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EFFICACY OF YAM AND SWEET POTATO STARCH POWDER AS A REPLACEMENT FOR SYNTHETIC TABLET BINDERS

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Abstract

This study investigates the efficacy of yam and sweet potato starches as alternative, natural binders in paracetamol tablet formulations, compared to synthetic binders. The granules and resulting tablets (Sample A: Yam, Sample B: Potato) were evaluated for key physicochemical properties using standard procedure. Analysis revealed that potato starch granules exhibited superior flow properties (Carr's Index: 11.31%, Hausner's Ratio: 1.06, Angle of Repose: 34.61°) compared to yam starch. Tablets formulated with potato starch (Sample B) demonstrated higher hardness (2.53 Kg/cm²) and lower friability (0.84%). While yam-based tablets disintegrated faster (14.41 min vs. 16.56 min), the potato starch-based tablets showed a significantly faster initial drug release, with 58.2% of the drug released within 5 minutes compared to 43.8% from the yam-based tablets. The results conclude that potato starch is a more effective excipient, producing tablets with excellent flow for manufacturing, good mechanical strength, and a superior dissolution profile that promises a faster onset of therapeutic action, making it a highly suitable natural alternative to synthetic binders for paracetamol tablets.

Keywords: Yam starch, Sweet potato starch, Natural binders, Paracetamol tablets, Flow properties, Drug release,

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Introduction

Starch is one of the most abundant biomolecules in nature. It is synthesized in the plastids of plant leaves and stored as an energy storage form in seeds, grains, roots, stems and tubers of most plants (Syuhada et al., 2018). Chemically, it is composed of two polymers: amylose and amylopectin. Apart from being a source of carbohydrates in the food, starch is most widely utilized in the pharmaceutical industry in the formulation of solid dosage forms where it serves as a binder and disintegrant (Samuel, 2023). Its usefulness here is due to its relative availability, abundance, pharmacological inertness, low cost, physicochemical properties as well as its renewability and environmental friendliness. Although corn starch is one of the most widely used carbohydrates in tablet formulations, pharmaceutical grade starch (PGS) has also been obtained from various botanical sources including maize, potato, cassava, rice, and yam (Nnaemeka et al., 2022, Marcel *et al.,* 2013). Starches from different plant sources show variations in the amylose-amylopectin ratio, granule structure, and granule size. Hence, differences in the functional attributes and physicochemical properties of starches depend to a large extent on the plant origin (Ogunwa *et al.,* 2016).

According to the Indian Pharmacopoeia Pharmaceutical tablets are solid, flat or biconvex dishes, unit dosage form, prepared by compressing a drugs or a mixture of drugs, with or without diluents. Tablet is defined as a compressed solid dosage form containing medicaments with or without excipients. They vary in shape and differ greatly in size and weight, depending on amount of medicinal substances and the intended mode of administration (Nandhini and Rajalakshm, 2018).

Starches from different plant sources show variations in the amylose-amylopectin ratio, granule structure, and granule size. Hence, differences in the functional attributes and physicochemical properties of starches depend to a large extent on the plant origin (Ogunwa *et al.,* 2016).

Pharmaceutical excipients refer to all materials other than the active drug essential to the manufacture and administration of the dosage form. Pharmaceutical diluents provide bulk and adjust weight of the dosage form; binders glue together powders of other excipients and the drug to form compacts. In view of the forgoing, this research assessed the comparative efficacy of potato and yam starch powder as a replacement for synthetic tablet binders.

Materials and Methods

Tubers of yam and sweet potato were obtained locally from Sabon-gari Market Kano, Kano State of Nigeria. Starch was extracted using a method reported previously, (Emmanuel *et al*., 2018). The tubers were washed free of soil and then peeled, peeled tubers were cut to small sizes and grated. The grated portion was soaked in water and sieved using a nylon sieve. This ensured the removal of unwanted debris. The starch slurry was collected in a large basin and allowed to settle for 10 hours. The supernatant was decanted. The resultant starch slurry was severally washed with distilled water while passing through a 100-mesh sieve. The final starch slurry was allowed to settle for 10 hours, decanted and dried to a constant weight in a hot air oven set at 60^0 C for 2 hours. The dried starch was pulverized, passed through a 200 – mesh sieve and stored in well closed container. Weighed quantity of the starch (100 g) was defatted with 85% aqueous methanol according to the method previously described by Emmanuel *et al*. (2018). The starch was subjected to some micromeritic (particle size and particle size distribution) evaluation using standard methods.

Preparation of granules

Granules of all sweet potato, potato, maize corn and starch available in the laboratory were prepared by wet granulation method. This process involves wet massing of powder blend with a granulating liquid, wet sizing and drying.

Determination of pH

The pH of the starches was determined potentiometrically with a pH meter (HI – 98108) according to the manufacture's instruction. PH meter whereby 5.0g of each of the starches (sweet potato starch or cow peas starch) was be added to 25ml of distilled water followed by shaking for 60 seconds. The solution was then allowed to settle for 15 minutes and the PH reading was taken from the digital PH meter.

Determination of bulk and tapped densities

Exactly 50 g of the starch was weighed on a chemical balance and transferred into a dry 100 ml measuring cylinder. The cylinder was dropped from a height of 2.5 cm three times at 2 s intervals. The volume occupied by the starch was recorded as the bulk volume. The cylinder was then tapped on the wooden platform until the volume occupied by the starch remained constant. This was repeated three times and average bulk volume and tapped volume recorded. The same procedure was repeated for the other starches and results obtained

Moisture content

The moisture content of the starches was determined using a hot air oven where 1g of starch powder was weighed and spread out on a pan. The sample was then dried at 130C for 90 minutes using a hot air oven. The difference in weight due to loss of moisture was calculated and expressed as the percentage moisture content using the formula below;

% Moisture content = Initial weight – weight after drying X 100 Initial weight

Hardness test

Hardness of tablet was determined by using a tablet hardness tester

Hardness test: The force required to break a tablet in a diametric compression was determined by using tablet hardness tester (Model No. LTHT A12).

Friability test

A friability test machine was used for the test. Twenty tablets were weighed and subjected to attrition at 25 rpm for 4 min and the tablets were reweighed. The percentage loss in weight equivalent to friability was calculated from the equation:

Friability (%) = (loss in weight/initial weight) x 100

Disintegration time

Disintegration time was measured by using the pharmacopoeia method (USP) by using a USP apparatus

Hausner's ratio

This was calculated as the ratio of tapped density to bulk density of the starches. Hausner's ratio = tapped density-Bulk density

Carr's compressibility index

Carr's index was then calculated from thebulk and tapped density data using therelation:

Carr's index ={Tapped density - Bulk density} ×100

Angle of repose

A funnel was clamped with its tip 2 cm above a 9 cmwide petri dish. The starch powders were allowed to flow throughthe funnel until the apex of the cone thus formed just touched thetip of the funnel. The mean diameter (D), of the base of thepowder cone was determined and the tangent of the angle ofrepose (θ), calculated using the relation:

$\tan\theta = 2h$

D (Where; h is the height of the heap of powder)

Statistical Analysis

For statistical analysis, Student's t-test was used to determine the significant association of dependent variables at 5% level of significance or using one-way analysis of variance (ANOVA) test and values of $p \leq 0.05$ will be considered significantly different.

Results and Discussion

As can be observed in Table 1, which revealed the evaluation test of granules. The table assesses the flow properties of the granules before compression, which is critical for ensuring a consistent and efficient tableting process. Bulk Density and Tapped Density: Potato starch granules have higher bulk (1.26 g/ml) and tapped densities (1.76 g/ml) compared to Yam (1.02 g/ml and 1.43 g/ml). This suggests that Potato granules are more closely packed. This is in-line with report of Immaculate, S. (2023). Carr's Index and Hausner's Ratio are key indicators of powder flowability. Yam starch samples had (Carr's Index: 9.43%, Hausner's Ratio: 1.25 indicates good flowability. Powders with a Carr's Index below 10% are considered to have very good flow. Potato (Carr's Index: 11.31%, Hausner's Ratio: 1.24): This indicates good flowability. However, a Hausner's ratio of 1.06 indicates cohesiveness with excellent flow. Similar observation was reported by Alebiowu, andItiola (2001). Lower angle of repose was recorded with 34.61° in potato indicating better flow when compared with yam 36.94 which falls within the "good" flow range. Potato starch granules demonstrate superior flow properties compared to Potato starch granules. This means that during industrial manufacturing, Potato starch would likely feed more evenly into the tablet press, resulting in more uniform tablet weight and content. This is in agreement with the work of Jemimah (2023) and Muhangi (2023),

Table 1: Physicochemical and powder properties evaluation of the sweet potato and Yam Starches

Properties	Yam	Potato
Bulk density	1.02	1.26
Tapped density	1.43	1.76
Carr's index	9.43	11.31
Hausner' ratio	1.24	1.06
Angle of repose	36.94	34.61
Mass (g)	25	25

As can be observed in Table 1, properties of paracetamol compare the critical physical attributes of the finished tablets. For hardness, sample B (2.53 Kg/cm²) is slightly harder than Sample A (2.39 Kg/cm²). Both values are typical for conventional tablets, but the higher hardness of Sample B suggests it may be more resistant to chipping and breaking during handling and packaging. Similar observation was reported by Alebiowu and Itiola (2001). For friability test measures the tablet's resistance to abrasion. The present study showed that sample B shows lower friability, which aligns with its higher hardness, indicating a more mechanically robust tablet with both samples recording a limit of 0.93% (sample A) and 0.84% (sample B) within the acceptable limit of less than 1.0%. This is in agreement with the work of Azizurrhman et al. (2011).

For disintegration time, which is crucial for a drug to be released and absorbed. Sample A disintegrates significantly faster at 14.41 min than Sample B with 16.56 min. From the present finding both tablets are within the approved timeframe for immediate-release tablets, although sample A has a clear advantage in terms of rapid breakdown. Similar observation was reported by of Immaculate (2023) who reported tablet thickness in paracetamol tablets formulated using sweet potato starch as a disintegrant. He reported that tablet hardness formulated using sweet potato starch as a disintegrant were generally harder than those formulated using peas starch as a disintegrant. With respect to thickness, there was in-significant difference between the two with sample having 3.34mm and B, 3.61mm respectively. The insignificant variation is attributed to the variations in granule density and compression force. This is in agreement with the work of Muhangi (2023).

Table 2: Comparison of Properties of Paracetamol Tablets Formulated Using Sweet Potato and Yam Starch Powders

Sample	Hardness test Kg/ cm^2	Friability	Disintegration time(minutes)	colour	Thickness (mm)
A	2.39± 0.01	0.93± 0.00	14.41± 0.01	White	3.34
B	2.53± 0.00	0.84± 0.01	16.56± 0.01	white	3.61

As can be observed in Table 2, comparative dissolution test which has direct impacts on the therapeutic efficacy is evaluated. It is the most critical test, as it measures the rate and extent of drug release. Early time points of 5-10 minutes, revealed that sample B had a significantly faster drug release initially. At 5 minutes, 58.2% of the drug is released from Sample B compared to only 43.8% from Sample A. This is a substantial difference, suggesting that Sample B facilitates a more rapid onset of drug action. This is in agreement with the work of Nakazibwe (2023). Mid time points of 15-20 minutes, sample A catches up by 15 minutes, with both formulations releasing over 78% of the drug. At 25 minutes, both formulations achieve nearly complete drug release (A: 96.6%, B: 98.7%), which is a requirement for effective tablets, characterized by a much faster initial drug release. This rapid onset is a highly desirable property for pain relievers like paracetamol. Similar observation was reported by Immaculate (2023). Granule properties indicates that Potato starch (Sample B) produces granules with superior flow properties, which is advantageous for manufacturing compared yam starch (Sample B) which produces mechanically stronger tablets (higher hardness, lower friability), but they disintegrate more slowly than those made with potato. This is in-line with the work of Esezobo andAmbujam (1982). Potato starch is the more effective excipient in this formulation for paracetamol tablets. While Yam starch offers better processing characteristics, the primary goal of a tablet is to deliver the drug effectively. The superior initial dissolution rate of the Potato starch-based tablets (Sample B) suggests it would provide a faster onset of therapeutic action, which is a key performance indicator for

analgesics like paracetamol. The slightly slower disintegration time of Sample B is not a hindrance because its dissolution rate is faster, indicating that the drug is being released from the tablet matrix more efficiently once disintegration begins.

Table 3: Comparative Dissolution Test of Prepared Tables

Time (min)	Absorbance		% Drug release	
	A	B	A	B
5	0.328 ± 0.02	0.352± 0.01	43.8	58.2
10	0.571± 0.01	0.584± 0.02	58.4	58.9
15	0.786± 0.10	0.726± 0.04	78.0	78.3
20	0.805± 0.05	0.783± 0.00	80.5	88.3
25	0.960± 0.04	0.957± 0.00	96.6	98.7

A= Yam, B= Potato

Conclusion

The results compares the performance of two tablet formulations (Sample A and Sample B) using Yam and Potato starches as excipients. The analysis covers the properties of the granules, the physical attributes of the final tablets, and their drug release profiles. The results indicate that while both starches produce tablets that meet many standard requirements, one formulation demonstrates superior performance in key areas, particularly in drug release efficiency.The percentage of drug release shows that the potato starch had a great influence on binding strength of the tablet than yam starch powders.

Recommendations

It is recommended that more research should be carried out by local Pharmaceutical industries to evaluate all the properties of potato and yam starch powders relating to their compatibility with other commonly used ingredients.

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