INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Research Paper

The Potential for Using Ginger Root (Zingiber Officinale) And Tiger Nut (Cyperus Esculentus) Starches for Pharmaceutical Formulations

Helegah Foster[1]*, David Kofi Essumang[2], Donkor Darious[1]

[1]*Industrial Chemistry Unit, Department Of Chemistry, School Of Physical Sciences, College Of Agriculture And Natural Sciences, University Of Cape Coast, Cape Coast, Ghana.*
[2]*Department Of Chemistry, School Of Physical Sciences, College Of Agriculture And Natural Sciences, University Of Cape Coast, Cape Coast, Ghana*

ARTICLE INFO
Published: 20 May 2025
Keywords:
Ginger starch; Tiger nut starch; Potato starch; Pharmaceutical excipients; binder, disintegrant.
DOI:
10.5281/zenodo.15474854

ABSTRACT

Conventional starches from potato and maize are widely used in pharmaceuticals for their favorable physicochemical properties and accessibility. However, increasing demand for these starches in the food and biofuel industries has necessitated the exploration of alternative starch sources with comparable or superior excipient properties. This study looked at the potential for the use of Ginger and Tiger Nut Starches for Pharmaceutical formulations. Starch was extracted from fresh ginger root and tiger nut using the wet milling and sedimentation method, followed by drying and pulverization. The extracted starches were analyzed and compared to potato starch as a reference standard. Ginger starch had a 4.6% yield, while tiger nut starch yielded 10.8%, with both meeting British Pharmacopoeia (BP) standards. Ginger starch exhibited higher bulk density, hydration capacity, swelling index, and moisture sorption, making it a strong candidate for binding and disintegration. In contrast, tiger nut starch demonstrated greater particle density and porosity, indicating better stability. FTIR analysis confirmed no significant interaction with paracetamol powder, supporting its suitability as a pharmaceutical excipient. While potato starch remains the preferred option overall, ginger starch offers superior binding and disintegration compared to tiger nut starch. In contrast, tiger nut starch provides more stable moisture content, indicating its suitability for formulations requiring extended shelf life and stability.

INTRODUCTION

Pharmaceutical excipients are non-active substances that are combined with active

---

***Corresponding Author:** Helegah Foster
Address: *Industrial Chemistry Unit, Department Of Chemistry, School Of Physical Sciences, College Of Agriculture And Natural Sciences, University Of Cape Coast, Cape Coast, Ghana.*
Email ✉: foster.helegah@stu.ucc.edu.gh

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

pharmaceutical ingredients to enhance their formulation, stability, and bioavailability of the resulting dosage form, ensuring effective delivery to its site of action (1). Natural polymers have been used in different pharmaceutical formulations as they are easily available, non-toxic, biodegradable, and cost-effective as pharmaceutical excipients (2). Some natural polymers used in pharmaceutical formulations include xanthan gum, alginate, starch, chitosan, gelatin, pectin, dextran, and guar gum. Starch is one of the most widely used natural polymers for pharmaceutical formulations. The two naturally occurring high molecular weight polymers that makeup starch are branched soluble amylopectin and largely linear insoluble amylose, and both are made up of repeated D-glucose units connected by glycosidic linkages comprising 75–80% amylopectin and 20–25% amylose, depending on the botanical source(3). In pharmaceutical formulations, starch is often employed as a binder, diluent, and disintegrant. The main reasons for their functional flexibility are their varied inherent physicochemical features, biocompatibility, biodegradability, and relative simplicity of modification (4). The attraction to using starch as a pharmaceutical excipient in various drug delivery technologies and formulations arises primarily due to its physicochemical and functional properties (5). Conventional starch sources, such as potato, maize, and cassava, have been extensively utilized in the pharmaceutical industry due to their excellent physicochemical properties and widespread availability. However, the increasing global demand for these starches in the food and biofuel industries has necessitated the exploration of alternative starch sources with comparable or superior excipient properties(6,7). Among these alternatives, non-conventional starches such as ginger root (Zingiber officinale) and tiger nut (Cyperus esculentus) starch have gained attention for their potential pharmaceutical applications due to their biochemical profiles(8). Some of the required properties that make native starch valuable as a pharmaceutical excipient include: their white, soft, smooth dryness as well as gelling, and viscosity imparting properties, Additionally, when modified, new properties are impacted which expands their functions and uses, making them more efficient in both conventional and novel drug delivery systems (9).

Ginger (Zingiber officinale) is an herbaceous perennial plant belonging to the order Scitamineae and the family Zingiberaceae. It is a perennial reed-like plant with annual leafy stems about a meter (3 – 4 feet) tall(8) Ginger thrives in tropical and subtropical regions, requiring well-drained, fertile soil and a warm, humid climate for optimal growth(10). Natural ginger is harvested based on the size of the bulb and the age of the leaves. It contains substances including fat, starch, volatile oil, and gingerol(11). The constituent substances are well-known for their antibacterial, antioxidant, and anti-inflammatory properties (12). Ginger is a good source of starch, comprising approximately 56.0% starch, and its dry powder form has a carbohydrate content ranging from 61.93% to 67.21% (13).

Cyperus esculentus is an edible grass plant that produces nut-like tubers known as tiger nut. The nuts, which are about 30 mm long, are characterized by a sweet and somewhat milky taste (14). It is cultivated and consumed in many tropical and subtropical countries. According to earlier isolation and characterization, tiger nut starch satisfies US Pharmacopeia requirements for commonly used starches, including potato and maize (15). Extraction methods of starch include wet milling, dry milling, mechanical pressing, enzymatic hydrolysis, solvent extraction, ultrasound-assisted extraction, and pulsed electric field (PEF) technology (16). However, a wet extraction method was chosen for this study because of its affordability, ease of use, environmental friendliness, and high-purity starch yield.

Recent studies have explored the potential usage of non-conventional starches as pharmaceutical excipients. For instance, ginger starch has been investigated for its binding and disintegrant properties, demonstrating superior performance to cassava starch in ibuprofen tablet formulations (11). Also, Ibezim et al. (13) demonstrated that ginger starch could function as a binder in acetaminophen tablets, showing comparable performance to maize starch. Similarly, the starch of tiger nut has been reported to exhibit potential as a disintegrant and binder, pointing to significantly high levels of amylose and remarkable gel-forming ability(17).

Comparative studies with other more conventional sources indicate that tiger nut starch offers better flow properties and stability, whereas ginger starch has greater hydration capacity and swelling power, which can be utilized for fast release of drugs(18,19). Ginger and tiger nut starch are two of the most commonly researched non-conventional starch sources for pharmaceutical formulations. However, despite the growing interest in unconventional starches like tiger nut (Cyperus esculentus) and ginger root (Zingiber officinale) as pharmaceutical excipients, there is a critical knowledge gap concerning comparative studies that determine their functional properties based on established standards like potato starch. While previous studies have compared unconventional starches, like ginger or tiger nut starch, to traditional starches, such as cassava starch, highlighting potential alternatives(20,21), a systematic comparison of ginger and tiger nut starches with each other and with pharmaceutical-grade starches, such as potato starch, has not been conducted, while assessing both drug compatibility and physicochemical functionality (binding, disintegration, flow) within the same experimental framework.

To address this gap, this study extracted and characterized starches from ginger root and tiger nut using a standardized wet milling method and assessed their physicochemical properties, including hydration capacity, swelling index, flowability, moisture sorption, and API compatibility. The extracted starches were systematically compared against pharmaceutical-grade potato starch as a reference standard, with particular emphasis on binding and disintegration potential quantified through bulk density, tapped density, and swelling capacity measurements. Flow and stability characteristics were evaluated using the angle of repose, Carr's index, Hausner ratio, and porosity analysis. Finally, through FTIR spectroscopic analysis, excipient-API compatibility was assessed using paracetamol as a model drug to determine their potential as pharmaceutical excipient options.

MATERIALS AND METHODS

2.1. Materials and Equipment

The materials used for the experiment included tiger nut, ginger root, and distilled water. Equipment such as a 25 ml pycnometer bottle, centrifuge (model TG16-WS), thermometer, pH meter, Analytical balance (model Sartorius CP3202P), and blender were the types of equipment employed in this study. All other reagents used for the physicochemical analysis were of analytical grade.

2.2. Sample collection, Pretreatment, and starch Extraction

The Tiger nuts and ginger root were collected from Abura market, Cape Coast, Ghana. The fresh tiger nut and ginger root were washed, and the ginger root was chopped into small pieces. The ginger roots (400 g) and tiger nut tuber (400 g) were soaked in water for 2 days at room temperature. Thereafter, the chopped pieces of ginger root and tiger nut tuber were wet-milled into a slurry separately using a blender and water. They are filtered through a white muslin cloth. The filtrates were allowed to stand for 5 hours, and the supernatant was carefully decanted. The resulting starch was dried in the sun for a day and dried at 60°C in an oven for 24 hours, pulverized, weighed, and sealed air-tight in a plastic container for analysis.

2.3. Identification test for tiger nut and ginger root starch.

2.3.1. Iodine test.

0.5g of ginger root and tiger nut starch were separately placed in a clean test tube to which 1 ml of 0.2N of freshly prepared iodine was added, shaken, and observed for the presence or absence of starch (11).

2.3.2. Solubility test.

0.5g of the ginger root and tiger nut starch were separately weighed and poured into a beaker containing 1 ml, 2 ml, 10 ml, 1.0 L, and 10.0 L of distilled water at 25°C and stirred, and the solubility was observed. The same procedure was repeated using 95% alcohol as a solvent (24)

2.3.3. pH determination.

Approximately 0.5 g of the ginger root and tiger nut starch were separately weighed into 40ml distilled water and the mixture was thoroughly mixed for 5 minutes, and the pH was determined using a pH meter. The determination was done in triplicate and the mean value was considered as the pH of starch.

2.4. Determination of physicochemical properties of the starches.

2.4.1. Angle of repose-

The starch powder was sieved to obtain the correct and somehow uniform particle size. A glass funnel was clamped on a retort stand at a 25 cm distance from the flat surface covered with paper. 15 g of the sieved ginger and tiger nut starch powders were weighed and separately placed in the glass funnel and were then allowed to flow through the funnel to form a heap. The height (h) of the heap formed was noted. A circle was drawn around the heap. The radius from the different parts of the circle was measured as r1, r2, and r3. The mean radius was calculated as (r). The determination was done in triplicate and the mean value was considered as the angle of repose of the starches. The angle of repose was calculated using the relation

$$\theta = \tan^{-1}\left(\frac{h}{r}\right) \quad (1)$$

2.4.2. Hydration capacity

Following the protocol used by Hasan et al.(18), 0.5 g sample of each powder (ginger and tiger nut starch) was placed in a centrifuge tube and 6 ml of distilled water was added. The tubes were shaken for about 2 minutes and left to stand for 20 minutes before centrifuging at 3000 rpm for 15 minutes. The supernatant was decanted and the weight of the powder after centrifugation was recorded. Hydration capacity (H) was determined using the equation below

$$\text{Hydration capacity} = \text{Ws}/\text{Wd} \quad (2)$$

where Ws = weight of sediment formed and Wd=weight of the dried starch powder.

2.4.3. Moisture sorption capacity

Approximately 0.5 g of the individual starch powders (W) were weighed and put into a tarred petri dish. The samples were then placed in a desiccator containing distilled water at room temperature and the weight gained by the exposed samples at the end of four days (Wg) was recorded and the amount of water absorbed (Wa) was calculated from the weight difference as

$$Wa = Wg - W \quad (3)$$

2.4.4. Determination of swelling capacity

Following the protocol used by(24), the tapped volumes occupied by 5 g (Vp) of the starches each were noted. The starches were then dispersed in 85 ml of distilled water, and the volume was made up to 100 ml with more distilled water. It was allowed to stand for 24 hours. The volume of the sediment was then recorded (Vs), and the swelling capacity(S) was calculated as

$$S = [(Vs - Vp)/Vp] \times 100 \quad (4)$$

2.5. Determination of Starch Density.

2.5.1. Bulk density (Bd) and Tapped density (Td)

Approximately 15 g each of the ginger and tiger nut starch powder was separately introduced into a clean, dry 100 ml measuring cylinder through a short-stemmed glass funnel, and the volume occupied by each was recorded as (VB). The measuring cylinder was then tapped on a wooden table at a fixed height until no further change in volume was observed. The new volume occupied by the starch powder is recorded as the tapped volume (VT). The determination was done in triplicate and the mean value was considered as the bulk density and tapped density of the starch. The bulk density and tapped density of the individual starches were obtained by using the relations respectively.

$$Bd = \frac{Mp}{Vb} \quad (5)$$

$$Td = Mp/Vt \quad (6)$$

Where, Mp = Mass of the powder, Vb = Bulk volume of the powder, Vt = tapped volume of the starch powder.

2.5.2. Carr’s index

The difference between the tapped and bulk density divided by the tapped density was calculated, and the ratio was expressed as a percentage.

$$Carr's\ Index = \frac{Bd - Td}{Td} \times 100 \quad (7)$$

2.5.3. Hausner ratio

This is the ratio of tapped density to bulk density and was calculated for all the starches. That is,

$$Hausner\ Ratio = Td/Bd \quad (8)$$

2.5.3. Determination of Starch particle density

An empty pycnometer bottle with the stopper was weighed as W_1. The bottle was filled with water (water was used as the displacement liquid) to the brim, and all spilled-over liquid(water) was wiped off with an absorbent cloth and the bottle and water were weighed as W_2 with the stopper on. The water was carefully removed from the bottle and approximately 0.5 g of the starch was transferred into the bottle, and the bottle was closed with the stopper. The bottle, together with the starch, was weighed as W_3. Water was added to the starch in the bottle to fill the bottle to the brim, and the bottle was closed with the stopper. The weight of the bottle together with the starch and water was weighed as W_4.

$$Weight\ of\ Starch(X) = W_3 - W_1 \quad (9)$$

$$\text{Weight of pycnometer bottle + water present with starch}(W_5) = W_4\text{-X} \quad (10)$$

Weight of water displaced by starch (Y) = $W_2 - W_5$ (11)

$$True\ Density = X/Y \qquad (12)$$

2.5.4. Porosity

The powder porosity (E) was calculated by the equation

$$E = [1 - (Bd / Pd)] \times 100 \qquad (13)$$

Where Bd=bulk density, Pd=particle density of starch (Hasan et al., 2014)

2.5.5. Packing fraction

The packing fraction (P_f) was expressed as the ratio between the bulk density (Bd) and the particle density (Pt) as

$$P_f = (Bd / Pt). \qquad (14)$$

2.6. FT-IR compatibility test:

The interactions between paracetamol powder, an active pharmaceutical ingredient (API), and the two starches were investigated by FTIR studies. The compatibility of a mixture of paracetamol and both ginger root and tiger nut starches was studied by IR spectra (C:\OPUS_7.2.139.1294\MEAS\.8828)

RESULTS AND DISCUSSION

The percentage yield of ginger root starch was 4.6 %wt / wt, while that of tiger nut starch was 10.8% wt / wt. The results indicate that the percentage yield of extracted starch from tiger nuts is significantly higher than that of ginger root starch. This suggests that tiger nut may be a potentially more cost-effective source of starch over ginger root starch as a pharmaceutical excipient.

3.1 Identification Test

The identification test shows that both the ginger root and tiger nut starches are insoluble in water and 95% alcohol at room temperature, the same as potato starch. All three starches tested positive for the iodine test, confirming the presence of starch. It shows that both the ginger root and tiger nut starches compared well with the standard potato starch. The pH of the three starches was up to the standard limit of 4.5-8 (25). The closeness of the pH of the three starches to 7.0 could be an advantage because a neutral pH might decrease the tendency of the interaction of excipient with an active pharmaceutical ingredient (API). The neutral pH helps maintain the compatibility of the excipients with other components of the drug formulation, avoiding potential adverse reactions. The odor and solubility test for these starches were within the official recommendation (BP, 2010). The results of the identification tests are shown below in Table 1.

Table 1. Results of the identification tests for ginger root, tiger nut starches, and Potato Starch

Properties	Ginger root starch	Tiger nut starch	Potato starch
Solubility test	Insoluble	Insoluble	Insoluble
pH	6.67	6.77	6.52
Iodine test	Positive	Positive	Positive
Odor	Odorless	Odorless	Odorless

Source: The results of the potato starch were obtained from (18)

3.2 Physicochemical Parameters of Starch

The physicochemical parameters of the various starches are presented in Table 2 and Figure 1. Ginger starch possessed higher hydration capacity (2.11) and swelling index (56.1%) compared to tiger nut starch (1.30 and 44.4%, respectively). These parameters suggest improved disintegrant performance for ginger starch because hydration and swelling are crucial for tablet disintegration by capillary action and polymer relaxation (26). The hydration of starch represents the amount of water absorbed by the particle of the starch or the particle surface (27). This result implies that all three starches could have valuable disintegrant properties and could adopt the disintegration mechanism of wicking and swelling (26). The result and values obtained, ginger starch can be a better disintegrant than tiger nut starch, with potato starch showing the highest disintegrant ability. The higher swelling of ginger starch follows studies on other tuber starches, where amylose content (approximately 20–25%) is responsible for higher water absorption (28). Potato starch, with the highest hydration (2.33) and swelling (69.5%), remains the standard due to its high amylopectin content, which results in rapid water absorption(29).

The Compressibility index, angle of repose, and Hausner ratio predict the flow and compressibility of powders. Hausner ratio above 1.2 and Carr's index above 23% do not indicate good flow or good compressibility. Ginger starch has a compressibility index of 30.16%, indicating a very poor flow property, while tiger nut starch has a Carr's index of 40.5%, indicating an awful flow property. Potato starch has a Carr's index of 22.4%, indicating a passable flow. Ginger starch has a Hausner ratio of 1.44, implying a poor flow, while tiger nut starch has a Hausner ratio of 1.68, indicating a very poor flow. Potato starch has a Hausner ratio of 1.2, which indicates a fair flow. From the result obtained, it means that granulation and/or addition of glidants might be necessary before formulation. The poor flowability of tiger nut starch was likely due to its irregular particle shape and high porosity (75.92%), which increases interparticle friction (30). Ginger starch showed relatively better flow but was still worse than potato starch. This is consistent with observations by (Builders et al., 2013), who observed that indigenous tuber starches tend to need glidants (e.g., silica) for direct compression. The angle of repose was also used to determine the flow properties of the starches. The angle of Repose of tiger nut starch is greater than that of potato starch, and that of potato starch is also greater than ginger starch. An angle of repose above 50° indicates poor powder flow characteristics (24). All three starches fall within the limit. Ginger starch flows better than both tiger nut and potato starch, with tiger nut starch having the least flow according to the angle of repose. The low packing fraction of tiger nut starch (0.24) supports its loose, cohesive nature (18). From the results of porosity and packing fraction, tiger nut starch has the highest porosity, followed by ginger starch and potato starch. Higher porosity indicates a more porous and permeable starch, which can be beneficial for drug release and absorption. A lower packing fraction indicates a more loosely packed starch powder, which can improve flow properties and compressibility. Tiger nut starch has the lowest packing fraction, followed by ginger starch and potato.

The moisture sorption capacity of the starch refers to the ability of the starch to absorb and retain moisture from its surrounding environment, that is, the moisture sensitivity of the starch. It often reflects the relative physical stability of the tablets formulated with the starch when stored under humid conditions. (31). Tiger nut starch absorbed less moisture compared to ginger and potato starches and showed better stability in conditions of moisture. The property is important for tropical climates, where low-hygroscopic excipients minimize tablet degradation(31). This shows that tiger nut starch, when used in tablet formulation, may absorb less moisture, resulting in tablets with better physical stability than both ginger and potato starches. As for all theories of disintegration, the penetration of water (or another liquid media) before disintegration is necessary, and their degree can be assessed by the determination of hydration capacity, porosity, and swelling capacity (32). The porosity of tiger nut starch is high (75.92%) and may inhibit water entry, as reported with phosphorylated starches by (19).

Tiger nut starch had the highest particle density (1.60 g/ml) and porosity (75.92%), which may enhance drug release due to greater pore connectivity (33). Ginger starch's intermediate porosity (61.31%) indicates balanced binding-disintegration properties, similar to phosphorylated plantain starches, which have enhanced disintegrant efficiency owing to their porous nature (34). Also, the tapped density of the starch powder refers to the density of the starch and its ability to compact to form a tablet(11) . Tiger nut starch has a tapped density of 0.65 g/ml, as compared to ginger starch with a value of 0.76 g/ml, and potato starch has the highest tapped density value. The bulk density of tiger nut starch is 0.39 g/ml, and that of ginger starch is 0.52 g/ml. Potato starch has the highest bulk density value. Hence, tiger nut starch could be more compact and less fluffy than ginger starch, and ginger starch could also be more compact than potato starch. Therefore, they could retain moisture, and this could aid in improving binding properties in both tiger nut and ginger starch than the potato starch. Potato starch has the highest swelling capacity value, followed by ginger starch and tiger nut starch. Swelling capacity is an indicator of the disintegrating property of starch(35). This property is important for formulations that require good disintegration and dissolution of the drug.

These physicochemical properties directly influence or impact the functional performance of the starches in pharmaceutical applications, particularly in terms of disintegration and stability. Tiger nut starch is more structurally stable with its higher density and lower moisture sorption and, therefore, can be best utilized as a filler or binder in solid dosage forms. Ginger starch, with its higher hydration and swelling properties, is better suited as a disintegrant, which may be useful in rapid drug release but may be less stable in moisture-sensitive formulations. Potato starch possesses a balanced structural behavior and is a reliable standard excipient that can be utilized for diverse pharmaceutical applications. Thus, the choice between ginger and tiger nut starch should be based on the specific formulation requirements.

Table 2. Results on the physicochemical properties of tiger nut and ginger root starch compared with Potato Starch

Physicochemical properties	Ginger Root starch	Tiger Nut starch	Potato starch
Bulk density (g/ml)	0.52	0.39	0.69
Angle of repose (°)	33	40	34
Hydration Capacity	2.11	1.30	2.33
Tapped density(g/ml)	0.76	0.65	0.89
Carr’s index (%)	30.16	40.5	22.4
Hausner ratio	1.44	1.68	1.2
Swelling capacity (%)	56.1	44.4	69.5
Particle density(g/ml)	1.37	1.60	1.42
Porosity (%)	61.31	75.92	52
Packing fractio	0.39	0.24	0.48
Moisture Sorption Capacity	0.05	0.04	0.081

Source: The results of the potato starch were obtained from (18)

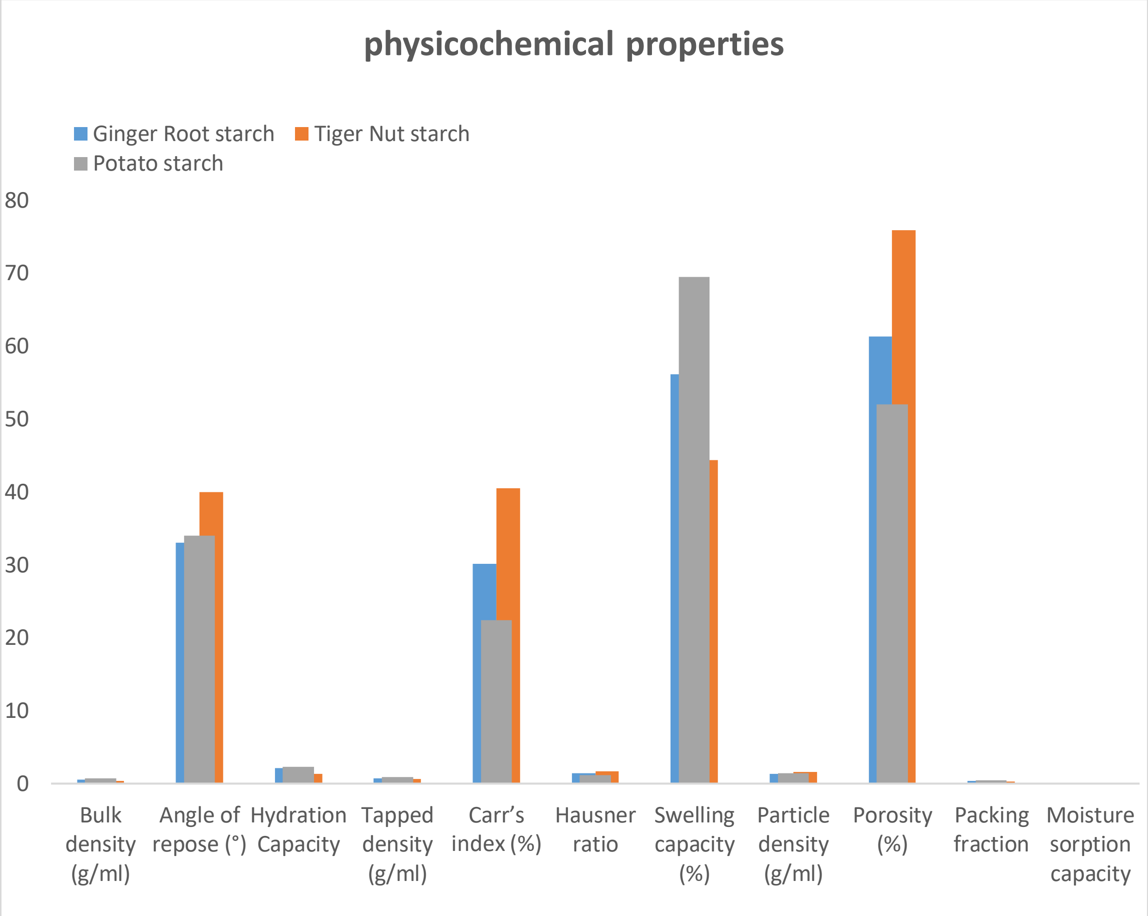

Figure 1. Comparison of the physicochemical properties of the extracted starches

3.3 Fourier-Transform Infrared Spectroscopy (FT-IR) Compatibility Test

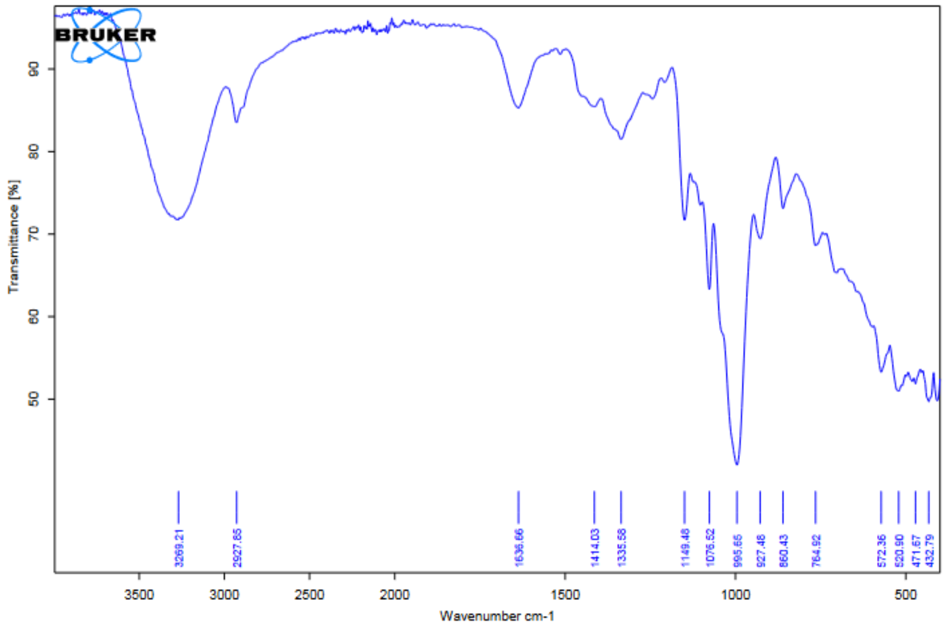

Figure 2. FT-IR Spectra of Ginger Starch

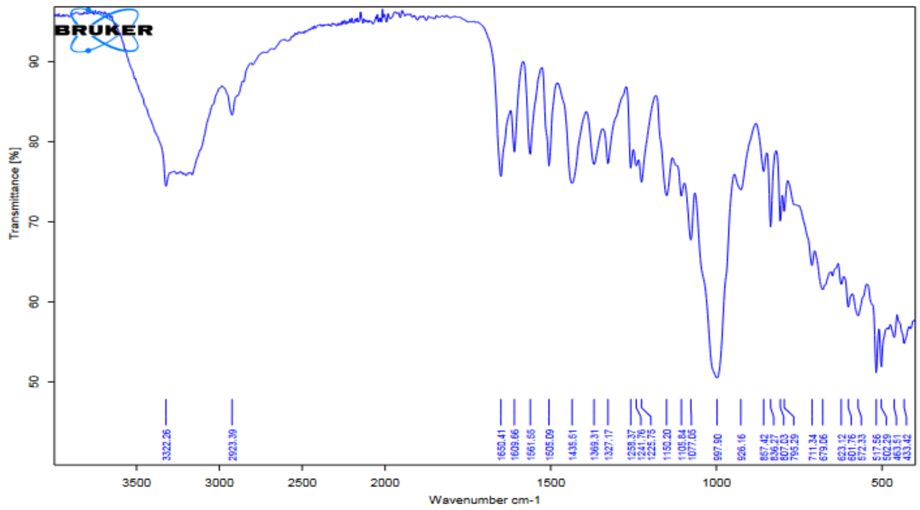

Figure 3. FT-IR Spectra of a mixture of Ginger Starch and paracetamol

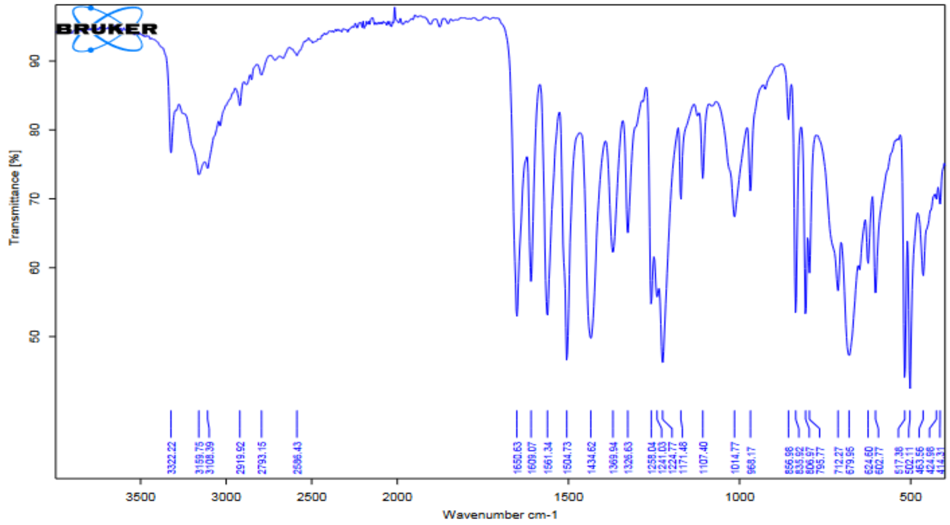

Figure 4. FT-IR Spectra of paracetamol powder

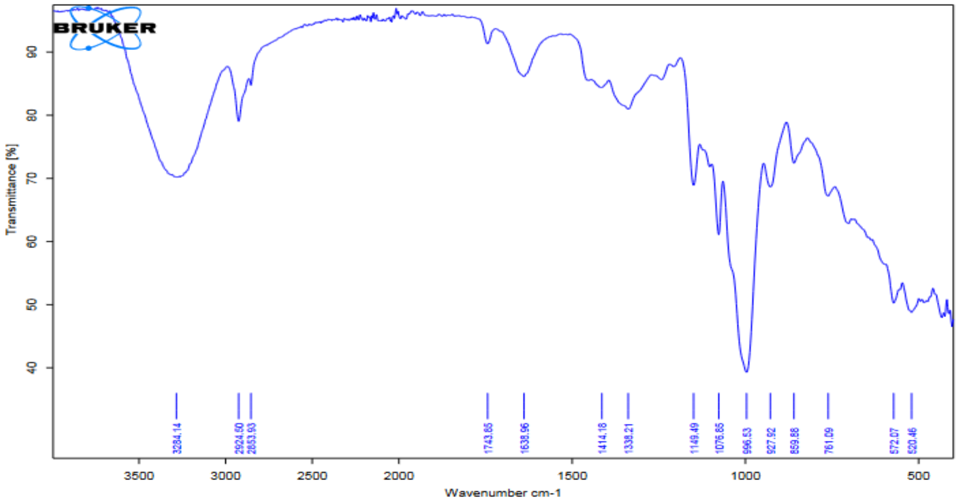

Figure 5. FT-IR Spectra of Tiger Nut Starch.

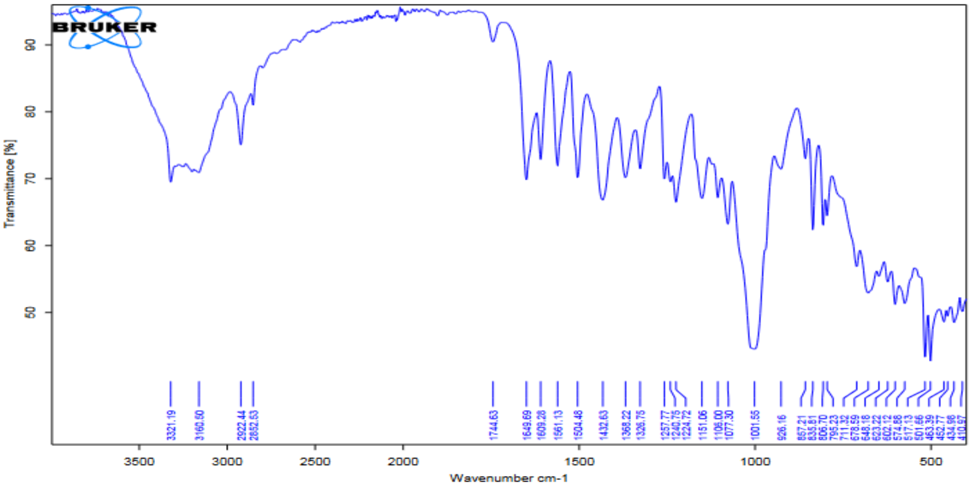

Figure 6. FT-IR Spectra of a mixture of Tiger Nut Starch and paracetamol powder.

From Figure 2, there exists a broad peak around 3269 cm^{-1} which is indicative of O-H stretching vibrations commonly associated with hydroxyl groups in polysaccharides like starch. The peak around 2927 cm^{-1} is $-CH_2$ stretching vibrations associated with methylene groups in starch molecules. Also, the peaks 1414 cm^{-1} and 1336 cm^{-1} are related to C-H bending vibrations, which further confirm the presence of aliphatic chains in the ginger starch structure. From Figure 4, there exists a peak around 3300 cm^{-1}- 3400 cm^{-1} which indicates the presence of amine (N-H) stretching groups in paracetamol. Peaks around 1650 cm^{-1} represent the carbonyl (C=O) groups in paracetamol. From Figure 5, there exists a broad peak around 3200 cm^{-1}- 3600 $cm^{-1,}$ which indicates the presence of O-H functional stretching vibrations associated with the presence of hydroxyl functional group in the tiger nut starch. Also, peaks around 1150 cm^{-1}- 900 cm^{-1} are associated with C-O stretching vibrations which is a characteristic of glycosidic linkages in starch. From Figure 6, the spectrum indicates that the characteristic peaks of tiger nut starch and paracetamol are retained. This suggests that there was no significant interaction between the tiger starch and the paracetamol. Also, from Figure 3, there were no significant shifts in the peaks of ginger root starch and paracetamol powder, indicating no significant interaction between the ginger starch and the paracetamol mixture. This suggests the two starches are compatible with the drug and can be used in pharmaceutical formulations.

CONCLUSION

The characterization of these non-conventional starches compared well with standard potato starch in physicochemical properties, despite potato starch showing the best excipient properties among them. Although ginger root starch has a lower yield as compared to the yield of tiger nut starch, it produces a good quality starch that has excellent binding and disintegrant properties when used in pharmaceutical solid dosage formulations such as tablet formulations as compared to tiger nut starch. The IR spectrum of ginger root and tiger nut starches shows no significant interaction between the Paracetamol and starches, which confirms their potential use as pharmaceutical excipient options. This study demonstrates that ginger and tiger nut starches are promising alternatives to conventional starch excipients with each having distinct advantages. Ginger starch is preferable for applications requiring rapid drug release, while tiger nut starch is better suited for stable, long-lasting formulations. In high-speed tableting, ginger starch provides a balance between these two non-conventional starches. Based on the outcome of this study, large-scale cultivation of ginger crops should be encouraged, especially in regions with favorable climatic and soil conditions, to avoid the overdependence on conventional starch sources, which are the major component in many food products. To enhance flow, future research should investigate excipient blending or particle size modification.

Acknowledgement

The authors gratefully acknowledge the Department of Chemistry at the University of Cape Coast for granting laboratory access and supplying certain chemicals essential for the experiments.

Declaration of Competing Interest

The authors declare that they have no known competing financial
interests or personal relationships that could have appeared to influence
the work reported in this paper.

Data availability

The data supporting this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Obidiro OP, Eraga SO, Iwuagwu MA MA. Investigation of the Tableting Properties of Modified Dioscorea dumetorum Starch in Direct Compressed Diclofenac Tablet Formulations. J Basic Soc Pharm Res. 2022;2(3):36–47.
2. Prajapati VD, Jani GK, Moradiya NG, Randeria NP. Pharmaceutical applications of various natural gums, mucilages and their modified forms. Carbohydr Polym. 2013 Feb 15;92(2):1685–99.
3. Azubuike CP, Fabiyi RO, Oseni BA, Igwilo CI. Evaluation of disintegrant potential of carboxymethyl starch derived from Cyperus esculentus (Cyperaceae) tubers. Trop J Nat Prod Res [Internet]. 2019 [cited 2025 Mar 23];3(7):246–51. Available from: https://ir.unilag.edu.ng/handle/123456789/6970
4. Builders PF, Anwunobi PA, Mbah CC, Adikwu MU. New direct compression excipient from tigernut starch: Physicochemical and functional properties. AAPS PharmSciTech. 2013;14(2):818–27.
5. Singh J, Kaur L, McCarthy OJ. Factors influencing the physico-chemical, morphological, thermal and rheological properties of some chemically modified starches for food applications-A review. Food Hydrocoll. 2007;21(1):1–22.
6. Garba Mohammed K. Modified Starch and its Potentials as Excipient in Pharmaceutical Formulations. Nov Approaches Drug Des Dev. 2017;1(1):1–4.
7. Tester RF, Karkalas J, Qi X. Starch - Composition, fine structure and architecture. J Cereal Sci. 2004;39(2):151–65.
8. Michael A, Patrick I, Olutayo O, Adedayo A, Olakunle F, Ademola A, et al. Isolation and Characterization Studies of Ginger (Zingiber officinale) Root Starch as a Potential Industrial Biomaterial. Int J Chem Appl [Internet]. 2013;5(2):117–26. Available from: http://www.irphouse.com
9. Builders PF, Arhewoh MI. Pharmaceutical applications of native starch in conventional drug delivery. Starch/Staerke. 2016;68(9–10):864–73.
10. Adewale A, Ifeoluwa AP, Olusoji OA, Bukunmi AA, Simeon OO. Historical, Botanical and Medicinal Perspectives on Ginger (Zingiber officinale). J Complement Altern Med Res. 2021;(September):44–67.
11. JI O, Res JOIJLSS, 2018 undefined. Comparative assessment of ginger and cassava starch as a binder on ibuprofen tablet

formulation. iijls.com [Internet]. 2015 [cited 2025 Mar 24]; Available from: https://iijls.com/currentissue/Comparative_Assessment_of_Ginger_and_Cassava_Starch_as_a_Binder_on_Ibuprofen_Tablet_Formulation.pdf

12. Mao QQ, Xu XY, Cao SY, Gan RY, Corke H, Li HB. Bioactive Compounds and Bioactivities of Ginger (Zingiber officinale Roscoe). 2019 [cited 2025 Mar 25]; Available from: www.mdpi.com/journal/foods
13. Ibezim EC, Ofoefule SI, Omeje EO, Onyishi VI, Odoh UE. The role of ginger starch as a binder in acetaminophen tablets. Sci Res Essays. 2008;3(2):046–50.
14. Akonor PT, Tortoe C, Oduro-Yeboah C, Saka EA, Ewool J. Physicochemical, microstructural, and rheological characterization of tigernut (Cyperus esculentus) Starch. Int J Food Sci. 2019;2019.
15. Manek R, Builders P, Kolling W, Pharmscitech MEA, 2012 undefined. Physicochemical and Binder Properties of Starch Obtained from Cyperus esculentus. Springer [Internet]. 2013 Jun [cited 2025 Mar 23];14(2):818–27. Available from: https://link.springer.com/article/10.1208/s12249-012-9761-z
16. Dorantes-Fuertes MG, López-Méndez MC, Martínez-Castellanos G, Meléndez-Armenta RÁ, Jiménez-Martínez HE. Starch Extraction Methods in Tubers and Roots: A Systematic Review. Agronomy. 2024;14(4).
17. Olayemi OJ, Apeji YE, Isimi CY. Formulation and Evaluation of Cyperus esculentus (Tiger Nut) Starch-Alginate Microbeads in the Oral Delivery of Ibuprofen. J Pharm Innov. 2022 Jun 1;17(2):366–75.
18. Mahadi Hasan M, Sohel Rana M, Uddin N, Jamiur Rahman K, Sharmin Chowdhury S. Comparative Evaluation of Solanum tuberosum L. and Manihot esculenta Starch as Pharmaceutical Excipients: Assessment by Preformulation Studies. Bangladesh Pharm J. 2014;17(2):128–34.
19. Onwuatuegwu OD, Azubuike CP, Aloko S, Ologunagba MO, Igwilo CI. Characterization and Disintegrant Potential of Phosphorylated Tiger Nut (Cyperus esculentus) Starch in Immediate Release Ibuprofen Tablet Formulation. Dhaka Univ J Pharm Sci [Internet]. 2019 May 16 [cited 2025 Mar 25];18(1):21–9. Available from: https://banglajol.info/index.php/JPharma/article/view/41423
20. Ji O, Ji O. Evaluation of Starch from Ginger and Cassava as Pharmaceutical Tablet Excipient. 2015;(March):2–7. Available from: www.ijlssr.com
21. Phukan M, Pharmaceutical FNCT in, 2022 undefined. Starch: an overview of its conventional and unconventional sources, pharmaceutical and industrial applications. oldweb.dibru.ac.in [Internet]. [cited 2025 Mar 23]; Available from: https://oldweb.dibru.ac.in/wp-content/uploads/2022/10/8.-Review_07_CTPR_Mayuri-et-al_DONE.pdf
22. Arun Raj R. Comparative evaluation of potato starch and banana powder as disintegrating agents in aceclofenac tablet formulation. Int J Pharm Pharm Sci. 2013;5(2):204–7.
23. Builders P, Anwunobi P, Mbah C, PharmSciTech MAA, 2013 undefined. New direct compression excipient from tigernut starch: physicochemical and functional properties. Springer [Internet]. 2013 Jun [cited 2025 Mar 24];14(2):818–27. Available from: https://link.springer.com/article/10.1208/s12249-013-9968-7
24. Muazu * J, Musa H, Bhatia PG, Tom GM. Extraction and characterization of Kaffir Potato Starch: A potential source of pharmaceutical raw material. J Nat Prod Plant

Resour [Internet]. 2011;1(2):41–9. Available from: http://scholarsresearchlibrary.com/archive.html

25. Rowe RC, Sheskey PJ, Quinn ME. Handbook of Pharmaceutical excipients. 2009 [cited 2025 Mar 25];917. Available from: http://repositorio.ub.edu.ar/handle/123456789/5143
26. Bakre L, Jaiyeaoba K. Studies on the physicochemical properties of Abelmuscus esculentus L. (Okra) pods - a potential tablet excipient. Int J Biol Chem Sci. 2009;3(3):448–56.
27. Ohwoavworhua FO, Adelakun TA, Kunle OO. A Comparative Evaluation of the Flow and Compaction Characteristics of a-Cellulose obtained from Waste Paper. Trop J Pharm Res. 2007;6(1):645–51.
28. Afolayan MO, Adama KK, Oberafo A, Omojola M, Thomas S. Isolation and Characterization Studies of Ginger (Zingiber officinale) Root Starch as a Potential Industrial Biomaterial. Am J Mater Sci [Internet]. 2014 [cited 2025 Mar 25];2014(2):97–102. Available from: http://journal.sapub.org/materials
29. Odeku OA. Potentials of tropical starches as pharmaceutical excipients: A review. Starch/Staerke. 2013;65(1–2):89–106.
30. Manek R V, Builders PF, Kolling WM, Emeje M, Kunle OO. Physicochemical and Binder Properties of Starch Obtained from Cyperus esculentus. Springer [Internet]. 2012 Jun [cited 2025 Mar 24];13(2):379–88. Available from: https://link.springer.com/article/10.1208/s12249-012-9761-z
31. Ohwoavworhua FO, Adelakun TA. Non-wood fibre production of microcrystalline cellulose from Sorghum caudatum: Characterisation and tableting properties. Indian J Pharm Sci. 2010;72(3):295–301.
32. C C. Novel methods for disintegrant characterization, part I | CiNii Research. 1991 [cited 2025 Mar 25];48–56. Available from: https://cir.nii.ac.jp/crid/1570291224731977984
33. Azubuike CP, Fabiyi RO, Oseni BA, Igwilo CI. Evaluation of disintegrant potential of carboxymethyl starch derived from Cyperus esculentus (Cyperaceae) tubers. Trop J Nat Prod Res [Internet]. 2019 [cited 2025 Mar 24];3(7):246–51. Available from: https://ir.unilag.edu.ng/handle/123456789/6970
34. Adetunji O, Research OKNJ of P, 2018 undefined. The influence of phosphate modified and pregelatinized plantain (Musa paradisiaca, family: Musaceae) starches as disintegrants in paracetamol tablet formulations. ajol.info [Internet]. 2018 [cited 2025 Mar 24];14(1):15–24. Available from: https://www.ajol.info/index.php/njpr/article/view/175419
35. Chemistry HLF, 2001 undefined. Effects of hydrothermal treatment on the physicochemical properties of pregelatinized rice flour. ElsevierHM LaiFood Chem 2001•Elsevier [Internet]. [cited 2025 Mar 26]; Available from: https://www.sciencedirect.com/science/article/pii/S0308814600002612.

HOW TO CITE: Helegah Foster*, David Kofi Essumang, Donkor Darious, The Potential for Using Ginger Root (Zingiber Officinale) And Tiger Nut (Cyperus Esculentus) Starches for Pharmaceutical Formulations, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 5, 3432-3445. https://doi.org/10.5281/zenodo.15474854