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Extraction and Characterization of Cassava, Potato and Mango Starches

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Starches from cassava tubers, sweet potato, and mango seeds were isolated and characterized. The starches' proximate, elemental composition, physicochemical and physical properties, were studied. Cassava tuber yielded 93.45 percent, while Potato and Mango seed yielded 88.65 and 78.45 percent, respectively, in the proximate composition. When compared to cassava at 5.49 and potato starch 5.72, which have a highly acidic pH, mango starch had a neutral pH of 6.9. The moisture content of starch extracted from cassava and mango was significantly closed values at 6.00 and 6.5 percent, respectively, when compared to potato, which had a moisture content of 4.5 percent. Cassava starch (0.0012±0.003, 0.08 ±0.01) had significantly lower protein and nitrogen levels than Potato (0.35±0.00001) and (0.06±0.03), and was significantly lower than Mango starch (0.35±0.01) and (0.06±0.01) ($p < 0.005$). Cassava starch had the highest swelling capacity of 0.940 cm^3 compared to 0.285 and 0.250 cm^3 for mango and potato, respectively. Cassava and potato starches have significantly higher swelling capacities of 92.00 and 93.00 percent, respectively, than mango starch, which has a swelling capacity of 75.2 percent. Cassava starch had a greater moisture absorption index of 36.00, compared to Potato 24.10 and Mango starch 23.65 percent, which showed no significant difference. Mango starch had significantly higher sodium, potassium, and calcium concentrations than cassava and potato starch, but magnesium and phosphorus concentrations were significantly higher in mango starch than cassava and potato starch. All of the starches have outstanding characteristics and can be used interchangeably, especially in food and pharmaceuticals.

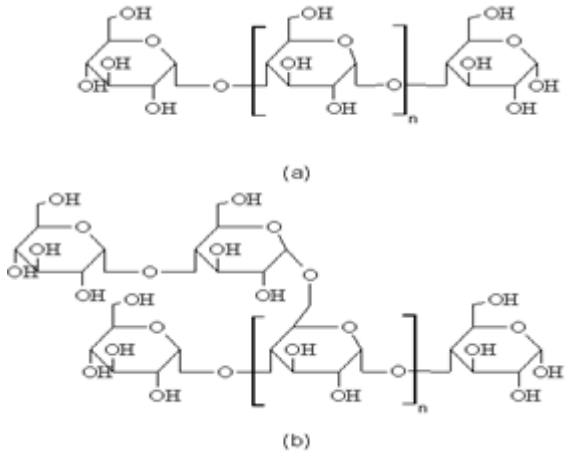
Keywords: Mango-starch; Cassava-starch; Potatoes-starch; Proximate analysis; Elemental composition.

1. Introduction

Starch is an essential component of human nutrition, housing, and clothing.[1] Starch is a carbohydrate that plants produce and store as an energy reserve in their structure. Starch can be found in seeds, tubers, and roots of plants. Higher plants biosynthesize starch and utilizes it as a type of storage for energy in the form of carbohydrate polysaccharide. Starch is a polymeric biomaterial consisting of repeating units of anhydrous glucose units (AGU) linked by glycosidic bond.[2,34] A polymeric carbohydrate made up of anhydrous glucose units is known as starch. These starch exist in the form of oval to spherical shape, known as starch granules, inside the cells. A glycosidic bond is a link between monomer glucose units that make up amylose and amylopectin, which are two distinct starch molecules, that exist in starch. Most starch contains between 70 and 90 % amylopectin and 10 to 30 % amylose. Potatoes and cassava are two of the most common food crops, with 100–180 species and thousands of varieties worldwide[3]. Both humans and animals rely on them for nutrition, but their full potential for long-term use has yet to be realized[5]. Because of their quick growth time and potential for usage, as well as their capacity to adapt to diverse climate conditions, they are now largely used in food production. It is an important attribute because of its nutritional composition such as; proteins, ascorbic acid, carbohydrates, minerals, vitamins, and fibre, making them alternative for low-fat food.[6] It is the most prevalent reserved polysaccharide in plants and is a key component of the human diet and a nutritional source of energy. A wide range of

green materials and process employs carbohydrates as a starting material, of which starches makes up around 75% of all the global demand and supply.[7] Wet milling methods are commonly used to extract starch from plant resources. Amylopectin is branched every 12-30 glucose residues, whereas amylose is not. Iodine solution is used to confirm the existence of starch; iodine binds to the starch helix, resulting in blue colouration. Corn (79 %), potato (9 %), wheat (7 %), rice, and barley make up the majority of commercially accessible starch. These plants have a lot of starch content, usually between 60 and 90 % by weight.[8]

The molecules of amylose and amylopectin clump together to form granules, which are tiny particles. Starch is a natural component found in the grains and roots of various plants (wheat, corn) (potato, tapioca). The difference between plant starches is because each plant's starch has various granular sizes and amylose/amylopectin molecule ratios. As a result, TPS films manufactured from various plant starches may have diverse characteristics, as described by literatures.[6,9–11]



Scheme 1: Structure of Amylose (a) with α-1, 4 – Glycosidic linkage and Amylopectin (b) α-1, 4 and α-1, 6 –Glycosidic Linkage.

Starch is one of nature's most intricate macromolecules, consisting primarily of a homopolymer of α-D-glucopyranosyl units. In granules with a semi-crystalline appearance, starch molecules are hydrogen bound and oriented radially. Starch granule organization and molecular structure, like many other complex materials, have been the focus of numerous studies by researchers from several disciplines.[12] Deviation in starch constituent and structural features will unavoidably change its fingerprint attributes.[10] The overall physicochemical properties of starch granules will limit the distinct applications of starch-based products in edible and non-edible applications due to the varied impacts of plant nutrients on reserve starch production. In addition, elements like phosphorus, potassium, sodium, calcium, and nitrogen have been shown to have a significant impact on starch constituents, configuration, physicochemical properties, and cooking quality, while the effects of other microelements on starch properties are yet to be fully explored and harnessed.[13] The main interest of this investigation is to compare and evaluate the physicochemical, proximate, elemental composition of unconventional starch source and conventional sources. To achieve this aim, the starch from unconventional sources like mango and conventional sources like cassava and potatoes were extracted and their properties evaluated. The outcome of this investigation will provide industrialists and related stakeholders with information on the potential of unconventional starch sources with respected to standard source for starches.

2. Materials and Method

2.1 Materials

Materials used in this research include; cassava, sweet potato and mango seed. Potato and cassava which were all purchased from Sokoto local market. Before the extraction of starch, sweet potato and cassava tubers were washed with ordinary water to remove clay, dust and other substances that stick to them. Mango fruits were processed by removing the fleshy endocarp and the mango starch was extracted from seed kernel. All other chemicals used in this study were analytical (AR) and laboratory-grade reagents (LR), which were used without further purification.

2.2 Extraction of Starch from Cassava and Sweet Potato

Starches were extracted from the tubers by wet milling processes according to Harunsyah et al.[14] Before grating, the tubers were washed, peeled, and immersed in a Sodium metabisulphite solution for 2 days. The resultant paste was combined with water and strained through a clean cloth to create a slurry. The collected filtrates were then allowed to stand for 6 hours before the supernatant was removed. This procedure was carried out five times more until the supernatant was colourless. The starch (white precipitate) was then recovered. The crude starches were refined in a centrifuge for 10 minutes at 4000 rpm. The silt was then dispersed in 100 cm^3 of distilled water and centrifuged to separate the pristine starches, which were then dried at 50 ^oC to produce white powder. The

starch powder was kept at room temperature in polyethylene receptacles**.**

2.3 Extraction of Starch from Mango Seed Kernel

The extraction method used was hot water extraction. In a 1000 cm^3 beaker, 100.00 g powder mango seed kernel was immersed in 200 cm^3 distilled water for 24 hours in a thermostatic water bath at a fixed temperature of 50 ^oC. Three parts distilled water and one-part soaking powder mango seed kernel were mixed for three minutes at medium and high rates. The resulting slurry was centrifuged at 5000 rpm for 20 minutes after passing through a double layer of muslin fabric. The supernatant was removed, and the sediment was re-suspended in more than 0.02 % NaOH (aq) to eliminate any remaining proteins and phenolic compounds. The supernatant was decanted and disposed after 4 hours of standing. This step was performed 6-8 times more until the supernatant was colourless. By adding distilled water, the residue was balanced to a pH of 7.0. Then filtered through a Buchner funnel and rinsed with deionized water completely. Before further investigation, the residue was oven-dried at 50 ^oC, ground to powder, weighed, and kept in an airtight plastic container.[15,16]

2.4 Characterization of Starch

2.4.1 Iodine Test for Starch

To a 15 cm^3 of deionized water in a small beaker, 1 g of starch was introduced and mixed. 1 cm^3 of the mixture was collected and 2 drops of 0.1 M iodine solution were added and agitated; the observed colour shift was documented.[17]

2.4.2 Determination of Amylose and Amylopectin Fraction

with some modifications, the amylose and amylopectin fractions in all samples were determined using the method reported by Zhu et al.[18] A flask was filled with 5.0 cm^3 of 10% w/v aqueous starch slurry and 55 cm^3 of 0.16 M sodium hydroxide, which was slowly swirled until the suspension clears. After 5 minutes, 15 cm^3 sodium hydroxide (5 % v/v) in 0.6 M hydrochloric acid was added and properly homogenized. Centrifugation at 10,000 rpm for 15 minutes was used to collect the precipitate. The supernatant was preserved in a separate flask, and the residue was washed by re-suspending it in 20 cm^3 of 1 percent sodium chloride and centrifuging it after overnight standing.

2.4.3 Proximate Composition of Starches Sample

Carbohydrate, moisture, lipid (fat) ash, fibre, and nitrogen were all determined as part of the proximate composition of these starches. The proximate analysis approach was carried out as per Association of Official Analytical Chemists' usual protocol[19] as follows:

(a) Determination of Ash content

The ash present in the sample was evaluated using the AOAC 2010 method.[19] Weighing a preheated and cool crucible. A Bunsen flame was used to char the sample inside a fume cupboard. The charred sample was placed in a muffle furnace heated to 550 ^oC for 2 hours to generate white or grey ash. The samples collected out, weighed, and then cooled within desiccators. The equation (1) was used to determine the proportion ash content of the samples.

$$\%\ Ash\ content = \frac{W3 - W2}{W2 - w1}\ x\ 100 \quad \text{..... (1)}$$

Where: *W*1= Weight of empty crucible, *W*2= Weight of crucible +Weight of the sample, *W*3=Weight of crucible + Weight of sample after ashing.

(b) Determination of Crude Lipid

A soxhlet apparatus method was used to extract crude lipid from petroleum ether. In the base of a 100 cm^3 beaker, a small amount of cotton balls was positioned. The base of an extraction thimble was stuffed with cotton balls, and the thimble was hauled up in the beaker. 5.00 g of powdered sample was accurately weighed into the thimble, next by 1.00 g of sand, and then blended with a stirring rod. A piece of cotton balls was used to wipe the glass rod, as well as the cotton ball was placed on top of the thimble. The pulverized sample mixture in the thimble was dried in a desiccator for 5 hours at 102 ^oC. On top of the thimble, a piece of cotton balls from the bottom of the vessel was inserted. A Soxhlet liquid/solid extractor was used to place the thimble. After carefully weighing a fresh clean 150 cm^3 round bottom flask, 90 cm^3 of petroleum ether was added to the flask. Over an electrically heated mantle, the extraction device was assembled and heated until the solvent commenced to boil. The heat source was set so that solvent drips at a rate of nearly 6 drops per second from the condenser into the sample chamber. After around 4 hours of separation, the source of heat was turned off and the solvent was emptied from the extractor into the flask. The mixture was moved to a pre-weighed 100 cm^3 beaker once the thimble was withdrawn from the extractor. The sample was broken up with a stirring rod. The sample was restored to the thimble, which was then reinserted into the extractor, and the beaker was rinsed with petroleum spirit before being emptied into the extract. The extraction was extended for a second time for another two hours.

The extractor and condenser were disconnected from the source of heat. The solvent was evaporated once the flask was positioned on the

heat source. The flask was placed in a 102 ^{o}C oven for 2 hours, and the contents were dried until they attained a consistent weight.
The flask was cooled in a desiccator and the flask and contents were weighed (*W2*).

$$\%\ Crude\ lipids = \frac{W3 - W2}{W1}\ x\ 100 \quad \text{..... (2)}$$

Where: *W1*=Weight of the sample, *W2*=weight of empty flask and *W3*=weight of the flask and extracted fat.

(c) Determination of Crude Fibre
The samples were oven-dried at 105 ^{o}C, as per the AOAC technique. Dry powder samples (2 g) were put in a 500 cm^3 beaker and heated for 3 minutes, swirling the beaker intermittently. The beakers were then chilled and filtered using a Buchner funnel using pressure. After that, two 50 cm^3 volumes of hot water were used to wash the beakers. After carefully moving the residue into a beaker, 200 cm^3 of 1.25 percent NaOH solution was introduced. They were heated in 50 cm^3 boiling water for 30 minutes, then cooled, strained, and cleaned thoroughly. Finally, 25 cm^3 of 95 percent ethanol was used to rinse the samples. The remnants were dried in hot air oven at 130 ^{o}C for two hours, cooled in desiccator and evaluated using equation (3).

$$\%\ Crude\ Fibre = \frac{Weight\ of\ residue}{Weight\ of\ sample}\ x\ 100 \text{.....} \quad (3)$$

(d) Determination of Moisture Content
The percentage moisture content was calculated using the oven approach, in which 2 g of starch were weighed and dried at 105 °C for 24 hours. The dehydrated samples were weighed again until a constant weight was established, and the percent moisture content was evaluated using the equation (4).

$$\%\ Moisture\ content = \frac{W2 - W1}{W1}\ x\ 100 \text{.....} (4)$$

Where: *W1* and *W2* = Weights of the sample before and after drying respectively

(e) Determination of Crude Protein
Crude protein was determined by the Kjeldahl method. Nitrogen was first determined before the determination of protein. To determine nitrogen, 2.00 g of powdered sample was weighed. 20 cm^3 of concentrated H_2SO_4 was added with the digestion tablet and mixed. Distilled water was added into the container until it reached 50 cm^3. The mixture was digested on the digestion block. After digestion, 10 cm^3 of the mixture was taken and added with 20 cm^3 NaOH (0.5 M) and 30 cm^3 distilled water. Exactly 20 cm^3 boric acid indicator was measured in a separate container. The prepared sample was taken to the Micro-Kjeldahl apparatus and set for distillation. The vapour condensed when passing through the condenser and the liquid dropped into the boric acid indicator in the separate container, which was set at the lower part of the Micro-Kjeldahl apparatus. The process continued until the boric acid indicator changed from pink to green colour. The green-colour sample was titrated using 0.005 M H_2SO_4 until it became pink colour again. The titre value was noted and the percentage nitrogen was calculated and the crude protein was obtained by multiplying the percentage nitrogen by the conversion factor of protein (% N x 6.25) as shown in equation (5).

% Crude Protein = % N x 6.25……(5)

Where N: Nitrogen

(f) Determination of Total Carbohydrates
Total carbohydrate was determined by deducting the sum of the percentages of the Lipids, Ash, protein and fibre content from 100 %, but excluding moisture content using equation (6)
% Carbohydrate = 100 % - (% lipids + % Ash + % Protein + % Fibre) ……. (6)

2.4.4 Elemental Analysis

(a) Determination of Phosphorus
The ash residue was dissolved with 5 cm^3 of 20 % HCl and distilled water was added to make 50 cm^3. 2 cm^3 of the mixture was taken and 2 cm^3 of the phosphorus-extraction solution was added and 2 cm^3 of Amocybolet was added with 1 cm^3 of dilute stannous chloride and distilled water was added up to 50 cm^3. The samples were scanned in a calorimeter at 660 nm.

(b) Determination of Magnesium
Ash residue (1 g) was taken and 19 cm^3 of distilled water was added and 5 cm^3 buffer solution was added, 3 drops of eriochrome black T was added and titrated with EDTA.

(c) Determination of Calcium
From the solution of dissolved ash residue, 1 cm^3 was taken and 19 cm^{3}of distilled water and 1 cm^3 of 10 % NaOH was added and a tip of muruxide indicator was added and titrated with EDTA.

(d) Determination of Sodium
Ash residue was dissolved in distilled water and measured in a flame photometer at 589 nm wavelength.

(e) Determination of Potassium

Ash residue was dissolved in distilled water and measured using a flame photometer at a wavelength of 766 nm.

2.4.5 Determination of physicochemical properties

(a) Hydration capacity

The method in liteturae[20] was applied. A 1 g sample of starch was positioned in every one of three 15 cm^3 plastic centrifuge tubes and 10 cm^3 of water was added from a 10 cm^3 measuring cylinder and then stopped, the components were blended in a homogenizer for 2 minutes, the mixture was kept for 10 minutes, and afterwards centrifuged instantaneously. The sediment was measured after the supernatant was thoroughly removed. The hydration capacity was estimated as the weight of sediment divided by the weight of the dry sample.

(b) Swelling capacity

This was calculated at the same time as the hydration content, using the procedure of Okhamafe et al.,[21] In this method, the tapped volume occupied by 1 g of the powdered samples was noted (*V1*) and The powdered materials were mixed in 30 cm^3 distilled water and the volume was brought up to 50 cm^3 with water in this way. The volume of the silt (*V2*) was measured after 24 hours of standing. The swelling capacity of the samples was calculated by using equation (7).

$$Swellingcapacity = \frac{V2-V1}{V1} x100 \text{.....(7)}$$

Where: *V1* and *V2* are volumes of the starches before and after soaking in water respectively.

(c) Moisture absorption index

Each sample was weighed and equally dispersed across the surface of a 70 mm tarred Petri dish with two grams of each sample. The samples were put in a huge desiccator with distilled water in its tank at ambient temperature for five days, and the weight increased by the samples was monitored, and the quantity of moisture lost was determined using the weight disparities.

(d) pH Determination

The pH of the samples was evaluated by agitating 2 g powdered samples with 100 cm^3 distilled water for 5 minutes and then measuring the pH of the supernatant solutions with a pH meter.

(e) Determination of Gelatinization Temperature

To 2 g of each of the samples in a 100 cm^3 beaker, 50 cm^3 of distilled water were added and heated to 105 ^oC, cooled to room temperature and the time taken for it to gel was noted.

3. Results and Discussion

3.1 Results

The results obtained from the analysis carried out on the starches extracted from mango, cassava and potato starches are represented as follows:

Table 1: Physicochemical Analysis of Cassava, Potato and Mango Starches

Parameters	Cassava	Potato	Mango
Yield (%)	93.450^a	88.65^b	78.45^c
Physical appearance	Brilliant white	Off-white	Brilliant white
Granular shape	Round(oval)	Round(oval)	Oblong(oval)
pH	$5.490^b \pm 0.40$	$5.720^b \pm 0.73$	$6.900^a \pm 0.03$
Gelatinization temp. (˚C)	83-87	75-80	78-80
Texture	Amorphous	Amorphous	Amorphous
Iodine test (Blue-black)	+ve	+ve	+ve
Amylose (%)	$20.400^b \pm 0.89$	$26.200^a \pm 0.92$	$27.230^a \pm 0.024$
Amylopectin (%)	$79.600^a \pm 0.60$	$73.800^b \pm 1.93$	$72.770^b \pm 0.012$

Values are presented as mean ± standard deviation of triplicate analysis. Means that share the same letter are not significantly different.

Table 2: Proximate Composition Analysis of Cassava, Potato and Mango Starches

Parameters	Cassava	Potato	Mango
Crude Lipids (%)	0.042^{b}±0.0007	0.046^{b}±0.0001	0.180^{a}±0.01
Ash content (%)	0.500^{b}±0.10	1.000^{a}± 0.27	0.460^{b}±0.005
Carbohydrate (%)	92.97^{b}± 0.84	94.150^{b}± 1.00	98.930^{a}±0.02
Fiber content (%)	6.488^{a}±0.002	4.804^{b}±0.01	0.020^{c}±0.01
Crude Protein (%)	0.0012^{b}±0.003	0.0001^{c}±0.00001	0.350^{a}±0.01
Nitrogen (%)	0.080^{a}±0.01	0.060^{b}± 0.03	0.060^{b}±0.01
Moisture content (%)	6.000^{a}±0.20	4.500^{b}±0.500	6.500^{a}±0.05

Values are presented as mean ± standard deviation of triplicate analysis. Mean that share the same letter are not significantly different.

Table 3: Physical Properties of Cassava, Potato and Mango Starches

	Swelling capacity (cm^3)	Hydration capacity (%)	Moisture uptake (%)
Cassava starch	0.940^{a} ± 0.10	92.000^{a} ± 0.65	36.000^{a} ± 3.37
Sweet Potato starch	0.250^{b} ±0.09	93.000^{a} ± 0.20	24.100^{b} ± 0.013
Mango starch	0.285^{b}±0.006	75.200^{b}±0.057	23.650^{b}±0.073

Values are presented as mean ± standard deviation of triplicate analysis. Mean that share the same letter are not significantly different.

Table 4: Elemental Composition of Cassava, Potato and Mango Starches

	Cassava	Sweet Potato	Mango
Na (mg/g)	0.0100^{a}±0.0010	0.0150^{a}±0.0030	0.0073^{b}±0.0010
K (mg/g)	0.0100^{a}±0.0030	0.01250^{a}±0.005	0.0032^{b}±0.00020
Ca (mg/g)	0.0003^{a}±0.00005	0.0003^{a}±0.00004	0.0001^{b}±0.00002
Mg (mg/g)	0.0003^{b}±0.0001	0.0002^{b}±0.0001	0.0041^{a}±0.00010
P (mg/g)	0.0013^{b}±0.0004	0.0013^{b}±0.0002	0.0262^{a}±0.00010

Values are presented as mean ± standard deviation of triplicate analysis. Means that shares the same letter are not significantly different.

3.2 Discussion

3.2.1 Physicochemical Composition of Cassava, Potato and Mango Starches

From

Table **1**, Cassava tuber showed a significantly higher white powder yield of 93.45, compared to Potato and Mango seed of 88.65 and 78.45 %. The difference in powder yield could be attributed to the biological origin of the starch and extraction method.

Amorphous brilliant white fluffy powders were obtained except for the sweet potato which was off-white but all gave a blue-black colouration on the addition of iodine solution indicating the presence of starch. This variation in sweet potato could be attributed to its high ash contents compared to Cassava and Mango starch.

The micrograph showed a starch granular morphology of round-oval for Cassava and Sweet potato starch but oblong-oval for Mango. The similarity in cassava and Sweet potato starch could be due to both being a tuber source and possibly the same Starch biosynthesis is regulated by biological factors when compared to mango seed starch.[22] As described by Cui[12], starch is found in nature in the form of granules that vary in size and shape. The size, structure, and hilum position, which is the granule's original growing point, can all be used to extrapolate the genesis of agglomerates''.

The pH of Mango starch was almost neutral, compared to cassava and potato starch, which are significantly acidic. This could be due to the method of extraction for Mango starch involving the use of NaOH (aq) to alter pH towards alkaline and further washing with distilled water could have contributed to making the pH almost neutral.

The gelatinization temperature range of Cassava starch is significantly more juxtaposed to the Potato and Mango starch that was almost similar. The higher gelatinization temperature of Cassava can be ascribed to the high amylopectin of 79.60 compared to Potato of 73.80 and Mango of 72.77 % respectively.

The amylopectin content in Potato and Mango starch were not significantly different but are both

significantly less than Cassava starch. the variation observed in the amylose and amylopectin proportion is attributed to the starch being from different botanical origin and this has a corresponding effect on the starch character.[23] The ratio could be responsible for the higher gelatinization temperature observed in Cassava starch compared to potato and mango starch which is much closer and less significantly.

3.2.2 Proximate analysis of Cassava, Potato and Mango Starches

From

Table 2, the results for the analysis show that moisture content for the starch extracted from cassava and mango was significantly similar at 6.00 and 6.5 compared to the potato at 4.5 %.

The relative humidity of the starches was lower than the standard moisture content of 14 % for hygienic starch storage.[24] The outcomes of this research matched those of the previous research of Fowomola[25] and Valdés et al.[26] for foods that are based on roots. The moisture level of a product is essential predictor of its lifespan, as high water content encourages microbial breakdown and spoiling.[27–30]

The fairly low moisture content of native cassava, sweet potato, and mango starch makes it easy to store at room temperature and less predisposed to colonization by microbial breakdown as shown for root, tuber, and cereal starches, making them a perfect for use in sectors such as healthcare that use reduced moisture content starches such as cereal starches, and this result is similar to those produced by Hassan et al.[1,31] for a various variety of native mango starches.

The losing on drying for all the native starches under investigation is within the official limit. The British Pharmacopoeia[17] stated that for most starch types, the moisture content value should not be more than 15% of its weight except potato starch which should not exceed 20%. This low value seen with all the native starches is due to resistance to water entrance caused by intramolecular hydrogen bonding in the amylase helix.[32]

The ash content is a fair approximation of the starch's entire elemental composition. The total ash value is significant because it suggests, to certain degree, how carefully the starch was prepared. Because substantial mineral content is often employed to inhibit the growth of certain microbes, a low ash percentage indicates that the starches are of top condition.[33]

The ash content of the starches was 0.5 and 1.5 for cassava and potato respectively which is much lower compared with the recommended 5 % by WHO.

The result indicated significantly low protein and nitrogen in Cassava starch (0.0012±0.003) (0.08±0.01) compared to Potato (0.35±0.00001) and (0.06±0.03), which in turn is much lesser than those in Mango starch (0.35±0.01) and (0.06±0.01).

The low protein and nitrogen content of less than 1% is a sign of kernel protein deficiency, which could compromise the purity and crystallinity of the starches, thus affecting the swelling capabilities[34] also studies done by Abd-Allah et al.[35] Mango seed kernel starch has a low protein and fatty acid profile, making it ideal for baking. By causing an interaction between the amino acid group and reducing sugars, protein can create undesired color in starch and starch hydrolysis intermediates. Furthermore, protein can influence the surface charge and hydration rate.[22]

According to Swinkels,[36,37] the diffusion of water into agglomerates is influenced by surface fats. As a result, it may change the characteristics of starches by reducing their water-binding activity, swelling, and solubilization. Furthermore, by creating a compound with amylase in the starch paste, surface lipids may restrict amylase from contributing to the hardening strength of gelatinized starch. Furthermore, significant concentration may influence the starch's purity and constitution, making starch isolation more difficult.[15]

Fowomola[25] analysed the mango seed proximate composition, amino acid profile, and anti-nutrient content Mango seed, according to the findings, contains (10.06 ± 0.12%) crude protein, (14.80 ± 0.13%) oil, (2.62 ± 0.02%) ash, (2.40 ± 0.01%) crude fibre, and 70.12 ± 1.34%) carbohydrate.

The results showed that cassava, potato and mango starches crude protein, oil, ash, crude fibre, and carbohydrate are all present. Variations in distinctive yield could be related to variances in plant variety, cultivation environment, maturity phase, seed kernel harvesting time, and processing conditions.[38]

The proximate analysis shows significant difference from studies carried out previously by Nzikou et al.,[39] Dhingra and Kapoor[40] and Changso[41] who obtained higher values in Moisture content, crude protein, fat/oils, Crude fibre, and ash content. This variation could be due to differences in geographical location and Species of the plant.

3.2.3 Physical Properties of Cassava, Potato and Mango Starches

From Table 3, Cassava starch showed the highest swelling capacity of 0.940 cm^3 compared to Mango and Potato which are significant similar 0.285 and 0.250 cm^3 respectively.

The Swelling Power is described as the proportion of swollen starch granule volume to dry starch volume. The assessment of hydration capacity, swelling capacity, and moisture content can all be used to estimate swelling capacity, moisture absorption and solubility index which is widely acknowledged as an indicator of tablet disintegration potential.[42]

Hydration capacity refers to the rise in starch volume as a result of water intake. The result indicated that the Cassava and Potato starches have a significant high swelling capacity of 92.00 and 93.00% compared to mango starch of 75.2%. The total quantity of moisture contained by a starch polymer under a particular environment is referred to as its hydration capacity.[43]

Moisture absorption index was higher in cassava starch 36.00 compared to Potato 24.10 and Mango starches 23.65% which showed no significant variation. Moisture absorption index (MAI) is the amount of water a material can absorb from the environment under standard temperature conditions (STP). The low swelling capacity, Hydration capacity and Moisture uptake for Mango starch compared to Cassava and Potato starches is influenced by the higher level of surface lipids of 0.18% compared to Cassava and Potato starches, which supports the conclusion of Chavan et al.[15]

3.2.4 Elemental Composition of Cassava, Potato and Mango Starches

From Table 4, cassava and potato starches showed significantly higher concentration of sodium ($0.0100^{a}\pm0.001$ and $0.0150^{a}\pm0.003$), potassium ($0.0100^{a}\pm0.003$ and $0.01250^{a}\pm0.005$) and calcium ($0.0003^{a}\pm0.00005$ and $0.0003^{a}\pm0.00004$) compared to Mango starch ($0.0001^{b}\pm0.00002$), while the concentration of magnesium and phosphorus was significantly higher in mango starch($0.0041^{a}\pm0.0001$ and $0.0262^{a}\pm0.0001$) compared to Cassava ($0.0003^{b}\pm0.0001$ and $0.0013^{b}\pm0.0004$) and potato starch ($0.0002^{b}\pm0.0001$ and $0.0013^{b}\pm0.0002$). Plant chemical elements are essential for normal growth and agronomic output, and they are hypothesized to play a role in starch biosynthetic pathway in a spatial and temporal manner [13].

Zhang et al., [13], inferred that nine mineral elements have primary impacts on transitory starch biosynthesis, seven elements have primary effects on storage starch biosynthesis, and six elements have primary effects on the cooking quality of mature starch, according to the findings. Under the deteriorating conditions caused by climate change, a better knowledge of the relation between nutrient supply and starch properties should translate into higher significance starch derivatives through targeted fertilization.

The study by Shegro et al., [44], there was a highly significant link between phosphorus and magnesium, as well as zinc, phosphorus, and protein, indicating that there was some interplay in chemical absorption and redistribution in sorghum. The mineral content of this study was at a trace level, with none of the starches above 1.00 mg/g.

4. Conclusion

The starches derived are all closely similar in their physicochemical, proximate composition, physical and elemental properties. Despite the starch being from different biological origins, they could all serve in same purpose or application especially in food, pharmaceutical and allied industries. Modification and application of the starches will lead to a similar outcome in the physical properties but may not be the same with chemical property, which is dependent on the close amylose and amylopectin ratio. All the starches will not need to be further dried before storage to avoid microbial deterioration as it indicates the low moisture content of below 10 %. The starches could serve as a source of carbohydrates for animal feed especially for the mango seed starch which has shown similar potential with already known food starch from cassava and sweet potatoes.

Conflict of Interest

The authors declare that there is no conflict of interest.

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