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Evaluation of pearl millet starch as tablet disintegrant

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ABSTRACT:

Objectives: This study aims to evaluate a novel tablet excipient obtained from local sources, Pearl millet *Pannistumamericanum* starch of family Poaceae which is used locally as food because of its high carbohydrate content. It was thought that the starch of Pearl millet *Pannistumamericanum may* serve as a tablet disintegrant.

Methods: The excipient properties of Pearl millet starch as well as the pregelatinized form were studied in paracetamol tablets produced by wet and dry granulation methods of massing and screening and compared with maize starch BP.

Results: Wet method showed superiority in all properties of both granules and tablets. Using wet method granulations Pearl millet *Pannistumamericanum* starch and maize starch BP have similar angle of repose, Carr's index, tapped density, bulk density, and Hausner's ratio, however, Pearl millet *Pannistumamericanum* starch has shown advantageous in some properties such as moisture content and swelling index. Tablet produced with Pearl millet *Pannistumamericanum* starch disintegrated almost the same of those produced with maize starch BP at all concentrations employed. It was also found that when used as a disintegrant, the pre-gelatinized form provide tablets with better hardness and friability values than maize starch BP.

Conclusion: This study confirmed the suitability of Pearl millet *Pannistumamericanum* starch as an alternative to maize starch BP as a tablet disintegrant, particularly, in paracetamol tablet formulation.

Key words: Disintegrant; Pearl millet; *Pannistumamericanum;* Paracetamol tablet*;* Starch; Friability; Maize; Angle of repose.

INTRODUCTION

Starch may be used to formulate tablets in which it acts as an excipient binder, diluent and disintegrant when incorporated in dry form mixed with the active ingredient prior to granulation (intragranular disintegrant) or may be mixed in dry form with lubricant/glidants prior to compaction of the granules into tablets (extragranular disintegrant) [1]. Disintegrants are substances incorporated into tablets to facilitate its break-up. After administration, the active ingredients in a tablet must be released from the tablet matrix as efficiently as possible to allow its rapid dissolution. Materials serving as disintegrants have been classified chemically as starches, clays, cellulose, sodium alginate, gums and cross-linked polymers that swell up in contact with moisture. The oldest and still the most popular disintegrants are corn and potato starch which have been used as dried form [1, 2].

The mode of disintegrant addition either internal or external, normally has an effect on the breaking-up pattern (intra-granular or extra-granular). Disintegration of the tablet matrix into granules is usually accomplished through one or more of the following processes: swelling of the tablet in an

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aqueous environment as a result of water intake with subsequent bursting resulting in tablet break-up as hydration leads to the weakening of bonds in tablets.

Disintegrant efficiency depends on some factors such as: capacity for water uptake, disintegrant concentration, wettability of other components of the tablet, porosity of the system and size of disintegrant particles in relations to other tablets components [3].

For a drug to be fully available for absorption, the tablet must first disintegrate and discharge the drug to the body fluid for dissolution. Disintegration is also important for drugs acting locally in the GIT without absorption, it regulates their onset of action and availability. All tablets and capsules must pass a test for disintegration except chewable tablets, troches and modified or extended release tablets. Tablets meet the requirement if no fragments remain on the screen after the specified time in the monograph. The BP recommends a disintegration time of 15 min or less for uncoated tablets [4].

This study was carried out to investigate the disintegrant ability of Pearl millet *Pannistumamericanum* starch, in order to evaluate its disintegrant properties compared with maize starch MS BP in paracetamol tablets formulation.

MATERIALS AND METHODS

Materials

Pearl millet *Pannistumamericanum* grain was obtained from the market (Sebha, Libya). Paracetamol BP was obtained from (Anqui Lu'an Pharmaceuticals, China), magnesium stearate was obtained from (Hopkin and Williams, U.K). Hydrochloric acid was obtained from (Fisher Scientific, U.K.), Iodine solution was obtained from (Sigma-Aldrich, Germany), Potassium hydroxide, Glycerin and Sodium hydroxide were obtained from (Carlo Erba Reagenti, Spain), Sulphuric acid 96% was obtained from (Park Scientific, Ltd., U.K.), Polyvinyl pyrrolidone, Potato, Lactose, Na-meta bisulphate and corn were obtained from (BDH "General purpose reagent" England).

Methods

[1] EXTRACTION OF STARCH FROM PEARL MILLET PANNISTUMAMERICANUM GRAINS

The starches were separated by a wet-milling technique. Seeds were steeped for 24 hours at 4°C in 1% sodium metabisulfite, and then thoroughly washed. The grains were mixed with two volumes of distilled water at 37°C and milled in a one-gallon warring blend for several minutes at low speed. The slurry was then screened on a 115-mesh screen. The residue was replaced in the blender and homogenized with two volumes of water. The slurry was rescreened. The procedure was repeated until the residue appeared to be essentially free of starch, which required 5-6 cycles. The suspension that passed through the screen was centrifuged in a solid bowl centrifuge, and the dark layer on top of the bowl was removed with a spatula. The clear supernatant fluid was poured away while sedimented starch was collected on a tray and air-dried. Using pestle and mortar the dried starch lumps were grinded and fine powder passed through 180 µm sieve. The starch was dried in oven at 60°C.

A. Determination of Total Ash

Total ash content was determined as total inorganic matter by incineration of sample at 55°C. About 2-4 g of the ground air-dried material, accurately weighed, in a previously ignited and tarred crucible (usually of platinum or silica). The material was spread in an even layer and ignited it gradually while increasing the heat to 450°C until it is white, indicating the absence of carbon, then, cooled in desiccators and weighed. Ash value was then calculated by using the following formula:

$$Ash\ value = \left[\frac{initial\ weight - final\ weight}{initial\ weight}\right] X100$$

The percentage of water soluble and acid insoluble ash was calculated with reference to the air-dried starch.

B. Determination of moisture content

First, the container with lid were dried in the oven at 105ºC for 3 hours then transferred to desiccator to cool. The empty dish and lid were weighed. About 5 g of the sample was weighed and spread uniformly. The dish with the sample were placed and dried in the oven for 3 hours at 105ºC. Then the dish was transferred to the desiccator to cool. The dish and its dried sample were weighed.

Calculation: The % moisture content was calculated using the following formula:

$$Moisture\ \% = \left[\frac{W1 - W2}{W1}\right] X100$$

Where*:* W1: weight (gm) of sample before drying, W2: weight (gm) of sample after drying**.**

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C. Determination of loss on drying

The starch was dried in an oven at 103°C by using halogen moisture analyzer, Halogen, (Mettler Toledo, USA) [5].

D. Determination of pH

The pH of 1 % w/v slurry was measured using a digital pH meter (Mathrom Ltd, Herison, Swizerland).

E. Determination of melting temperature and melting range

The melting range of a substance is the range between the corrected temperature at which the substance begins to collapse or form droplets on the wall of a capillary tube and the corrected temperature at which it is completely melted as shown by the disappearance of solid phase, the instrument used was BUCHI melting point B-540, Switzerland.

F. Determination of protein content

Crude protein was determined by the kjeldahl method. In present investigation kjeltic 2200 analyzer unit was used for determination of total crude protein according to total nitrogen amount and then multiplied by a factor of 6.25 to determine the total protein content.

[2] Optical rotation principle

The method comprises two determinations. Firstly, the sample is treated while hot with diluted hydrochloric acid 28 % v/v. After filtration, the optical rotation of the solution was measured using a polarimeter (Ap-100 Automatic Polarimeter at AGO, USA).

Secondly, the sample was extracted with 40 % ethanol (v/v). After acidifying the filtrate with hydrochloric acid, clarifying, and filtering. The optical rotation of the solution was measured by a polarimeter.

The difference between the two measurements, multiplied by a known factor that gives the starch content of the sample.

[3] Spectrometry in Infrared region

The infrared region of the electromagnetic spectrum used in pharmaceutical analysis covers the range 250-4000 cm^{-1} (2.5-40 µm). Spectrophometric measurements in the infrared region were used mainly as an identification tool. The instrument used was Fourier Transform infrared spectrophotometer (Shimadzu, Japan).

Sample preparation: about 1 mg of the test sample was fine powdered, 200 mg of dried KBr fine powder were mixed well. The base sample was placed in the concave on the base (with shiny surface facing up).

[4] Microscopic view of the starch

One ml of glycerin and equal amount of water were mixed thoroughly and used as a diluent for the samples. Clean glass slide was taken and two drops of above prepared diluents were added. A loop full of sample was mixed with the diluent and covered with a cover slip. The structure of starch was viewed and the foreign particles were investigated in the samples [6].

Swelling index: Prepared starch (100 mg) was added to 5 ml of each of water and light liquid paraffin taken in two different graduated test tubs and mixed. The dispersion in the tubes was allowed to stand for 12 hours. The volumes of the sediment in the tubes were recorded. The swelling index of the material was calculated as following formula:

$$S.I.\% = \left[\frac{VW - VL}{VL}\right] X100$$

Where: S.I. is the swelling index. V_W is the volume of sediment in water. V_L is the volume of sediment in liquid paraffin.

[5] Pharmaceutical evaluation of starch

A. Angle of repose

The determination of powder flow properties using angle of repose was done and then the evaluation of the influence of particle size on the powder flowability was carried out.

B. Funnel method

The funnel was fixed on the stand then the distance between the lower edge of the funnel and the glass plate were adjusted to be 2 cm. The powder was allowed to flow through the funnel onto the glass plate beneath and formed a cone touching the lower edge of the funnel. The stand with the funnel was removed and the diameter of the circle formed at the bottom of the powder cone at two sides was determined. The average radius was estimated and the average was taken. The angle of repose was calculated using the following formula:

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$$\text{Tan } \theta = h / r.$$

The same previously mentioned steps were repeated for three times and the average was taken. The angle of repose for other size fraction was calculated as well.

[6] PARTICLE SIZE ANALYSIS

A. Particle size analysis by sieving method:

The particle size reduction was performed using hammer mill. A stack of sieves consisting of (1000, 710, 350, 250 &180 mm) sieves were used (Sieves Shaker RETSCH, Germany). The sieves were weighed and their weights were recorded. The sieves were arranged from smallest to the largest. A sample of 20 g was placed on the coarsest sieve at the top of the stack.

The stack was placed on the mechanical shaker for a period of 10 min Each sieve was weighed with the material retained. The weight of each fraction was determined. The mean particle (d_s) diameter was calculated using the following formula:

$$(d_s) = \sqrt{\frac{\varepsilon\, d^2 x}{\varepsilon\, x}}$$

The data obtained were analyzed and presented using over size and histogram.

B. Electron microscopy

Electron microscopy has been useful in the morphological study of starch granules. Scanning electron microscopy (SEM) exhibits good depth of field and gives detailed information about the surface of dry granules.

[7] GRANULATION AND GRANULE EVALUATION

In order to perform granulation and to evaluate the granules obtained.

A. Preparation of granules

Wet granulation:

The sample (s) and excipients (lactose + p.v.p) were mixed. The binder solution and powder mixture were mixed to form wet mass. Then, the wet mass was subjected to granulation by using oscillating granulator. The wet granules were weighed, before and after drying. Finally, the dry granules were screened through asuitable sieve (250-100 µm).

Dry granulation:

The weighed test sample was placed on the top sieve of the chosen nest. Then shaken for a pre-determined period. The sieving continued to an "end point". After which, the sieves were individually removed from the nest and shaken virgorously by hand. Any sieve load that failed this test was returned to the nest for further sieving.

B. Evaluation of granules

Friability of granules:

The granule friability was determined in a friabilator, (TA-20, Erweka, Germany). The drum was rotated at a speed of 25 rpm for 10 min, by subjecting 10 g (I_{wt}) of granules ($F_{250\text{-}1000\ \mu m}$) together with 200 glass beads (mean diameter 4 mm) to falling shocks. Afterwards the glass beads were removed and the weight of the granules retained on a 250 µm sieve (F_{wt}) was determined after vibrating for 5 min. The friability was calculated as follows:

$$\%\, F = \left[\frac{Iwt - Fwt}{Iwt}\right] \times 100$$

Bulk and tapped density:

The bulk volume (V_o) of 50 g (weight that overfills 100 ml measuring cylinder) granules ($F_{250\text{-}1000\mu m}$) were recorded in a 100 ml measuring cylinder as well as the volume after x taps (V_x). Bulk and tapped densities were calculated as 50 g / V_o and 50 g / V_x, respectively.

Compressibility index and Hausner Ratio:

The bulk and tapped densities were used to calculate the carr's compressibity index "CI" and the Hauser ratio "HR" to provide a measure of the flow properties.

$$\text{CI} = \frac{P_{tap} - P_{bulk}}{P_{tap}} \times 100$$

$$\text{HR} = \frac{P_{tap}}{P_{bulk}}$$

Where P_{tap} : is the density and the bulk density.

[8] PREPARATION OF TABLETS

Direct compression weight of 402 mg of granules were compressed using hand operated I.R press with a flat face 15 KN punch and set Hydraulic press, (Shimadzu, Japan). The ejection time was 1.9 seconds.

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A. Preparation of paracetamol granules

Working formula for the assessment of Pearl millet starch as disintegrant in paracetamol tablets is given in Table 1. The wet granulation method of massing and screening was used in preparing all batches of paracetamol granules. The paracetamol powder and the intradisintegrant maize starch or Pearl millet starch of concentration between 3 to 12 % w/w depending on the batch were dry-mixed for 5 min in a Z-blade mixer (Bibby Sterilin Ltd., UK). An appropriate quantity of freshly prepared starch mucilage of concentration 6 % W/V was added to each of the batch to produce granules. The wet mass was passed through a 1.8 mm 1800 µm sieve mesh screen, then wet granules were dried at 47°C to constant weight in a Memmert hot air oven (GmbH & Co. KG, Germany) and then later dried screened through sieve mesh 1-1.5 mm (150-100 µm).

B. Evaluation of starch powder and paracetamol granules

Particle size analysis:

The particle size distribution of the starches and the granules were determined by sieve analysis, using series of sieves of different sizes. The weight percentage oversize as a function of size was studied.

Friability of starch powder and paracetamol granules

The starch powder or granule friability was determined in a friabilator at a speed of 25 rpm for 5 min, by subjecting 10 g (Iwt) (F250-1000 µm) of starch powder and paracetamol granules with 200 glass beads (mean diameter 4 mm) to falling shocks. Afterwards the glass beads were removed and the weight of the granules retained on a 250 µm sieve (Fwt) was determined after vibrating for 5 min. The friability was calculated as:

$$\% F = [\frac{Iwt - Fwt}{Iwt}] \times 100$$

Bulk and tapped density of starch powder and paracetamol granules

The bulk density of the starches (Pearl millet starch and maize starch BP as a standard for comparison) and the granules samples were determined using a graduated measure. Fifty grams of each granules and starches powder were gently and slowly poured into the measuring cylinder. The volume occupied by the granules was read to the nearest 0.5 ml and the bulk density was calculated.

The tapped density of the various size fractions of the starches and the paracetamol granules was measured. A weighted quantity of each fraction was placed in a graduated measuring cylinder and tapped 50 times on a hard table surface, after which the volume was noted.

Starch powder and paracetamol granules flow properties

Methods described in the USP were used for the determination of angle of repose, Hausner's ratio and Carr's compressibility index [7].

[9] QUALITY CONTROL TESTS

Official tests described by the BP and USP include weight and content uniformity (uniformity of dosage unit), disintegration, dissolution and friability tests.

A. Non compendial tests

Tablet diameter, thickness and hardness (*Crushing strength:*

Diameter, thickness and hardness of tablets were determined by using hardness tester instrument (PHARMATEST PTB 311, Germany), measuring the average force in Kilogram by triplicate of tests as well as measuring in mm for thickness and diameter.

B. Compendial tests

Uniformity of weight:

Twenty tablets from each batch were randomly selected and weighed together; the tablets were then weighed individually. The weight of each tablet was subtracted from the mean tablet weight and the percentage deviation of each tablet from the mean was calculated as described in BP, 2014.

Friability:

Erweka tablet friabilator (Erweka, Milford CT, Germany) was used to determine the friability of Levar tablets according to the method described in the BP.

Disintegration study:

Disintegration studies were performed according to USP specifications using the disintegration test apparatus (Tablet Disintegration Tester, ZT-4, Erweka, Milford, Germany). Six tablets from each brand were placed in basket rack assembly of apparatus. Basket was moved with frequency of 29 to 32 cycles per minute in distilled water, maintained at 37 + 1°C.

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Dissolution Rate

The dissolution rates of the active drug from tablets were determined using BP specification equipment (Erweka dissolution Apparatus, Model DT 600, Germany). The dissolution medium was (900 ml) of phosphate buffer with pH 5.8 at 37°C ± 0.5°C and rotate the paddle at 50 rpm. The samples were withdrawn at specified time intervals. Filter and dilute to reach the solution expected to conation about 0.00075% w/v of paracetamol, then spectrophotometrically analyzed at 257 nm using 0.1 M sodium hydroxide in the reference cell. Samples removed for analysis were replaced with fresh aliquots of dissolution medium. The total content of paracetamol, $C_8H_9NO_2$, was calculated in the The dissolution rates of the active drug from tablets were determined using BP specification equipment (Erweka dissolution Apparatus, Model DT 600, Germany). The dissolution medium was (900 ml) of phosphate buffer with pH 5.8 at 37°C ± 0.5°C and rotate the paddle at 50 rpm. The samples were withdrawn at specified time intervals. Filter and dilute to reach the solution expected to conation about 0.00075 % w/v of paracetamol, then spectrophotometrically analyzed at 257 nm using 0.1 M sodium hydroxide in the reference cell. Samples removed for analysis were replaced with fresh aliquots of dissolution medium. The total content of paracetamol, $C_8H_9NO_2$, was calculated in the medium taking 715 as the value of A (1 %, 1 cm) at the maximum at 257 nm. All experiments were conducted in triplicates, and the average readings were recorded.

RESULTS

Organoleptic properties of the fresh Pearl millet starch and commercial maize are illustrated in Tables 1. The presence of starch in the samples used was confirmed by Molish's test and Iodine test.

Table 1: Organoleptic properties of fresh Pearl millet and maize starch BP.

Test	Pearl millet	Maize Starch BP
Color	White	White
Odor	No characteristic	No characteristic
Taste	Taste less	Taste less
State	Fine-powder	Fine-powder
Inference	Powder complied with the BP and USP organoleptic test for starch	

The physicochemical parameters of the Pearl millet compared with maize starch BP are shown in Table 2. The pH of the Pearl millet starch (4.06) was more acidic compared to commercial maize starch pH (5.0). Table 2 also shows the proximate composition which is a major determinant of starch purity. It also determines the presence of all other contaminants or impurities other than pure starch. The ash content of the Pearl millet starch was higher than that of commercial maize starch by 0.000176 % w/w.

Table 2: Physicochemical parameters of the Pearl millet and maize starch BP

Physicochemical Parameters	Pearl millet Starch	Maize Starch BP
Total ash	0.00026818%	0.0000923%
Water soluble ash	0.000051178%	0.00005047%
Acid insoluble	0.00006249%	0.000009128%
Sulphoric acid ash	0.000677%	0.000116%
Moisture content	18.897%	10.5045%
Loss on drying	17.62%	10.1%
pH	4.06	5.00
Melting point	289-290 ºC	299-300 ºC
Protein	5.737%	1.475%
Lipid	0.919	0
Fiber	0.0%	0.0%
Optical rotation	73.043%	70.923%
I.R.	96%	88%
Swelling index	58.33%	50%
Content CHO	74.44%	88.025%

The physico-chemical characteristic properties of granules of paracetamol produced with Pearl millet starch and maize starch are listed in Table 3. The angle of repose provides an insight into the extent of the cohesiveness and hence flow ability of the granules.

The results of granule size distribution as containing Pearl millet starch disintegrant were illustrated in Figure 1 using dry and wet granulation methods, indicating the suitability of the wet granulation method using Pearl millet starch as a disintegrant.

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Table 3: The physico-chemical characteristic properties of Paracetamol granules

The physico-chemical characteristics	Pearl millet	Maize Starch BP
Water soluble cold	Insoluble turbid white colour	Insoluble turbid white colour
Water soluble hot	Insoluble PPt	Insoluble turbid white colour
Ethanol cold	PPt	Sparingly soluble white colour
Ethanol hot	Insoluble	Sparingly soluble white colour
Petroleum ether cold	Insoluble PPt white colour	Insoluble
Ether cold	Insoluble PPt	Insoluble
Hot ether	Insoluble PPt	Insoluble
Molish's test	+ ve	+ ve
Iodine test	+ ve	+ ve
Shape	polyhedral	Polyhedral
Size	4.kx-2.85kx	4.kx-2.00kx
Angle of repose	38.12(±1.20)	37.67(±1.85)
Hausner's ratio	1.24(±0.18)	1.23(±0.10)
Carr's index	19.5%(± 0.21)	19.04%(± 0.32)

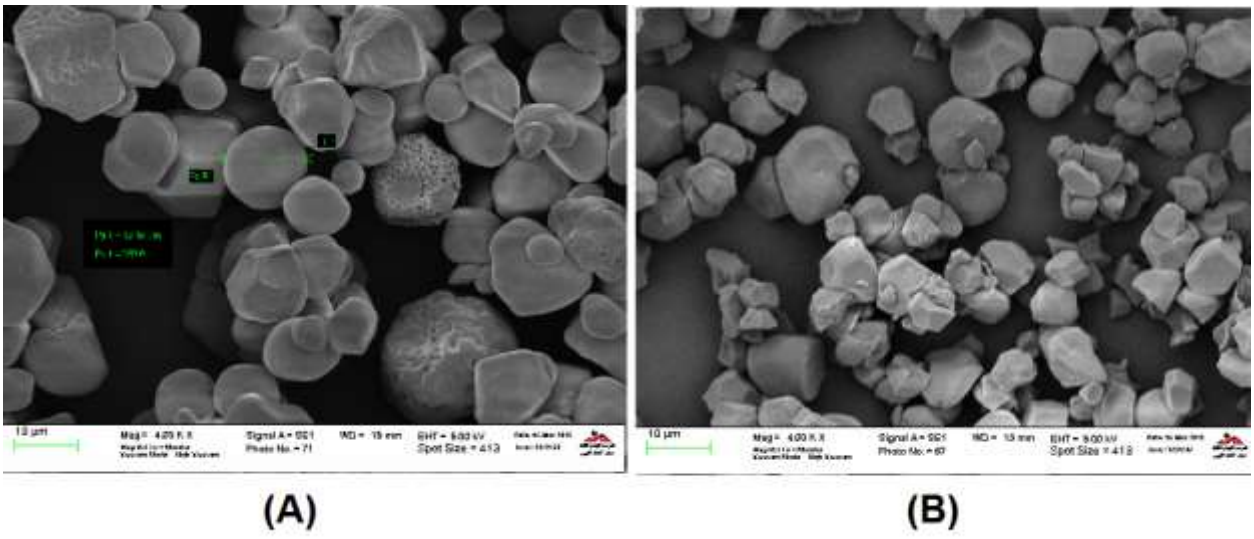

Figure 1: Particle size of maize starch BP at magnifications 4.00 KX (A) and particle size of Pearl millet starch at magnifications 4.00 KX (B).

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The disintegration time of paracetamol tablets containing the Pearl millet starches as disintegrant was not marginally faster than compacts containing the commercial maize starch (Table 4). In addition, similar pattern of variation was observed with dissolution time of the tablets, as the concentration of disintegrant has had impact in increasing dissolution time.

Figure 2 shows the normal distribution curve for wet method of paracetamol with Pearl millet starch, while figure 3 shows the IR spectra for Pearl millet starch, and maize starch,.

Table 4: Results of varying disintegrant type/concentration on paracetamol tablet properties produced by wet granulation method

Tablet properties	Disintegrant type /concentrations (% w/v)							
	Pearl millet				Maize starch			
	3 %	6 %	9 %	12 %	3 %	6 %	9 %	12 %
Weight variation %w/w	-0.98 to 1.379	0.2 to 0.907	0.2 to 0.4	-0.98 to 0.907	-0.51 to 0.4	- 0.98 to 0.4	-0.98 to 1.40	-1.1 to 3.74
Friability %w/w	0.56	0.53	0.49	0.32	0.59	0.53	0.37	0.29
Hardness (Kg F)	11.42	13.20	13.41	14.73	10.76	12.3	13.01	14.03
Tablet thickness (mm)	5.4	5.3	5.25	5.15	5.6	5.5	5.31	5.25
Disintegration* time (min)	10.37	6.07	5.57	3.07	15.68	5.45	4.5	3.5
Dissolution time T_{50} (min)	31.12	15.37	13.34	5.06	26.07	14.25	12.01	6
Dissolution time T_{90} (min)	59	30.44	23.23	11.58	40.5	28.76	21.2	10.45

***Disintegration times were not more than 15 min (BP, 2013).**

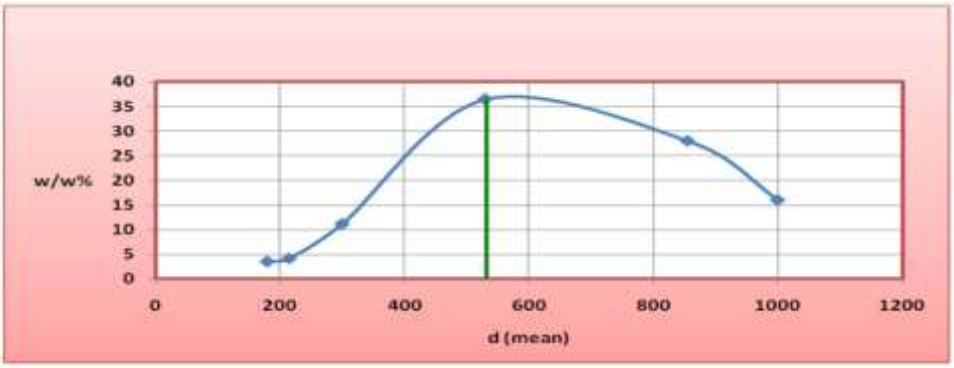

Figure 2: Normal distribution curve for wet method of paracetamol with Pearl millet starch showing the Mean diameter of particles = 530µm

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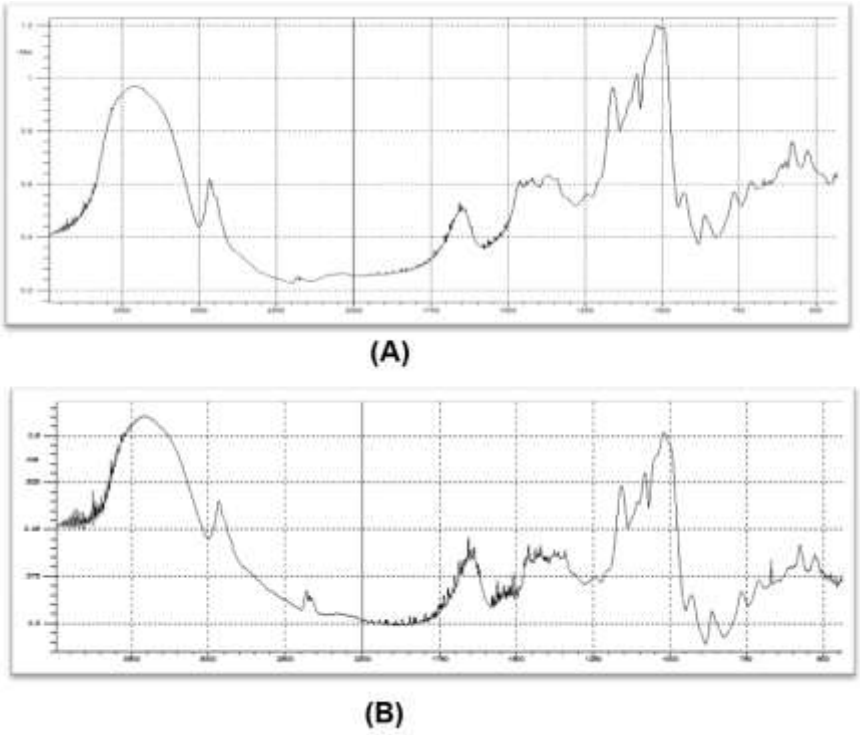

Figure 3: (A) Shows the IR spectra for Pearl millet starch, and (B) Shows IR spectra for maize starch

Discussion

Starch amylose is reported to form a characteristic dark blue color complex with iodine. This colour complex observed in the investigations confirmed the identity of materials obtained from the wet separation process as starch. The percentage yield of starch extracted from Pearl millet (Pannistumamericanum) crop was 65.6 % w/w which was a very good yield and high dry matter content 82.38 %, tend to have firm texture as tuber water content is relatively low [8], and can enhance water binding capacity and adhesive or binder property of the starch. It may however reduce flow properties as it causes adhesion to substrates. The Pearl millet starch granules as well as that of the commercial maize starch were either round, irregularly round or polyhedral in shape. Starch granule size and size distribution contribute to the temperature and rate of gelatinization. There are reports of less molecular bonding with faster swelling in larger starch granules, such starch granules would therefore be of interest to the pharmaceutical manufacturing industry, as their high swelling capacity will hinder them stronger tablet disintegrants [9, 10]. The physical and chemical properties showed differences in bulk and flow properties as well as acidity and hygroscopicity of Pearl millet starch. The high indices of powder flowability observed, confirmed reports of native starches generally having poor flow properties [11]. Both Pearl millet starch and commercial maize starch had high angle of repose and very similar Hausner's ratio and Carr's index values. They would therefore be ideal for wet granulations, where improved granule flow (as a result of the increased powder density) allows smooth tablet compression [12, 13]. The pH of the Pearl millet starch was more acidic compared to commercial maize starch, that was with pH value of 5. The starches should therefore be used with caution in formulations of low dose alkaline drugs to prevent drug-excipient interaction. On the other hand, effectiveness of other excipients such as the parabens, which act as antimicrobial preservatives may however be enhanced as they are more active in acidic conditions [14 ,15]. The BP recommends a pH range of 4.0 - 7.0 for starch [4].

The spectra for Pearl millet starch and Mize starch did not show any significant change in position of the absorption bands. The ash content indicates amount

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of insoluble salts and complexes in starch. Presence of inorganic salts and ions of phosphorous, sodium, iodine and hydroxyl groups in starch have been reported to contribute significantly to starch granule swelling and gelatinization [16].

Using dry and wet granulation methods, indicated the suitability of the wet granulation methods in using Pearl millet as a disintegrant. The angle of repose provides an insight into the extent of the cohesiveness and hence flowability of the granules. It was observed as the concentration of the disintegrant increased the crushing strength of the tablets increased. Pearl millet starch gave harder tablet than maize starch when used as disintegrant.

The differences in tablet hardness and friability among compacts prepared using the Pearl millet starch as disintegrant were however not significant. The tensile strength and mechanical integrity of tablets are known to improve significantly when low density regions or voids are eliminated [17]. Void elimination has been demonstrated to reduce incidences of tablet capping and lamination; and may be achieved if the material has either high binding capacity or the compression load or quantity of binder is increased [18].

Conventional compressed tablets of acceptable hardness (4-6 kg/cm^2) and friability (≤ 1%) are essential for handling during packaging, transportation and administration [19].

The disintegration time of paracetamol tablets containing the Pearl millet starches as disintegrant showed significant differences compared to that of compacts containing the commercial maize starch. Starch granules as extra-granular disintegrant undergo deformation during high pressure tablet compression; and these swell maximally in aqueous fluids to cause tablet disintegration. Its disintegration time decreased with increase in disintegrant concentration and friability values as well were found to decrease with an increase in disintegrant concentrations.

The BP, 2007 recommends a disintegration time of 15 min or less for immediate release tablets. The mechanisms of action of starch as a disintegrant in tablets is still not clear but some important postulates were proposed by Pate and Hopponen [20] and Nogami e*t al*, [21]. The mode of action of starch as a disintegrant is that water penetrates into the tablet porous structure causing the starch grains to swell and exert pressure on the granules to break them a part. The disintegration time decreased as the concentration of the disintegrant in the formulation was increased. Others proposed that starch does not swell when exposed to water but that the disintegrating force of starch is due to capillary action rather than swelling. This capillary action tends to bring aqueous fluids to the tablet, where they may exert hydrostatic pressure, dissolve the binding agents and cause swelling of some components, so that all or any of these actions may serve to break the tablet apart.

The pattern of *in-vitro* dissolution and drug release closely followed that of tablet disintegration. Tablets which disintegrated quickly released paracetamol faster than tablets which took a longer time to disintegrate.

CONCLUSION

The percentage yield of starch extracted from Pearl millet *(Pannistumamericanum)* crop was 65.6 % w/w which was a very good yield with high dry matter content 82.38% and identity of material obtained from it by wet separation is confirmed as a starch.

The residual moisture content of Pearl millet starch was 18.89 %. Starch moisture content is known to be largely influenced by its hygroscopicity, crystallinity, drying temperature and duration, particle size, humidity and the velocity of moist air. Optimal levels of moisture in starch which is 5 - 10 % have been shown to be essential in producing compacts with high tensile strength and low friability.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

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ملخص البحث باللغة العربية

تقييم نشأ لؤلؤة الدخن كمفتت للأقراص الدوائية

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الأهداف: **تهدف هذه الدراسة إلى تقييم مضاف جديد تم الحصول عليه من مصادر محلية، نشا لؤلؤة الدخن من عائلة بانيستوماميريكانوم التي تستخدم محليا كغذاء بسبب احتوائها على نسبة عالية من الكربوهيدرات. كان يعتقد أن النشا من لؤلؤة الدخن بانيستوماميريكانوم قد يستعمل كمضاف يساعد على تفكيك الاقراص الدوائية.**

الطريقة: **تمت دراسة خصائص مضاف النشا لؤلؤة الدخن وكذلك شكل المادة ما قبل الجيلاتين في أقراص البارسيتامول التي تنتجها أساليب التحبيب الرطب والجاف للتكتيل والكشف ومقارنتها مع نشا الذرة (دستور الادوية البريطاني).**

النتائج: **أظهرت طريقة التحبيب الرطب التفوق في جميع خصائص كل من حبيبات وأقراص البارسيتامول. استخدام التحبيب الرطب باستخدام نشا لؤلؤة الدخن بانيستوماميريكانوم ونشا الذرة (دستور الادوية البريطاني) أظهر خواص متشابهة في ما يخص بعض الخصائص مثل زاوية التراخي، مؤشر Carr's، كثافة الكتلة، الكثافة الظاهرية، ونسبة Hausner's، ومع ذلك أظهر نشا الدخن بانيستوماميريكانوم انه أجود في بعض الخصائص مثل محتوى الرطوبة ومؤشر التورم .القرص المنتج من نشا لؤلؤة الدخن بانيستوماميريكانوم أحتاج لنفس الزمن تقريبا للتفكيك مقارنة بتلك المنتجة من نشا الذرة في جميع التركيزات المستخدمة. وقد وجد أيضا أنه عندما تستخدم بوصفها مادة مفككة، فإن شكل ما قبل الجيلاتين توفر أقراص أفضل من ناحية الصلابة وقيم التفتيت من نشا الذرة.**

الخلاصة: **أكدت هذه الدراسة ملاءمة نشا لؤلؤة الدخن بانيستوماميريكانوم كبديل لنشا الذرة كمفكك للأقراص، لاسيما في صياغة قرص البارسيتامول.**

الكلمات المفتاحية: مفككة ، لؤلؤة الدخن ، بانيستوماميريكانوم ، أقراص الباراسيتامول ، النشا ، معدل التفتت ، الذرة ، زاوية التراخي

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