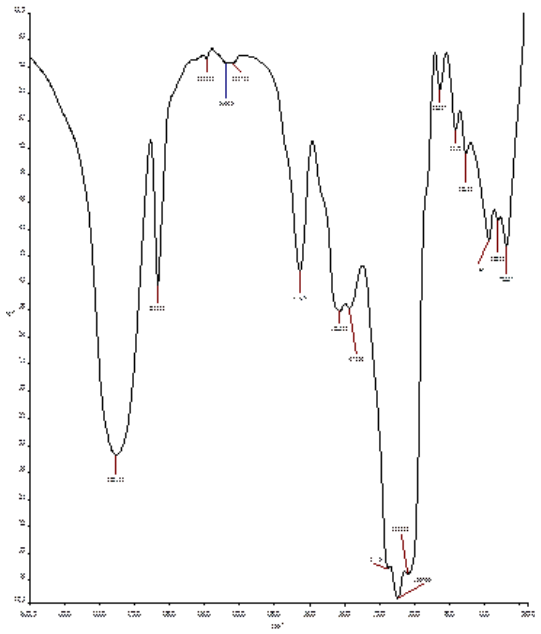
Confirmatory Test for Starch

The Sorghum bicolor starch (SBS) powder gave a blue-black colouration with N/50 iodine solution to confirm its identity as starch. The silicified sorghum starches (sSS) at different ratios also gave blue-black colouration with N/50 iodine.

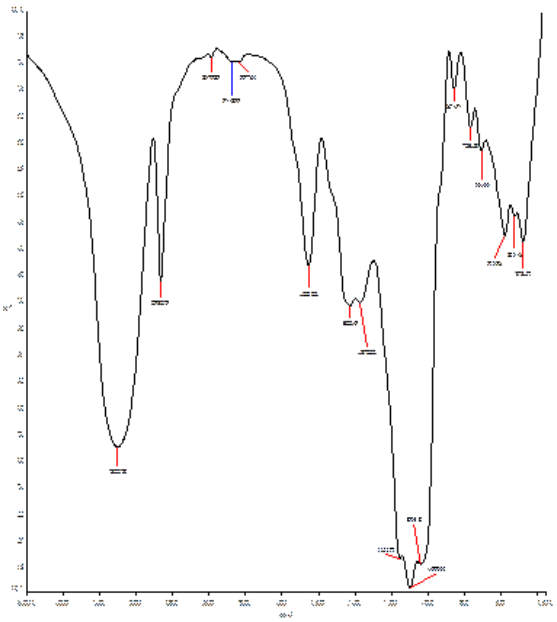
Fourier Transform Infrared (FTIR) Spectroscop

The results of the FTIR spectra obtained for unmodified sorghum starch (Uss) powder and the representative spectra for the sSS at ratios 95:5, 97:3 and 98:2 (Uss:colloidal silica) are shown in Fig(s) 1.

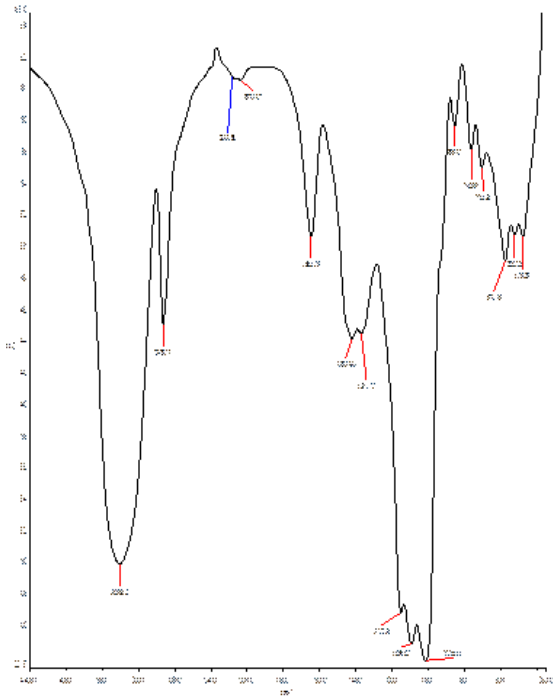
Fig. 1: FTIR spectroscopic pattern of starches



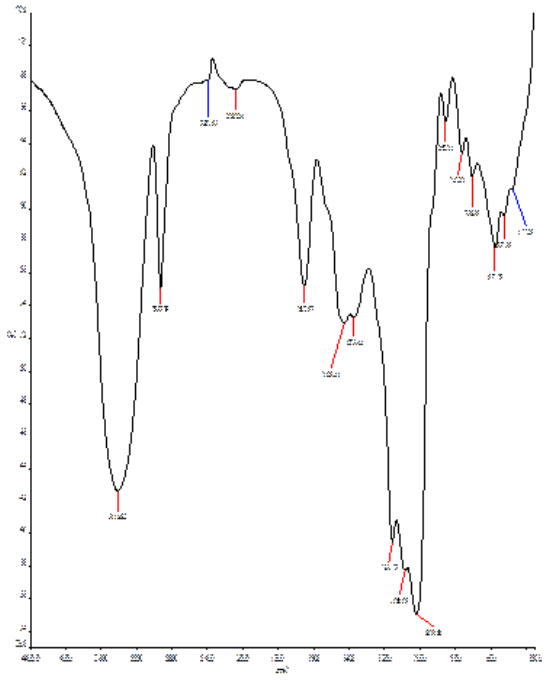
(a) FTIR spectroscopic pattern for unmodified sorghum starch



(b) FTIR spectroscopic pattern for silicified sorghum (95:5)



c) FTIR spectroscopic pattern for silicified sorghum (97:3)



(d) FTIR spectroscopic pattern for silicified sorghum (98:2)

Particle size

The morphology and size distribution of the Uss, sSS and Prosolv® are shown in the photomicrographs in Fig. 2.

Powder Properties

The angles of repose, bulk and tapped densities, Carr's indices, Hausner's ratios and particle densities of the powdered samples of the Uss, sSS (different ratios) and Prosolv® are shown in Table 2.

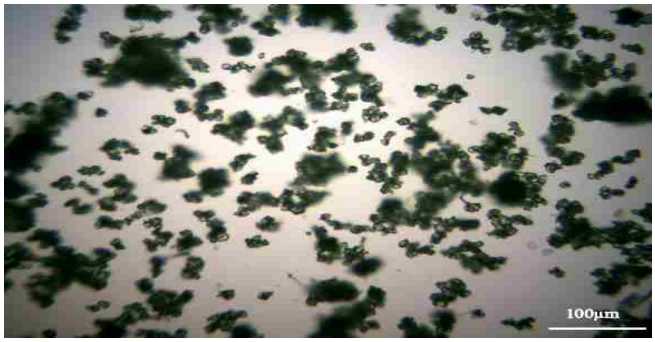
Table 2: Powder properties of unmodified sorghum starch, silicified sorghum (different ratios) starch and Prosolv®

Powder Properties	Uss	Prosolv®	Silicified Sorghum (Uss:CS)		
			(95:5)	(97:3)	(98:2)
Angle of repose (^{0})	64.7	33.7	61.9	63.3	64.3
Bulk density (gcm^{-3})	0.40±0.01	0.39±0.08	0.49±0.02	0.48±0.010.6	0.46±0.02
Tapped Density (gcm^{-3})	0.69±0.08	0.57±0.11	0.68±0.01	4±0.06	0.69±0.02
Carr's Index	40.4±4.65	31.58±0.13	29.68±0.40	24.14±4.66	31.99±2.29
Hausner's ratio	1.69±0.13	1.46±0.03	1.42±0.01	1.32±0.08	1.47±005
Particle density (gcm^{-3})	1.47±0.08	1.58±0.02	2.17±0.01	2.18±0.06	2.31±0.15

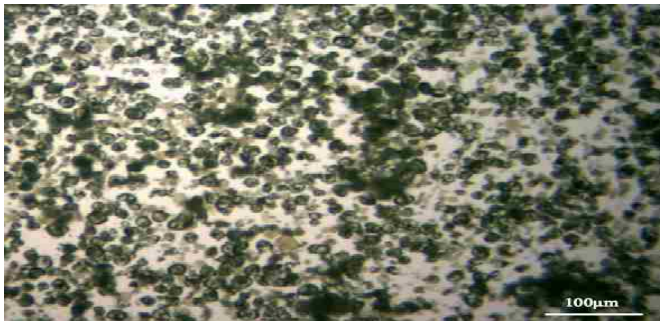
Uss= Unmodified Sorghum Starch, CS= Colloidal Silica

Fig. 2: Photomicrograph (x100) of Prosolv®, unmodified sorghum starch and different ratios of silicified sorghum starch (Unmodified Sorghum Starch: Colloidal Silica)

(a) Prosolv®



(b) Unmodified Sorghum Starch



c) Silicified sorghum (95:5)

(d) Silicified sorghum (97:3)

(e) Silicified sorghum (98:2)

Table 3: Measure of Tablet Properties

Disintegrant	Concentration (%w/w)	Disintegration Time (secs)	Tensile Strength(N/m^2)	Crushing Strength(N)	Friability (%)	CSFR	CSFR/DT
Uss	10	12.8	0.38	26.18±8.08	4.88	5.37	0.42
	15	13.8	0.36	23.85±3.92	4.03	5.92	0.43
	20	14.3	0.30	19.82±5.82	3.89	5.10	0.36
	25	11.2	0.23	15.78±5.51	3.91	4.04	0.36
Prosolv®	10	15.0	0.56	37.18±15.89	6.47	5.75	0.38
	15	13.3	0.35	23.08±4.44	5.41	4.27	0.32
	20	14.0	0.60	40.65±15.83	8.26	4.92	0.35
	25	13.3	0.37	24.37±8.51	5.02	4.85	0.37
Sss (Uss:CS)	10	10.7	0.51	32.72±9.89	18.12	1.81	0.17
(95:5)	15	10.2	0.55	36.52±8.73	18.70	1.95	0.19
	20	10.0	0.54	35.80±14.82	18.46	1.94	0.19
	25	10.0	0.44	9.43±5.08	18.13	1.62	0.16
Sss (Uss:CS)	10	10.0	0.41	27.20±14.72	15.13	1.80	0.18
(97:3)	15	9.7	0.41	26.95±5.92	15.36	1.76	0.18
	20	9.2	0.39	26.20±11.76	15.37	1.71	0.19
	25	9.0	0.62	40.23±13.13	15.19	2.65	0.29
		12.8	0.49	32.50±12.66	13.82	2.35	0.18
(98:2)	15	13.8	0.32	21.73±3.60	13.95	1.56	0.11
	20	14.3	0.40	27.88±4.69	13.48	2.07	0.15
	25	11.2	0.41	26.95±6.62	13.12	2.05	0.18

Sss = Silicified Sorghum Starch, Uss= Unmodified Sorghum Starch, CS= Colloidal Silica

DISCUSSION

The blue-black colouration formed with N/50 iodine for the unmodified sorghum starch (Uss) and modified sorghum starch indicates that the integrity of the starch was maintained after the modification process. This was further confirmed from the Fourier Transform Infrared (FTIR) spectroscopy.

The FTIR spectroscopy could be used to monitor various stages of matter based on harmonic oscillations associated with the bending and stretching of bonds. It has been applied to analyze the secondary and tertiary structures of compounds[13]. Thus, any significant change in a sample can be detected from changes in the bending and stretching of bonds as a result of intimate mixing of the sample with other components. The FTIR spectrum of Uss (Fig. 1a) indicates the presence of characteristic peaks at 3416.87 cm^{-1} and 2930.98 cm^{-1} which can be assigned to O-H stretching vibration in $CH_{2=}$C-H and stretching vibration in CH_3, CH_2 respectively. In addition, the absorption peak at 2358.50 cm^{-1} can be assigned to C-H stretching vibration in C-O-C. Significant peaks appearing at 1159.24 cm^{-1} due to C-H Stretching vibration and at 1012.71 cm^{-1} due to C-O bond absorption have been observed in the finger print region of the FTIR spectrum of Uss. Other significant peaks are presented in the absorptions shown in the range 856.97 cm^{-1} to 528.42cm^{-1} which have been attributed to C-C stretching vibration . The FTIR spectra for the silicified sorghum starch (sSS) at different ratios (Figs 1(b-c)) showed the relative replica of most of the peaks in the functional group region in the FTIR spectrum of the Uss. A typical example is the C-H Stretching vibration at 1159.24 cm^{-1} and the C-O bond absorption at 1012.71 cm^{-1} in the FTIR spectrum for sSS now appearing at 1151.79 cm^{-1} and 1097.62 cm^{-1} respectively in the FTIR for the Sss ratio 95:5. This shows that coprocessing of sorghum starch with silicon dioxide did not affect the integrity of the starch[14].

The morphological properties of the sSS indicate irregularly shaped particles that are slightly bigger than Prosolv® and Uss. The bulk density of a powder is the ratio of the mass to volume occupied by the powder and it majorly depends on particle size distribution, particle shape and the tendency of the particles to adhere to one another. Bulk density describes the packing behavior of a powder during the various operations of tableting such as die filling, mixing, granulation and compression. Particles can pack in such a way that leaves large gaps between individual particles resulting in a light powder of low bulk density. Conversely, smaller particles may sit between the large ones and form a heavy powder with high bulk density[15] Powders with large bulk densities are heavy powders while powders with low bulk densities are light powers. The tapped density indicates the rate and extent of packing that would be experienced by a powder during various unit operations of tableting[16]. The difference between tapped density may be as a result of difference in particle size distribution and particle shape, which affect packing of particles. A high tapped density is advantageous in tableting because of a reduction in fill volume of the die[17]. From the results obtained, sSS had comparatively higher bulk and tapped densities compared to the Prosolv®, thus indicating the possible reduction in the fill volume of the die with sSS preferred to Prosolv®. The packing and cohesive properties of starches influence the various aspects of powder processing such as milling, blending, flow from hoppers, compression and packing into capsule shells or containers[18]. Powder flow is a key requirement for pharmaceutical manufacturing process. Tablets are often manufactured on a rotary multi-station tablet press by filling the tablet die with powders or granules based on volume. Thus, the flow of powder from the hopper into the dies often determines weight, hardness, and content uniformity of tablets[17]. The ability to adjust and control the flow properties of powders during processing and formulation is of key importance for a successful product development. To evaluate powder flow properties, parameters such as, angle of repose, Carr's index, and the Hausner's ratio are generally employed.

The angle of repose is the angle formed by the horizontal base of the bench surface and the edge of a cone-like pile of granules. It is related to density, surface area and particles' shape. Angle of repose is a derived property of powders and it is a qualitative measure of cohesiveness or the tendency of the powder to flow. Generally, the rougher and more irregular the surface of the particles, the higher the angle of repose. According to Copley[19], powders with angle of repose values of 25-30°, 31-35°, 36-40°, 41-45°, 46-55°, 56-65° and >66° have excellent, good, fair, passable, poor, very poor and very poor flowability, respectively. The different ratios of sSS had an angle of repose value of 61.9° to 64.3°. This poor flowability of the sSS may be as a result of the irregular shape of the Sss grains or the cohesive interaction between the individual particles of the Uss. It has been suggested that the compressibility of a powdered material is an indicator of the tendency of the powder to flow. This is often expressed in terms of Hausner's ratio which is the ratio between the tapped density and the bulk density of a powder[20]. Carr's index, which is the ratio of the difference between the tapped density and the bulk density to the tapped density is

related to the Hausner's ratio and is also used in calculating the compressibility of a powder material. From the results obtained, the sSS had Hausner's ratios which range from 1.32 to 1.47 and Carr's indices ranging from 24.14 to 31.99, thus indicating that sSS had lower compressibility when compared with Prosolv®[19].

Crushing strength, which is a measure of the mechanical integrity of a tablet, is the force that is required to cause break up of a tablet. However, the crushing strength is not an absolute indicator of strength since some formulations when compressed into hard tablets tend to cap on attrition. There is an official requirement for crushing strength, but no clear limit for acceptance or rejection of tablet batches, probably because the desired crushing strength is largely dependent on the intended use of the tablets[7]. The tensile strength of a tablet is a more composite method of determining tablet mechanical strength because it incorporates the tablet crushing strength, diameter and thickness. Tablet tensile strength is an important property for safe transportation and handling. Insufficiently hard tablets, in addition to exhibiting the effects of excessive friability, are prone to breakage and chipping particularly during transportation[21]. From the results obtained, it was observed that at concentrations of 10%w/w and 20 %w/w, the tablets containing Prosolv® were stronger than those containing silicified sorghum starch. At concentration of 15%w/w, as the silicon dioxide concentration decreases, the tensile strength and crushing strength decreases for all the silicified starch, while at concentration of 25% w/w, the tablets containing silicified sorghum starch in the ratio, 97:3 was found to be the strongest amongst other proportions as well as stronger than those containing Prosolv®.

Friability is the ability of a tablet to withstand the movement of shipping and handling without breaking or chipping[22]. Friability value less than 1% is considered acceptable[23]. From the results obtained, it was observed that the tablets containing sSS were more friable than those containing Prosolv®. This could be as a result of the amount of binder used being insufficient or as a result of the compression pressure being too small to produce strong tablets. Particle shape could also affect friability as cohesive forces are usually weak in tablets formulated with irregularly shaped tablets[22]. Therefore, it is necessary to adjust the formulation process so as to obtain tablets with better strength. This may be achieved by increasing the compression pressure or by increasing the binder concentration or substituting the current binder with a more efficient binder like povidone. Disintegration exposes a greater surface area of tablets to the dissolution medium; hence it plays an important role in a tablet's dissolution before the active drug substance is finally released from the tablet's structure into the body[24]. Generally, the disintegration time is related to hardness. When the hardness increases, the disintegration time increases and the dissolution rate also increase[25]. It was observed in this study that as the hardness of the ibuprofen tablets increased, there was an increase in the disintegration time. In this study, the disintegration times of all the ibuprofen tablets were much lower than the Pharmacopeia limit (<15 min) (British Pharmacopoeia, 2009). From the results obtained in Table 4, it was observed that at all concentrations, the tablets that contained sSS had shorter disintegration time than the tablets that contained Prosolv®. Thus, sSS could be exploited as a disintegrant when there is need to formulate a quick disintegrating tablet dosage form.

Two parameters, CSFR (obtainable from the crushing strength and friability tests) and CSFR/DT (obtainable from ratio of CSFR to disintegration time) provide measures of tablet strength (crushing), weakness (friable), bond strength and disruption of bonds, which are useful indices for tablet quality. The higher the value of these indices, the better the tablet[26]. Results of this parameter confirm that tablets formulated with sSS are not as strong as tablets containing Prosolv®. The values obtained for all the batches were generally low. This suggests the need for improvement in the selection of disintegrants in the formulation of ibuprofen tablets.

CONCLUSION

Modification of sorghum starch powder through coprocessing with silicon dioxide by co-fusion enhanced the powder and disintegrant properties of sorghum starch with better results achieved as the concentration of silicon dioxide was increased. Further work will be carried out to exploit several formulation processes to ensure that the binding properties of the silicified sorghum starch in comparison with commercially available official binders.

CONFLICT OF INTEREST

All authors declare no conflict of interest.

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