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Research Article

PHYSICOCHEMICAL PROPERTIES OF *BORASSUS AETHIOPUM* STARCH

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ABSTRACT

The suitability of starch as a pharmaceutical excipient is based on its physicochemical properties. This study was aimed at evaluating the physicochemical properties of *Borassus aethiopum* starch (BAS). The starch was extracted by blending the peeled, boiled and cooled tubers of the plant. Distilled water was added and the starch recovered using a calico cloth. The physicochemical properties namely : organoleptic properties, hydration capacity, swelling capacity, moisture sorption capacity, % loss on drying, angle of repose, flow rate, bulk and tapped densities, Carr's index, Hausner's ratio and particle size analysis of the starch were studied and compared with those of maize starch B.P (MS). The BAS had higher hydration capacity, higher swelling capacity and better flow indices while the MS had lower moisture sorption capacity and lower % loss on drying. While the physicochemical properties of BAS are indicative of better flow and better disintegrant property, MS is likely to form a more stable tablet. The physicochemical properties of BAS are comparable with those of MS and the starch has the potential of being used as diluents, binder and disintegrant.

Keywords: *Borassus aethiopum*, physicochemical properties, starch.

INTRODUCTION

Pharmaceutical excipients are components of dosage forms that enable the formulations to acquire some characteristics which will establish the basic features of the formulated products. Starch is one of the most widely used excipients in the manufacture of tablets because of its physicochemical properties and relative inertness [1]. It is used as fillers, binders and disintegrants [2].

Maize, potato, rice, sorghum and cassava have been found to be common sources of starch and have been in common use for the last four decades [3]. They have been thoroughly investigated over this period. The tabletting properties of *Dioscorea dumetorum* was investigated and established by Adetunji *et al.* [3]. In recent times, wheat had been shown to be a good starch source for pharmaceutical use [4]. Also, the binding property of ginger starch had been evaluated by Ibezim *et al.* [5].

Borassus aethiopum (Family : *Palmea*) is a Tropical African plant that grows in various parts of the world including Nigeria; and it is propagated by seed. It is an unbranched palm growing up to 20 m tall characterized by a crown up to 8 m wide. The bark is pale green in older palms and is more or less smooth. The leaves are large, fan-shaped and bluish-green with petioles which are marked with black thorns. The fruit is an underground tuber about 15 cm in diameter, ovoid-shaped and orange to brown in colour when ripe. The tuber contains three woody kernels with hard albumen [6].

Since the suitability of starch as pharmaceutical excipient is based on its physicochemical properties [1], this study was aimed at evaluating the physicochemical properties of starch extracted from the tubers of *Borassus aethiopum.*

MATERIALS AND METHOD

Materials

Tubers of *Borassus aethiopum* (African fan palm) grown at Shika, Zaria town of Kaduna State, Nigeria were used as the starch source. Ethanol, maize starch B.P. and Iodine were used as obtained from BDH chemicals Ltd. Poole, England.

Collection and Identification of *Borassus aethiopum* Tubers

Borassus aethiopum tubers were obtained from African fan palm grown at Shika, Zaria town of Kaduna State, Nigeria. The plant material was identified, authenticated and assigned a voucher number 3081 by the Taxonomist in the herbarium section of the Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria.

Extraction of Starch

The bark of the tubers was peeled to remove the unwanted parts. The peeled tubers weighing 8 kg were boiled for 2 h, allowed to cool and the kernels were removed. Size reduction was carried out by milling using a blender (Mouline, type 242, France). A slurry of the starch was made by adding 16 L of distilled water and sieving was carried out using a calico cloth. The starch suspension was then allowed to settle for 24 h. The supernatant layer was decanted and the upper brown layer of the sediment was scrapped off leaving the lower off-white layer which was dried at 40 ^{0}C for 1 h in an oven (BS size 3, Philip Harris Ltd., England). The dried starch was pulverized using a blender (Mouline, type 242, France) and then stored in an airtight container.

Determination of Percentage Yield of *Borassus aethiopum* Starch

The percentage yield of the starch was calculated relative to the initial weight of the tubers.

Determination of Physicochemical Properties of the Starches

The following physicochemical tests were carried out on the two starches:

Organoleptic Properties

The taste, colour, odour and texture of BAS and MS were determined using the sense organs.

Iodine Test

A 50 ml volume of 2 % w/v starch suspension was produced. From this, 10 ml was taken, boiled and then cooled. Two drops of 0.1 N iodine solution were added and shaken. The resulting colour was examined and noted.

Hydration Capacity

The method of Sung and Stone was used [7]. A 10 ml volume of 10 % w/v starch suspension was produced, mixed on a vortex mixer for 2 min and then centrifuged for 5 min. The supernatant was decanted and the sediment weighed. The hydration capacity was calculated as ratio of W_2 to W_1 where W_1 = initial weight of starch used and W_2= weight of the sediment.

Swelling Capacity

The tapped volume occupied by 5 g starch was taken as V_1. This quantity of starch was dispersed in 100 ml distilled water and left over 24 h after which the volume of the swollen mass was noted as V_2. The swelling capacity was calculated as the ratio of V_2 to V_1 [8].

Moisture Sorption Capacity

Two gram starch sample was kept in a dessicator containing distilled water (R.H 100 %) for 5 days after which it was reweighed. The moisture sorption capacity was calculated as a ratio of change in weight to the initial weight expressed in percentage.

Loss on Drying

Five gram starch sample heated in an oven (BS size 3, Philip Harris Ltd., England) at 105 °C was examined every hour until a constant weight was obtained. The moisture loss was calculated as a percentage of the initial weight of starch.

Angle of Repose

A 20 g quantity of starch was poured inside a funnel of orifice diameter 0.8 cm clamped at the height of 10 cm. It was then allowed to flow freely. The height of the heap 'h' and the diameter 'D' were measured. The angle of repose, θ, was calculated using the equation :

$$\Theta = \tan^{-1}(2h/D) \quad ....1$$

Flow Rate

A 20 g quantity of starch was placed in a flow rate meter (Erweka Apparatebau, Germany). The time of flow was determined with the aid of a stop clock and the flow rate calculated as the ratio of weight of starch to the time of flow.

Bulk and Tapped Densities

A 10 g starch sample was placed in a dry 50 ml measuring cylinder and the bulk volume was noted. After 500 taps using a stampfvolumeter (model STAV 2003 JEF, Germany), the volume was retaken as tapped volume. The bulk and tapped densities (BD and TD) were then calculated as thus:

$$BD = \frac{weight}{bulk\ volume} \quad ....2$$

$$TD = \frac{weight}{tapped\ volume} \quad ....3$$

Carr's index (CI) and Hausner's ratio (HR)

The Carr's index and Hausner's ratio were respectively calculated using the formulae:-

$$CI = \frac{TD - BD}{TD} X\ 100\ \% \quad ....4$$

$$HR = \frac{TD}{BD} \quad ....5$$

Particle size analysis

Twenty grams of starch was placed on a nest of sieves (Endecotts Ltd., England) containing sieves arranged in descending order (500, 250, 150, 90 and 75 μm) and the shaker vibrated for 15 min. The weight of starch retained on each of the sieve was taken and % cumulative weight oversize was plotted against particle size.

Data Analysis

Data obtained from the physicochemical tests of the two starches were analyzed using Chi-squared test with P < 0.05 taken as level of significance.

RESULTS AND DISCUSSION

The *Borassus aethiopum* tubers gave a starch percentage yield of 6.25 % w/w. Some physicochemical properties of BAS and MS are shown in Table 1 while their flow properties are shown in Table 2.

The moderately coarse texture of *Borassus aethiopum* starch is an indication that it might possess a higher kinetic energy during mixing and hence, better flow compared to maize starch B.P [9]. The blue-black colouration of both materials on addition of iodine is an indication that they are both starches as specified by British Pharmacopoeia [10].

Table 1:Some Physicochemical Properties of the Two Starches

Property	*Borassus aethiopum* Starch	Maize Starch B.P
Taste	Bland	Bland
Colour	Brownish-white	White
Odour	Odourless	Odourless
Texture	Moderate-coarse	Fine
Iodine test	Blue-black	Blue-black
Hydration capacity	2.92	1.37
Swelling capacity	2.75	1.23
Moisture sorption capacity (% w/w)	24.50	20.00
Loss on drying (% w/w)	11.11	5.23

The most common features of all theories of disintegration is that water penetration must precede disintegration [8]. The ability of a material to take up water can be evaluated by determination of hydration capacity, swelling capacity and moisture sorption capacity [11]. BAS had higher hydration capacity, higher swelling capacity and higher moisture sorption capacity. Therefore, it might possess a higher disintegrant property which can be ascertained by comparing the disintegration time of tablets formed using the two starches as disintegrants.

Table 2:The Flow Properties of the Two Starches

Property	*Borassus aethiopum* Starch	Maize Starch B.P
Angle of repose (°)	28.15	40.66
Flow rate (g/sec)	1.88	1.31
Bulk density (g/cm³)	0.76	0.53
Tapped density (g/cm³)	0.87	0.65
Carr's index (%)	12.64	18.46
Hausner's ratio	1.14	1.23

The moisture sorption capacity is a measure of moisture sensitivity of a material and it reflects the relative physical stability of the tablet formulated with the material when stored under a humid condition [8]. Therefore, BAS with a higher moisture sorption capacity might form a less stable tablet. MS having a lower value of percentage loss on drying is a further indication that it might form a more stable tablet. A low value of moisture content is also indicative of suitability for formulation of hydrolyzable drugs such as aspirin [11]. For such drugs, MS will be a more suitable excipient.

The angle of repose of BAS (28.15) corresponds to a good flow while that of MS (40.66) corresponds to a very poor flow [12]. Also, the flow rate of BAS was higher than that of MS (Table 2). Therefore, BAS has a better flow.

The Carr's index and Hausner's ratio are reflective of the difference in the bulk and tapped densities. While the Carr's index shows the aptitude of a material to diminish in volume, the Hausner's ratio is indicative of inter-particulate friction [13]. As the values of these indices decrease, the flow of the powder increases. Generally, Hausner's ratio less than 1.25 corresponds to good flow, and Carr's (compressibility) index of 10 - 20 corresponds to good flow [12]. Based on these two indices, even though BAS had a better flow compared to MS, the difference is not significant.

There is a significant difference (P < 0.0001) in the particle sizes of BAS and MS (Figure 1). While 83.75 % of BAS had particle size above 250 μm, only 3.08 % of MS had particle size above this value. Also, while 0.25 % of BAS had particle size below 75 μm, 52.08 % of MS had particle size below this value. Therefore, BAS with significantly larger particle size will possess a higher kinetic energy during mixing and will exhibit a better flow [9].

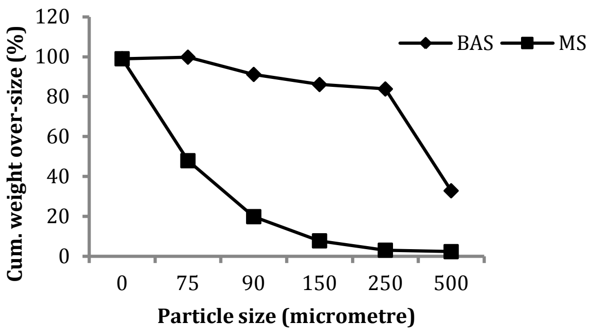

Figure 1:Graph of Cumulative Weight Over-size (%) Versus Particle Size (μm)

CONCLUSION

The physicochemical properties of BAS are comparable with those of MS and the starch might be suitable for use as a diluent, binder and disintegrant. While the physicochemical properties of BAS are indicative of better flow and better disintegrant property, MS is likely to form a more stable tablet and might be more suitable for formulation of hydrolyzable drugs.

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