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Extraction and characterization of Kaffir Potato Starch: A potential source of pharmaceutical raw material.

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ABSTRACT

The present study is aimed at extracting and characterizing a tablet excipient from a local source, kaffir potato which is used locally as a source of food because of its high carbohydrate content. Maize starch BP was used as a reference standard. Starch identification tests, were the characteristics evaluated. The result showed that kaffir potato starch has good yield and has similar characteristics with maize starch BP in all parameters evaluated as specified by BP and Handbook of Pharmaceutical Excipients. Therefore the starch can be used as an alternative to maize starch BP in pharmaceutical formulations especially solid dosage forms.

Keywords: kaffir potato, starch, characterization, excipient.

INTRODUCTION

Kaffir potato (*Plectranthuseculentus* N.E Br) is an African specie belonging to the family *Lamiaceae* to which many aromatic plants such as mints and sages belong [1]. These are erect perennial, herbaceous plant up to 60cm tall with yellow flowers and lumpy edible tubers at base of the stem that are used as potato substitute[2,3]. Kaffir potato is a plant that is widespread throughout the continent, this widespread distribution suggests that they were domesticated early by Niger-Congo speakers and were carried from West African North of the rain forest and spread down through the Bantu speaking areas of Eastern and Southern Africa. The rapid spread of cassava in the 20th century has confined these tubers to residual cultivation and they are now little known[4]. Kaffir potato was first described by Amman in 1904 and in more detail by Chevalier and Perrot in 1905. It is economically more important than solenostemon, its cultivation is more demanding than solenostemon but yields are correspondingly larger[4].

The plant is also known as Livingstone potato or finger potato in English, rizga in Hausa and called bugumji by fulanis.

The plant is widely cultivated as a minor root in Nigeria especially Kaduna and Plateau states, it is either eaten raw as snack after peeling and washing or boiled and eaten alone or with rice, while the leaves are also consumed as vegetable [5].

Chemical analysis of the raw tubers of kaffir potato have shown crude protein, crude lipid and crude carbohydrate values of 13.5, 0.6 and 81.4 g per 100 g, respectively[1], indicating that the tubers can be a potential source of starch.

The use of starch developed when Egyptians in the pre-dynastic period cemented strips of papyrus together with starch as adhesive made from wheat. The adhesive was made from fine ground wheat flour boiled with diluted vinegar[6]. A procedure for starch production was described in detail in a Roman treatise by Cato in 184 BC[6]. Starch grain is steeped in water for ten days and then pressed. Fresh water is added, mixed and the mixture is filtered through a linen cloth. The slurry is allowed to settle and washed several times with water and finally dried in the sun.

In 1732 a French scientist Sieur de Guife, recommended to the French Government that potatoes be used to manufacture starch after potatoes being discovered in America and used as food for over 13,000 years [7].

Published citations show that considerable work has been reported on starches of yam, potato, wheat, rice, millet, sorghum and plantain, Kaffir potato with high carbohydrate (84%) content has not been exploited for pharmaceutical utilization.

The study therefore aimed at extraction and characterization of starch from kaffir potato tubers.

MATERIALS AND METHODS

Maize starch (BDH, UK), Sodium hydroxide pellets (Merck, Germany), Butanol (Merck, Germany), Xylene (BDH, UK). All chemicals used were analar grade.

Collection and Identification of Starch

Kaffir potato was purchased from BarikinLadi market, Jos and was identified by Prof. S. Sanusi, a taxonomist of Department of Biological Sciences, University of Maiduguri, Nigeria.

Kaffir potato was thoroughly washed and all foreign materials were removed. The potato was peeled, weighed and washed. The washed potato was pulverised using a blender (Philips cucina HR1757, Japan). Enough quantity of water was added to the pulp which was then passed through an 180µm sieve. The filtrate was allowed to settle and 0.1N Sodium hydroxide was added to separate the starch and proteinous materials as well as to neutralize the prevailing slight acidity. Excess sodium hydroxide was removed by washing several times with distilled water.

The clear supernatant fluid was poured away while sedimented starch was collected on a tray and air-dried on a table at room temperature. The final weight of the starch was also noted.

Using pestle and mortar the dried starch lumps were ground and fine powder passed through 180 μ m sieve.

Identification Test

i. Solubility *test*: One gram of Kaffir potato starch was weighed and poured into a beaker containing 1ml, 2ml, 10ml, 1L and 10L distilled water at 25°C and was stirred, and the solubility was observed. The same procedure was repeated using 95% alcohol as a solvent. The procedures were repeated for Irish and sweet potato as well as maize starch.

ii. Iodine test: Using BP [8] starch identification test, 1g of starch was boiled with 15ml of water and allowed to cool. A few drops of 0.1N Iodine solution were added to 1ml of the mucilage and the colour changes recorded.

iii. Acidity test: Ten (10g) grams of Kaffir potato starch was added to 70% v/v alcohol which was previously neutralized using phenolphthalein solution as indicator. The mixture was shaken for an hr, filtered and 50ml of the filtrate titrated with 0.1N NaOH solution. And the quantity of NaOH used recorded. The same procedure was done for the Maize starch. The titration was done in triplicate and the mean value was considered.

iv. Determination of pH: Five grams of Kaffir potato starch was weighed into 15ml distilled water and was properly mixed. The mixture was poured into boiling distilled water to make up 100ml of slurry. The slurry was allowed to cool. Using a Blue line digital pH meter (Schott CG8842/14pH), the pH of the slurry was measured. The determination was done in triplicate and the mean value was considered as the pH of starch.

Determination of starch hydration capacity

The method of Odusote and Nasipuri[9] was adopted. One gram of each of the starch powder was placed in a tarred 20ml stopper centrifuge tube. The weight of the tube was noted; 10ml of distilled water was added and shaken vigorously for 2mins. It was then allowed to stand for 10 mins during which it was mixed by inverting the tube three times at the end of 5 and 10 minutes. The sample was centrifuged at 1000 revolutions per minute for 10 minutes. The aqueous supernatant was then carefully removed and the tube with the sediment was re-weighed. The hydration capacity was calculated as the ratio of the weight of the sediment to the initial weight of dry powder. The procedure was done in triplicate and the mean taken.

Determination of moisture content of starch

A 3g sample of starch was weighed into the pan of a moisture analyser (Sortius, Germany), set at 110°C for 3 hours[10]. The test was repeated twice and the mean of the three recorded

Microscopic examination of starch

Small quantity of each of the starches was mounted in a drop of glycerol on a glass slide and covered with a slip. The size and shape of starch particles were determined with a microscope (Olympus) equipped with a micrometer using 40 X magnification.

Determination of amylose/amylopectin ratio

The method of Onah and Bristol [11] was used, 2g each of the starches was suspended in 50ml distilled water. A 1:9 butanol: water mixture was added with continuous stirring and heating to boiling. Butyl and amyl alcohol (1:1) was added to the boiling suspension which was then allowed to cool in a cold water bath. The supernatant liquor was decanted and the microcrystalline precipitate formed was washed repeatedly with butanol saturated with water, dried in oven and weighed. The procedure was repeated twice and the mean value noted as the ratio of amylose. The supernatant was precipitated with excess methanol and the precipitated was dried in an oven and weighed to determine the ratio of amylopectin.

Determination of flow properties of starch

i. *Angle of repose*: A funnel was mounted on a laboratory stand at a height of 10cm from the bench. A 50g weight of each of the starches was poured into the funnel with the tip closed. The tip-plug was removed and the starch was allowed to pass through the orifice, the height and diameter of the starch heap were measured. The angle of repose, θ , was calculated by the following equation:

$$\theta = \tan^{-1}(h/r) \dots \dots \dots (1)$$

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

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

Determination of Starch Density

i. *Bulk density*: 50g each of individual starches were poured through a short-stemmed glass funnel into a 200ml graduated glass cylinder and the volume occupied by the starch/granules was read and the bulk density calculated.

ii. *Tapped density*: Graduated cylinder containing each of the starch powder was dropped on a bench 50 times from a height of about 20mm and the respective volumes recorded. Same was done for maize starch powder 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 all the starches.

v. *Determination of Starch true density*: The specific gravity bottle 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 X, the bottle was emptied and cleaned, 5g of starch was weighed into the specific gravity bottle, the weight of the starch powder was noted as W. The specific gravity bottle containing the starch 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 Y. starch true density was the calculated as

$$\rho = WS / [(X+W) - Y] \dots\dots\dots(2)$$

Where ρ is the particle density of starch and S is the specific gravity of xylene = 0.855.

Determination of swelling power

The method of Musa *et al* [12] was used, the tapped volumes occupied by 5g of the starches each were noted. The starches were then dispersed in 85ml of distilled water and the volume made up to 100ml with more distilled water. It was allowed to stand for 24hrs. The volume of the sediment was then determined and the swelling capacity calculated from the difference in volumes.

Determination of moisture sorption capacity

A 10g weight of each of the starch was spread evenly in Petri dishes; the Petri dish was placed in a desiccator with 98% relative humidity at room temperature. The samples were periodically weighed until a constant weight was attained. The percentage increase in weight was calculated and taken as the moisture sorption capacity.

Elemental Analysis

A 1g weight of each of the starch powders was placed in a furnace and reduced to ash. The residue was mixed with concentrated nitric acid and further ashed. The residue was then dissolved in distilled water and made up to 100ml. The elements present and their concentrations were determined using an earlier calibrated Atomic Absorption Spectrophotometer equipped with lamps of various metals.

Statistical analysis was carried out using SPSS version 16, and $p < 0.05$ was considered significant.

RESULTS AND DISCUSSION

The percentage yield obtained from extracting starch from kaffir potato tubers was 25.53. The yield was good for tubers that grow and mature within 1 year [13]. The higher yield and low cost of kaffir potato indicate that it can be potential source of pharmaceutical raw material.

Identification test

The identification tests carried out showed that kaffir potato and maize starches were insoluble in water and alcohol (95%) at room temperature. The starches were all positive to acidity and iodine tests. It showed that the starch compared well with maize starch BP and BP (2002) identification tests. Maize starch was more acidic than the extracted starch as shown in table 1. The nearness of the starches to pH 7 could be an advantage because neutral pH might decrease tendency of interaction of excipient with active pharmaceutical ingredient. The pH were all within the acceptable limit of 4.5-8 [14]

The extracted starch was off white while the maize starch BP was white. This might be as a result of treatment (bleaching) the maize starch went through before releasing to market.

Table 1: Results of identification tests of Kaffir and Maize starch BP.

Properties	Starches	
	Kaffir	Maize
Odour	odourless	odourless
Colour	off white	white
Solubility	Insoluble	Insoluble
Acidity test	Positive	Positive
pH	6.8	6.5
Iodine test	Positive	Positive

Microcopy of starch

When viewed under the microscope, maize starch particle were small angular polyhedral and round with particle sizes ranging from 0.5 -29.49 with a mean of 9.28µm. Kaffir potato starchparticles were larger in sizes ranging from 9.5-44.49µm and mean particle size of 20.16. The particle shapes of the potatoes starch were mainly spherical and polyhedral. This is in conformity with common starch [15]. The large particle size is an advantage because large particle has smaller surface area and hence smaller surface activity. Larger particles flow better than smaller particles because particulate function is more of surface phenomenon by generation of resistance to flow. The smaller particles (large surface area) having more surface energy to attract with one another tends to adhere together have more resistance to flow [10]. It is however pertinent to note that is not only particle size that is involved in the flow of powders, other characteristics of excipients such as densities and moisture content may also affect flow properties of powder.

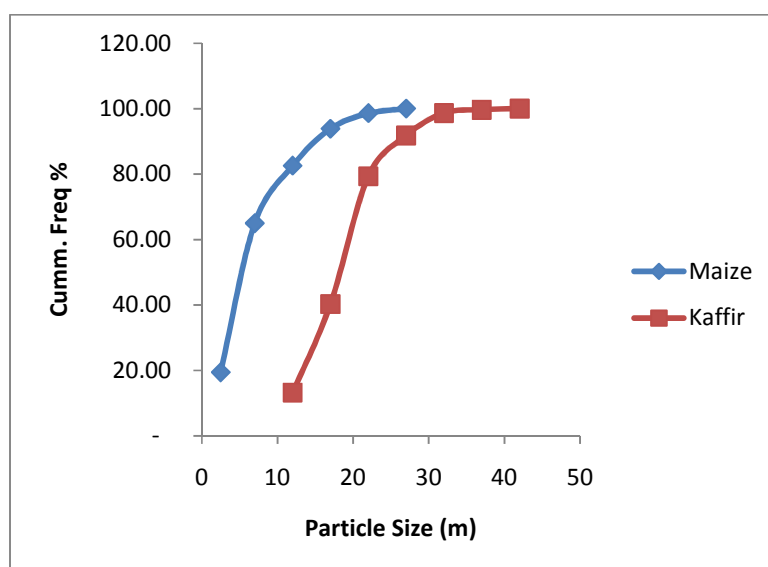


Figure 1: Particle size distribution of kaffir and potato starch.

The particle size distribution of the starches is shown in figure 1. When extrapolated from zero, they both gave a sigmoid shaped graph indicating that the particle sizes were distributed along the mean, the plot of Maize starch BP was for apart because of the smaller particle size.

Physicochemical parameters of starch

The physicochemical parameters of the starch was presented in table 2 the hydration capacity of starch Maize starch was higher than that of the potato starches, which followed the particle size of the starches. It is assumed that the hydration of starch represents the water absorbed by the particle or the particle surface [10]. As observed earlier, the smaller the particle size, the larger the surface area for absorption of water. Statistically, the hydration capacity, of maize starch was significantly higher than that of Kaffir potato starch ($P < 0.05$). The potato starch has higher moisture content than maize starch this might be as a result of larger particle size of the potato starch. Regulation of moisture in formulation is very important as high moisture content may interfere with active ingredient.

The amylose: Amylopectin ratio was 81:19 and 76:24 respectively for Kaffir potato starch and maize starch. The ratios were within the specified limit (Amylose 15-25 and amylopectin 75-85). There was no significant difference between the starch ($P > 0.05$).

The flow characteristics of the starch were measured using both flow rate and angle of Repose. The angle of Repose and flow rate of maize starch were greater than those of Kaffir potato starch. Potato starches flow better than maize starch because of larger particle size that lead to less adhesion as well as spherical shapes of the potato starch as compared to angular polyhedral maize starch BP. Angle of repose above 50° is an indication of poor flow characteristics of powder [16].

Table 2: physicochemical parameters of Kaffir and Maize starch BP

Properties	Starch	
	Kaffir	Maize starch
Hydration capacity	1.62±0.01	1.71±0.01
Redispersion time (min)	3.35±0.02	3.44±0.04
Moisture content (%)	17.16±0.06	11.42±0.01
Amylose (%)	24.00±1.00	19.00±2.00
Amylopectin (%)	76.33±1.00	81.00±2.00
Angle of Repose (°)	33.65±0.07	36.08±0.17
Flow rate (g/sec)	54.20±0.03	58.62±0.55
True Density (g/ml)	1.45±0.01	1.42±0.01
Bulk Density (g/ml)	0.57±0.02	0.59±0.01
Tapped Density (g/ml)	0.74±0.02	0.76±0.01
Carr's Index (%)	22.97±0.11	22.37±0.02
Hausner Ratio	1.30±0.02	1.29±0.01
Swelling Power (%)	20.04±0.09	21.91±0.92
Particle size (µm)	16.05±0.12	13.32±0.61
Gelatinization Temperature (°C)	66.67±1.53	69.00±1.00

The Bulk densities of the starches followed the order of particle size of the starches and there was no significant difference ($p > 0.05$) in the tapped densities of Kaffir potato starch and maize starch BP. The true densities were all within the specified limit [14].

The Carr's index 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. From the result obtained of Hausner ratio, it means that granulation and/or addition of glidants might be necessary prior to formulation.

The swelling power of maize starch was significantly higher ($p < 0.05$) than that of Kaffir potato starch this parameter is an indicator of disintegrating property of starch. It means that maize starch may have better disintegrating property than other starches. But it is important to note that it is not the only mechanism of disintegration.

The gelatinization temperatures were all within specification [14] and there was no significant difference ($p > 0.05$) between the starches. However, the gelatinization temperature of Maize starch was higher than that of Kaffir Potato starch; this higher gelatinization temperature might be as a result of higher amylopectin content of maize starch BP.

Elemental analysis

The elemental analysis of 1g weight of starch is presented in table 3.

Table 3: Elemental constituents of 1g weight of Kaffir, and Maize starch BP

Starch Elements	Kaffir	Maize
Aluminium	0.000	0.000
Calcium	0.007	0.006
Copper	0.001	0.000
Iron	0.002	0.000
Lead	0.000	0.000
Magnesium	0.009	0.003
Manganese	0.000	0.000
Potassium	0.102	0.014
Sodium	0.030	0.007
Zinc	0.000	0.000

All elements present in potato starch were also present in maize starch BP which indicates that they can all be used as pharmaceutical excipients. There was absence of heavy metals like lead, zinc and manganese in all the starches, which are not required in excipients because of their potential interaction with active pharmaceutical ingredients.

CONCLUSION

kaffir potato starch compared well to maize starch BP in physicochemical properties and could therefore serve as an alternative to maize starch BP as an excipient in the pharmaceutical industries especially in the manufacture of solid dosage forms.

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