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Research Article

EVALUATION OF TABLETS BINDING PROPERTIES OF *DIGITARIA IBURUA* STARCH IN PARACETAMOL TABLETS FORMULATION

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ABSTRACT

The binding properties of the starch obtained from *Digitaria iburua* crop (Family: poaceae) were evaluated. The starch from the crop was extracted, evaluated and it binding ability compared with gelatin B.P in paracetamol 500mg tablets formulation produced by wet granulation method of massing and screening. was studied.

The results showed that granule and tablet properties of paracetamol produced using 0% to 12%w/v Digitaria iburua starch mucilage produced hard and good quality tablets comparable in Crushing strength, weight variation, Dissolution rate and Disintegration rate with gelatin B.P mucilage binder at most of the concentration tested. The study revealed that the mucilage of Digitaria iburua starch when used as binder produced tablets of standard pharmaceutical quality.

Keywords: Evaluation, Tablet, Binding, *Digitaria iburua* Starch, Paracetamol

INTRODUCTION

Binders are agents used to impart cohesive qualities and structural strength to powdered materials in tablet formulations. A good binder ensures that tablets remain intact after compression and can withstand handling during transportation and packaging processes (1). Binders are mostly employed in the wet granulation methods of tablet production. In this process, a solution previously prepared is used in wetting the dry power mix to form a damp mass, kneaded and screened to give granules. The quantity of binder used has considerable influence on the characteristic of the compressed tablets. Generally increasing the binder concentration invariably causes a corresponding increase in the disintegration times of tablets (2,3).

Examples of materials commonly used as binders are starch, gelatin, sugar, acacia sodium alginate, methyl-cellulose, microcrystalline cellulose, polyethylene glycol, waxes and water.

The aim of these studies is to investigate on the tablet binding properties of Digitaria iburua stach in paracetamol tablets.

MATERIALS AND METHODS

Digitaria iburua was obtained from Sabon Gari market in Zaria, Kaduna State, Nigeria. Paracetamol (May and Baker (Nigeria), Maize starch and Talc (B.D.H. Laboratories, U.K) and magnesium stearate Hopkin and Williams, U.K.). They were all utilized as obtained.

Table 1: Shows the working formula for studying the binding properties of Digitaria iburua starch compared with gelatine in Paracetamol 500mg tablets

Ingredient	Quantities per tablet	Quantities in 200 tablets
Paracetamol	500mg	100g
Maize starch	60mg	12g
Gelatin or Digitaria iburua starch (binder)	0%2%5%7%10%12% w/v	Qs
Exodisintegrant /lubricants/glidant		
Dried maize starch	7.8% w/w	7.8% w/w
Magnesium stearate	0.2% w/w	0.2% w/w
Talc	2% w/w	2% w/w

Preparation of paracetamol granules

Using the techniques of wet granulation method of massing and screening, paracetamol granules were made based on the calculations as shown in Table 1, using varying concentrations of gelatin and *Digitaria iburua* starch as binder.The procedure used in the granules formulation includes:-

i. Weighting:- appropriate amounts of all the ingredients as shown in tables above with the exception of the exodisintegrants/lubricants/glidants were weighted for different batches of the granules formulation.
ii. Mixing:- The ingredient weighted were then mixed in a Z blade mixer for ten minutes.
iii. iii.) Addition of Binder Solution:- According to the formulars, gelatin and digitaria iburua starch were used in varying concentrations as a binder for granules formulation.

Gelatine binder solution was prepared as follows:

Appropriate amounts of gelatin was weighted in varying concentrations as calculated and shown in Table 1 . The gelatin was then put into a clean glass beaker and a small amount of calculated distilled water was added to make a solution. Boiling water of calculated amount at 60^{o}c was poured. The beaker was put on a hot plate and was stirred with a stirring rod until the gelatin was dissolved.

Digitaria iburua starch binder solution was prepared as follows:-

Appropriate amounts of *Digitaria iburua* starch powder was weighted in varying concentration as calculated and shown in Table 1. A small quantity of calculated distilled water was poured in different glass beaker containing varying amounts of *Digitaria iburua* starch powder to make it into a solution. Varying calculated quantities of boiling water was then poured into the solution. The beaker was then put on a hot plate with continuous stirring until a translucent paste was formed.

.Small quantities of the binder solution of gelatin and *Digitaria iburua* respectively formulated were added gradually to the varying powder mixtures until moist mass was formed. The quantity of the binder paste used was determined.

Wet screening:- The moisted mass was then passed through a sieve size of 1.7um using a spatula to get wet granules .

Drying:- The wet granules were dried in a hot air oven (gallenhamp oven) at 40°c.

Dry screening**:-** The dried granules were then passed through a sieve size of 1.6nm size and oversized granules were sized reduced.

Determination of moisture content

The moisture content of the granules of each batch which ranged between 0.8%$^{w}/_{w}$ to 7.8% $^{w}/_{w}$ was determined by drying the samples to constant weight in a hot air oven at 105°c.

Analysis of paracetamol granules:

The following tests were carried out on the granules-sieve analysis,moisture content,angle of repose,bulk and tapped densities, Carrs index,and Hausner ratio .

Determination of flow properties of granules

i. *Angle of repose:* A funnel was mounted on a laboratory stand at a height of 10cm from the table-top. 50g of *granules.* was poured into the funnel with the tip closed. The tip-plug was removed and the starch was allowed to flow, the height and diameter of the *granules.* heap were measured.. The angle of repose, θ, is given by the following equation:

ii. $\theta = \tan^{-1}(h/r)$……..(1)

iii. Where h is height of conical powder heap and r is the radius of the circular base

iv. *Flow rate:* using Erweka Flow tester, 50g each, of the *granules.* Was allowed to pass through its orifice and the time taken was recorded. Mean of three readings was taken as the flow rate of the *granules.*.

Determination of granules density

i. *Bulk density***:** 20g each, of individual granules was poured through a short-stemmed glass funnel into a 200ml graduated glass cylinder and the volume occupied by the granules was read and the bulk density calculated.

$$\text{Bulk density} = \frac{\text{mass of the starch/granule}}{\text{volume of the starch/granule}} \quad (4)$$

ii. *Tapped density:* Graduated cylinder containing *granules.* was dropped on a bench 50 times from a height of about 20mm and the respective volumes recorded. and the tapped density was then calculated in g/ml

iii. *Carr's Index:* The difference between the tapped and bulk density divided by the tapped density was calculated and ratio expressed as a percentage.

iv. *Hausner ratio:* (i.e. the ratio of tapped density to bulk density) was calculated for the *granules.*.

v. *Determination of granules. true density:* The specific gravity bottled method was adopted, and xylene was used as displacement fluid. The bottle was cleaned and filled with xylene, all spilled over liquid (xylene) was wiped off with an absorbent cloth. The weight of the bottle filled with xylene was noted as (a), the bottle was emptied and cleaned, 2g of *granules.* was weighed into the specific gravity bottle, the weight of the *granules.* was noted as (w). The specific gravity bottle containing the *granules.* was almost filled with xylene, stirred with glass rod and allowed to stand for 10 minutes for air bubbles to be released. The bottle was then carefully filled with xylene and the final weight of the bottle was noted as (b). *granules.* true density was the calculated as

$$\ell = w/[(a+w)-b]S \quad \text{……..(5)}$$

Where ℓ is the particle density of *granules.* and S is the specific gravity of xylene = 0.86

Sieve analysis of granules. :-

50g of the *granules.* was weighted and put in the uppermost sieve of a set of sieves arranged in decreasing sizes. The sieves were then mounted on a sieve shaker and shaken for 10mins.The *granules.* retained on each sieve after 10mins was measured and recorded.

Addition of exo-exciepients to paracetamol granules:

The exo-exciepients was then added to the granules based on the calculations as shown on the tables above.The granules were then mixed using an automated granules mixer.

Compression of granules:

After the addition of the exo-disintegrant,lubricants and glidants,the granules were then mixed gently using an automated tumble mixer and pressed into tablets using the erweka manual tabletting machine at pressures varying from the lowest until best tablets were formed.

After the tablets were produced,they were kept in dessicator for 24 hours for elastic recovery and drying.The following Quality control tests were carried out on the batch of tablets that gave the best formed tablets.

Quality control tests on the tablets

Weight variation test: The weights of 20 randomly selected tablets were taken as a whole and individually using metler electronic balance (P163, Melter, Switzerland) and the mean weight was calculated.The variations of the weights of the individual tablets from the mean were also noted.

Friability test: Friability was determined using a friabilator (Erweka TA – 3R Erweka Apparatebau GmbH, Germany). Ten tablets per batch were weighted and caused to cascade in the drum of the friabilator which rotated at 25rpm for 4min. The tablets were dusted and reweighed. The loss in weight expressed as a percentage of the original weight of the tablets represented the friability [4].

Crushing strength test: The crushing strength of each of 10 tablets was determined using a monsanto hardness tester (Manesty Machines Liverpool, England). The mean crushing strength was calculated. **Disintegration Times:** Disintegration times of six tablets randomly selected from each batch was individually determined in a B.P specification apparatus (Erweka disintegration tester type ZT3, Germany) containing purified water at 37 + 0.5°C. The mean disintegration times were calculated [5].

Dissolution rates test: The dissolution rates of the active drug from the tablets were determined using B.P specification equipment (Model DT 80, Erweka Germany dissolution Apparatus). The dissolution medium was (900ml) of 0.01M Hcl at 37°C ±0.5°C. The paddles were caused to rotate at 100rpm. Samples were withdrawn at 50 and 90 minutes and spectrophotometrically analysed for Paracetamol at 243 nm. Samples removed for analysis were replaced with fresh aliquots of dissolution medium. All the experiments above were conducted in triplicates and the average readings recorded.[6]

f. **Determination of tablet packing fraction:** Tablet packing fraction was determined for all the batches of tablet produced using the following equation.

Pf = bulk density of tablet(D_B)/Particle density……..(7)

And $D_B = 4W/\P d^2h$……(8)

g. **Determination of tablet porosity:** The tablet porosity was calculated from the formula

Tablet porosity = 1- Pf……..(9)

Table 2: Granule Properties for *Digitaria iburua* Starch and Gelatin Used at Different Binder Concentrations in Paracetamol Tablets

Granule Properties	Digitaria Iburua Starch						Gelatin					
Binder Concentrations % w/w	**0**	**2**	**5**	**7**	**10**	**12**	**0**	**2**	**5**	**7**	**10**	**12**
Flow rate (g/secs)	1.52	4.25	3.28	3.88	3.34	3.62	1.52	4.13	3.57	4.17	4.27	3.64
Moisture contents (%)	2.00	3.00	3.00	2.00	3.00	3.00	2.00	3.00	4.00	2.00	3.00	2.00
Angle of repose(o)	28.20	20.32	19.40	22.50	20.04	21.45	28.00	21.32	18.52	20.20	20.66	20.30
Bulk densities (g/ml)	0.405	0.400	0.410	0.434	0.405	0.410	0.496	0.402	0.429	0.408	0.408	0.389
Tapped densities (g/ml)	0.5	0.476	0.5	0.508	0.508	0.5	0.684	0.508	0.491	0.487	0.49	0.476
Carrs index (g/ml)	19.0	15.96	18.0	14.56	20.2	18.0	28.36	20.86	13.44	16.22	16.73	18.27
Hausner ratio	1.23	1.19	1.21	1.17	1.25	1.21	1.37	1.26	1.15	1.19	1.20	1.22

Table 3: Effects of Binders at Different Concentrations in Paracetamol Tablet

	Tablet thickness (mm)		Tablet weight variation(mg)		Tablet friability(%w/w)		Disintegration time (minutes)		Crushing strength(kgf)	
Binder conc (%w/w)	**DI**	**Gel**	**DI**	**Gel**	**DI**	**Gel**	**DI**	**Gel**	**DI**	**Gel**
		5.73				0.9		32		4.17
(0%)			0.677±(0.02)	0.677±(0.02)	0.9		32		4.17	
(2%)	5.88	5.11	0.666±(0.02)	0.615±(0.022)	0.82	0.70	43	44.6	4.07	10.25
(5%)	5.86	5.41	0.655±(0.033)	0.624±(0.218)	0.69	0.64	69	78.6	8.17	8.25
(7%)	5.88	5.29	0.636±(0.032)	0.605±(0.021)	0.42	0.48	32	83.6	8.17	5.92
(10%)	5.98	5.57	0.625±(0.025)	0.613±(0.025)	0.25	0.23	95	97.3	8.07	6.25
(12%)	5.25	5.67	0.608 ±(0.03)	0.610 ±(0.027)	0.17	0.12	38	106.6	6.12	5.60

DISCUSSION

The particle size distribution of granules containing *Digitaria iburua* (DI) as binder at varying concentrations (Fig.1) was analysed..Statistically there was no significant difference between any batch amongst the six batches meaning that (p>0.05).

The Flow rate for granules was found to increase as the concentration of binder was increased up to certain limit after which it decreases.[7] This is because as the concentration of binder was increased, more binding bridges are increased within the granules leading to increase in particle size of the granules which then decreases attractive forces of (cohesion) and friction within the particles of the granules leading to increase in flow rate [8].On statistical analysis of flow rates of the *Digitaria iburua* and gelatin,the t-score (-0.404) and the t-critical value (2.228) with p >0.05.There is no significant differences between *Digitaria iburua* and gelatin.This is observed as the absolute value of t is less than the critical value with p>0.05.

As the binder concentration was increased there was only a slight change in Bulk densities which means that increasing the concentration of binder does not have much influence on the bulk density of both granules. On statistical analysis of bulk densities of *Digitaria iburua* and gelatin,the t-score (-0.732) and the t-critical value (2.228) with p >0.05.There is no significant differences between *Digitaria iburua* starch and gelatin.This is observed as the absolute value of t is less than the critical value with p>0.05.[9]

Initially there was a rise in Moisture Content of *Digitaria iburua* starch and gelatine as the binder concentration was increased. The initial increase in binder concentration did not increase the particle size of the granule thereby retaining more moisture which in turn decreased the moisture content.[10,11] On statistical analysis of moisture contents of *Digitaria iburua* and gelatin,the t-score (0.00) and the t-critical value (2.228) with p >0.05.There is no significant differences between *Digitaria iburua* and gelatin.This is observed as the absolute value of t is less than the critical value with p>0.05.

Carr's Index describes the percentage compressibility of the granules. As the binder concentration of the granules was increased up to 10% there was an increase in Carr's index. These could be due to the fact that at that concentration, enough binding bridges have been formed giving densier granules([12]). On statistical analysis of carrs index of Digitaria iburua and gelatin,the t-score (-0.596) and the t-critical value (2.228) with p >0.05.There is no significant differences between Digitaria iburua and gelatin.This is observed as the absolute value of t is less than the critical value with p>0.05.

The Hausner ratio also explains the compressibility of the granules. As the binder concentration was increased, there was an initial decrease in Hausner ratio, it then rose at 10% which may be due to the fact that at 10% concentration the binder has effect on the compressibility of the granules[13]. On statistical analysis of Hausner ratio of *Digitaria iburua* and gelatin,the t-score (-0.649) and the t-critical value (2.228) with p >0.05.There is no significant differences between *Digitaria iburua* and gelatin.This is observed as the absolute value of t is less than the critical value with p>0.05.

Angle of Repose also explains the flowability of granules. Granules with large angle of repose has low flowability (up to 50%). Any powder below 25^{o} flows better.

As the binder concentration was increased angle of repose decreases up to certain level which means better flowability of granules of both starch powders. At concentration of 7% binder the angle of repose then increased which means it has reached its maximum concentration after which any addition had little or no effect on the angle of repose. On statistical analysis of angle of repose of *Digitaria iburua* and gelatin,the t-score (0.256) and the t-critical value (2.228) with p >0.05.There is no significant differences between *Digitaria iburua* and gelatin.This is observed as the absolute value of t is less than the critical value with p>0.05.

Tapped density explains the density of the powder after packing. Tapped density gives you an idea of how well it will compact to make tablet. As you increase the binder concentration, the granules size increases meaning that there will be more voids in between the granules thereby decreasing the tapped density([14]). On statistical analysis of tapped densities of *Digitaria iburua* starch and gelatin,the t-score (-0.772) and the t-critical value (2.228) with p >0.05.There is no significant differences between *Digitaria iburua* and gelatin.This is observed as the absolute value of t is less than the critical value with p>0.05.

The result shown in Table 3 indicates that as you increase the binder concentration for *Digitaria iburua* starch, the tablet thickness remain the same up to a concentration 7%, above which there was a slight increase followed by a decrease. This increase in tablet hardness with increase in binder concentrations is as a result of increase in strength of forces that bind the particles together (Vander Waals forces) as well as mechanical interlocking .As the concentration of gelatin was increased, there was a decrease in tablet hardness at 2%.

The results shown in Table 3 indicates an increase in the concentration of *Digitaria iburua* starch and Gelatin as binder causes a marked decrease in tablet friability. These means that the binders increased the binding bridges in between the granules thereby giving additional bonds which makes the tablets stronger which in turn decreases its friability.

Table 3 also shows that as the concentration of DI starch and gelatin was increased as binder there was an increase in Disintegration time for DI. This could be due to increase in granules interparticulate forces with increase in binder which then increased the hardness of the tablet making it harder up to a maximum concentration of 5% above which it decreased remarkably for DI. In case of gelatin as binder, disintegration time kept increasing as the concentration of binder was increased which means that as you increase the binder concentration stronger granules were obtained which in turn produce stronger tablets with higher disintegration time.

Table 3 also shows that there was an increase in crushing strength of tablets with an increase in the concentration of gelatin as binder. This increase in crushing strength corresponds to the decrease in tablet friability of gelatin. In case of DI as the binder concentration was increased, there was an initial decrease in crushing strength of the tablets meaning that the binder added at concentration of 2% acted as a disintegrant above which crushing strength increased resulting in harder tablets as supported by several authors [1,11, 15,16,and 17]. This increase in crushing strength might be as a result of increase in bonds formed within the tablets because the strength of the inter particulate bonds and the number of bonds depends on the concentration of binder used.

According to official limit set out in B.P 2002 for compressed tablet, the tablet should release 75% of the active content in less than 30mins. Although all the tablets dissolved within 20mins, the dissolution was found to increase with increasing the binder concentration.(Figure 2).

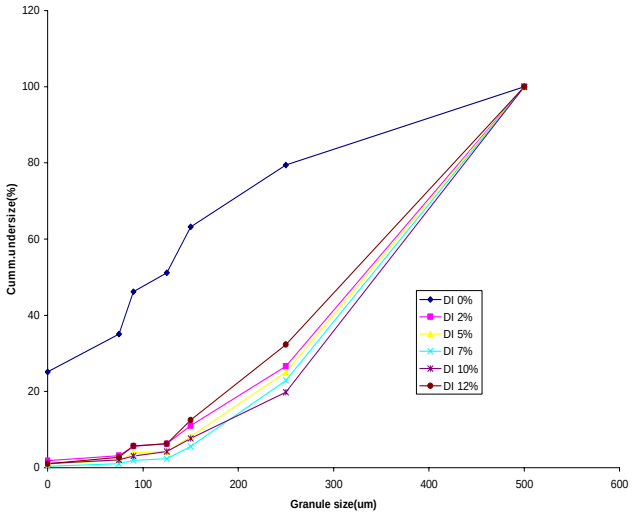

Fig. 1: Size distribution of granules produced with *Digitaria iburua* starch as binder in paracetamol tablet formulation

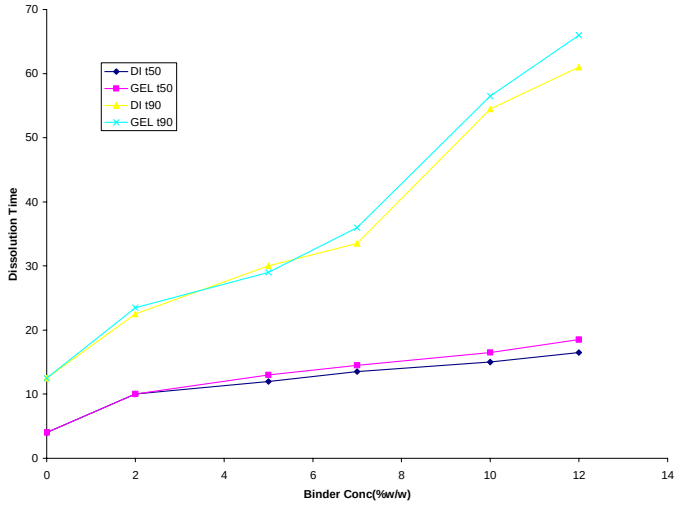

Fig. 2: Effect of binder type and concentrations on Dissolution Time of paracetamol Tablets produced

CONCLUSION

The *Digitaria iburua* starch was compared with maize starch as a binder at various concentrations and was found to be as good as maize starch in the formulation of paracetamol tablets. *Digitaria iburua* starch when used at 7%w/w to 10%w/w concentration as binder is recommended in the formulation of 500mg Paracetamol tablet

From the results of the study conducted above it can be inferred that starch extracted from *Digitaria iburua* may be suitability used as binder to formulate paracetamol tablets. Also the paracetamol granules obtained from the extracted starch have similar physicochemical properties with that of paracetamol granules prepared with maize starch B.P.

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