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Characterization of starch from hot water treated and untreated *anchomanes differmis* rhizome

Abe T.O*[1] and Lajide L[2]
Department of Chemistry, Federal University of Technology, Akure, Ondo State, Nigeria

Abstract: *Starches were prepared from Forest anchomanes´ rhizome by Sedimentation method. Forest anchomanes (Anchomanes differmis) is herbaceous plants with prickly stem having huge divided leaf occurring in the forest of West Africa. One part (treated) steeped in hot water (80^{o}C) and the other part in cold water (untreated) yield 18% and 16 % respectively. The starches obtained were slightly off white with true density of 1.58 and 1.54; percentage solubility at 85^{O}C were 17.05 and 28.27 while swelling power were 31.42 and 40.25; water absorption capacity were 13% and 14.67% for hot water and cold water respectively. The proximate analysis of treated and untreated sample (%) was found to be: fat(3.3 and 2.3), ash(1.0), crude fibre(0.4), protein(1.3 and 1.5), moisture(5.6 and 5.8), and carbohydrates(88.1 and 88.9) respectively. Phytochemical composition (mg/100g) of the starch revealed the presence, saponins (11.76 and 5.36), phytates (0.1 and 0.08), tannins (1.0 and 1.3), oxalates (1.97 and 1.94), cyanides (0.01), flavonoid (0.84 and 0.56), alkaloids (1.40 and 2, 79) and cardiac glycosides (0.48 and 0.55). While the peak viscosity (BU) was 254.17 and 245.75, pasting temperature (^{o}C) was 81.65 and 82.46 from treated and untreated respectively. The photomicrograph indicates that the starch granule is generally small sized, not distinct but clustered with size ranging between 0.5–10µm which is a reflection of the parent source. The starches from untreated sample have smaller granule size and higher peak viscosity than treated one. The flours (treated and untreated) analysis show that proximate composition is least affected by steeping in hot water but reduced the toxicity level and enhance the availability of minerals composition. Generally, the values obtained from the physicochemical characterization of A. differmis starch show that it has high potential for industrial applications especially in the food, textile and pharmaceutical industries.*

Keywords: *Anchomanes differmis, steeped, physicochemical, phytochemical, starch, photomicrograph.*

I. Introduction

Starch is one of the most abundant substances in nature and is a renewable resource. It is a semi- crystalline carbohydrate synthesized as rough spherical granules in many plant tissues including roots, tubers, rhizomes and seeds. The major botanical sources of starch are wheat, maize, potato, cassava and taro (Tester et al., 2004). Starch is a basis of our food and industrial economy. Although it is mainly used as food, it can also be readily converted chemically and biologically into many useful and diverse products such as paper, textiles, adhesives, beverages, confectionery, pharmaceuticals, and plastics.

The conversion of starch into biodegradable plastics is being researched on by many countries. This is being achieved either by chemically modifying the starches or by blending them with other polymers (Parra et al., 2004). In both case, it is important to know the chemical as well as physical characteristics of the starch. While various attempts have been made to characterize starches derived from cassava (Sriroth et al. 1999) and taro (Moorthy.1991), little information of such studies have been reported on forest anchomanes. *Anchomanes differmis* is a member of Araceae family (Burkill, 1985), an herbaceous plant with prickly stem having huge divided leaf and spathe that arise from a horizontal rhizome occurring in the forest of West Africa. It is sometimes called forest Anchomanes in English (Oyetayo, 2007), while in Southwest Nigeria (Yoruba) it is known as Abirisoko, Ogirisako and Igo (Soladoye et al., 2005). The rhizome is eaten but only after special preparation that entails prolonged washing and cooking of early shooting stage (Oyetayo, 2007)The rhizomes could be vertical or horizontal, creeping at or near surface, sometimes branched; corms underground and starchy (Bown and Deni, 2000).

In the present study, starch was extracted from treated forest anchomanes rhizome (steeped in hot water at 80^{o}C for 4h) and (steeped in cold water at 25^{o}C for 4h) untreated. The physicochemical, phytochemical level and rheological properties of starches were determined in other to compares with other raw materials. Therefore, the aim of the research project is to explore the possibility of starch from *A. differmis* as a potentially useful raw material.

II. Experimental details

2.1. Materials

Freshly harvested *A. difformis* rhizome, grown naturally in West African climatic and agronomic conditions, was collected from Ipinsa, Akure South local Government. Nigeria. The Sampling locations and geographical references of sampling points taken with a Global Positioning System (Garmin GPS 12 model) (N 07^0 19^1 145^{11} and E 005^0 08^1 45.8^{11}) was authenticate at Crop and Pest management, Federal University of Technology, Akure.

2.2. Dry matter content

Flour extraction was conducted by modified procedure (Alves et al, 2002).One hundred grams of freshly washed, peeled and shredded undamaged rhizome were placed in weighed petri dishes. The samples were dried at 65°C for 72 h, cooled in a desiccator and weighed immediately. The drying and weighing steps were repeated until consecutive constant weights were achieved. These steps were carried out within 24h after harvest to avoid post-harvest changes through physiological deterioration or moisture loss of the rhizome. Dry matter (DM) contents of the rhizome were calculated after repeated dry to constant weights.

2.3. Preparation of starch

Starch extraction was conducted following modified procedure of Alves et al (2002).Fresh rhizome were washed, peeled, chopped into approximately 1 cm cubes, these was divided into two part with one part steep in hot water(80^oC) for 4h (treated) and the other untreated(steeped in cold water at 25^oC for 4h)and then pulverized in a high-speed blender for 5 min. The pulp was suspended in ten times its volume of water, stirred for 5 min. The resulting slurry was left to stand overnight at 4^oC and then centrifuged (5,000 rpm; 20 min). After this, the supernatant was discarded and the colored layer manually scraped off of the starch. This centrifugation step was repeated until the supernatant layer was almost colorless. After the last centrifugation, the supernatant was decanted and toluene was added to the remaining sediment (starch). This was followed by addition of deionized water to wash the pellets until their pH was neutral. The recovered starch was dried using an air oven at ~40°C for24h, ground, sieved using a 425 µm sieve. The yield of starch based on dry mater was determined before stored in an air tight container under dry conditions (Alves et al., 2002).

2.4 Proximate analysis

Moisture, protein, fat, ash, crude fibre and carbohydrates were determined from each of the flour (treated and untreated) and their starch according to A.O.A.C. (1990).

2.5. Determination of pH

Five grams of the forest anchomanes flours and starches was weighed and added to 20 ml of water in a volumetric flask. The mixture was shaken for 3 min and then filtered using a filter paper. The filtrate was then tested for acidity and alkalinity using a pH meter (Jenway3505 pH meter).

2.6 Functional properties

2.6.1. Determination of physico-chemical properties

Bulk and loose densities were determined by Narayara and Narasinga (1989). Bulk density was determined by placing 20 g of the sample into a weighed measuring cylinder and tapped gently to eliminate air spaces, the resulting volume was recorded and loose density was determined by placing 20 g of the sample into a measuring cylinder and the volume was recorded without tapping. Swelling capacity was determined by Leach et al. (1959) method while the procedure of Sathe et al., (1982) was used for water and oil absorption capacity. The Least Gelation Concentration (LGC) of the sample was determined using the method of Coffmann and Garciaj (1977).The procedure of Kim et al. (1995) using the Rapid Visco Analyzer (RVA) model RVA-3D was used in determining the pasting properties.

2.6.2 Scanning electron microscopy

A scanning electron microscope (SEM) model EVO/ MA 10 was used to determine the particle size at 100X, 500X and 1KX magnifications. The sample was imaged with the secondary electron detector at an accelerating voltage of 20 kV, probe current of 200 PA and variable pressure of 50 Pa. (Fanon et al., 1992).

2.7. Determination of mineral composition

Mineral elements composition was determined using methods (A.O.A.C. 1990) recommended methods. One gram of dry sample was ashed in a furnace at 550^{o}C;The ashed samples were digestion with 5ml of 10% HNO_3prior to analysis; preparation of stock solution of the elements and the determination of the concentration of the elements using a calibration curve obtained by plotting the concentration of the pure elements against their absorbance readings from BulkScientific(210) Atomic Absorption Spectrophotometer (Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Ni, Zn), flame photometer (Na and K.) and of phosphorus in the starches and flours was determined by colorimetric in accordance with the approved A.O.A.C. (1990) methods.

2.8 Determination of Phytochemicals Levels in Samples

Spectroscopic and titrimetric methods were used to determine the levels of phytochemicals in the Forest anchomanes samples. The phytochemicals determined in the samples are total oxalates (Dye, 1956) phytates (McCance and Widdowson, 1953) and hydrogen cyanide (A.O.A.C., 1990). The others were flavonoids, saponins alkaloids (A.O.A.C., 1990), tannin (Markkar et al. 1993) and cardiac glycoside. (Gaur et al., 2009).

2.9. Statistical Analysis

The triplicate results were statistically analyzed using ANOVA and means were compared using least significant difference (L.S.D.) at $p \leq 0.05$ levels using the Duncan Multiple Range Test from Statistical Package for Social Science (SPSS) 15.0 version (Snedecor and Cochran, 1980).

III. Results and discussion

3.1. Starch yield

A. difformis starch was isolated from freshly harvested (untreated -sample A) and hot water (80^{o}C) treated (sample B) rhizome. The starches obtained were slightly off white in colour without smell and 18% and 16% yield respectively. This yield might be an indication of appreciable accumulation of starch in the fresh rhizome, the percentage starch yield of A. difformis was similar to potato starches as reported by Parvu (1997) and higher than some un-conversional wild edible rhizome reported by Veerabahu and Chinnamadasamy (2010); Shanthakumaril et al., (2008).

3.2. Proximate composition

Fresh *A. difformis* rhizome used contains about 88% dry matter. The results of the proximate composition are presented in Table 1. Variations occurred in the proximate composition of the un- treated (sample A) and the treated (sample B) rhizome ($p<0.05$) except for the Crude fibre and crude fat contents; these show that steeping in hot water has little effect on the proximate composition of the rhizome. The samples are less - proteinous with values about 5% for the treated and untreated sample; the result are comparable to the reported values of white yam, water yam and sweet potato (Longe, 1986; Alaise and Linden, 1999). Fiber is regarded as essential, as it absorbs water and provides roughage for the bowels, assisting intestinal transit. Very low fiber such obtained in these work; in foods is however, helpful to digestive process but it lowers the vitamin and enzyme content of the food material. This might have accounted for 10% level of *A. difformis* inclusion in ruminant animal concentrate diets as a safe level that will guarantee no negative effect on nutrient intake and performance (Moses et al. 2010).The carbohydrate values of 70.9 -88.9 % are quite reasonable as the dry matter of most root crops is made up of about 60 – 90% carbohydrate (Oyenuga, 1968). The values are comparable to the carbohydrate contents of white yam (Longe, 1986).

The starches from hot water treated sample (sample Bs) and un-treated (sample As) had no significant different at $P <0.05$ in their proximate composition except in carbohydrate, these show that steeping in hot water has little or no effect on the proximate composition of the starch. The starches indicate less inorganic content (ash and crude fibre) as well as protain content as shown by their low value in Table 1. This was not unexpected as starches always have less inorganic (ash and crude fibre) content and the present of protein was taken as a contaminant whenever the starch meant for adhesive (Morrison, 1981).

Table1. Proximate % composition of sample from Anchomanes difformisrhizome and its starch

Sample	Moisture	Ash	Crude Fat	Crud Fibre	Protein	Carbohydrate
A	7.54^{b}± 0.27	5.30^{b}± 0.75	4.99^{b}± 0.02	5.69^{b}± 0.18	3.40^{b}± 0.25	73.09^{b}± 0.87
B	8.03^{c}± 0.08	7.38^{c}± 0.08	3.07^{b}± 0.18	5.82^{b}± 0.04	5.33^{c}± 0.01	70.09^{a}± 0.06
As	5.63^{a}± 0.38	1.02^{a}± 0.02	3.27^{a}± 0.23	0.42^{a}± 0.01	1.33^{a}± 0.45	88.06^{c}±0.11
Bs	5.81^{a}± 0.06	1.01^{a}±0.03	2.32^{a}± 0.17	0.42^{a}±0.01	1.48^{a}± 0.25	88.87^{c}± 0.11

Results are mean± standard deviation of triplicate determinations expressed on dry weight basis. Values along the same column with different superscripts are significantly different (P <0.05).
Where **A** = untreated *A. differmis* rhizome sample, **B** = treated *A. differmis* rhizome sample,
As = starch from untreated *A. differmis* rhizome sample And **Bs** = starch from treated *A. differmis* rhizome sample.

3.3. Functional properties of the flours and starch

The water absorption capacity (WAC) of differmis flour and isolated starch presented in Table3 showed that soaking of the sample in hot water as treatment before extraction of the starch increased the water absorption capacity which agrees with the findings of Sefa-Dedeh and Agyir-sackey (2006). The values obtained are higher than sweet potatoes flour, red 24% and white 26% in the flour (Osundahunsi et al.,2003). The extent of protein hydration correlates strongly with the content of polar residues as well as the interaction between water molecules and hydrophilic groups which occurs via hydrogen bonding. The higher protein content of the treated sample might be responsible for high hydrogen bonding and high electrostatic repulsion, both conditions facilitating binding and entrapment of water (Altchul and Wilcke, 1985). Hence, WAC of the treated sample gave it an advantage of being used as a thickener in liquid and semi-liquids foods since the flour and its starch has the ability to absorb water and swell for improved consistency in food.

Table2. Functional properties of the samples

Sample	WAC%	OAC%	Loose bulk density	Pack-bulk density	True density	Gelation strength%	pH	Swelling power	Solubility
A	31.00^{a}±0.00	28.17^{b}±0.29	0.58^{a}±0 02	0.63^{a}± 0.02	1.39^{a}±0.02	17.33^{a}±0.58	5.74^{a}±0.02	41.03^{b}±0.03	23.25^{b}±0.03
B	32.00^{c}±0.10	24.00^{c}± 0.00	0.50^{b}±0.00	0.53^{b}±0.01	1.45^{a}±0.02	17.33^{a}±0.58	5.60^{ab}±0.01	59.91^{a}±0.14	17.11^{c}±0.02
AS	13.33^{d}± 1.16	30.00^{a}±0.00	0.69^{b}±0.03	0.77^{b}±0.02	1.54^{b}±0.02	10.33^{b}±0.58	6.14^{b}±0.02	31.42^{c}±0.21	17.05^{c}±0.12
Bs	14.67b± 0.58	22.00^{d}±0.00	0.69^{c}±0.03	0.78^{c}±0.02	1.58^{b}±0.2	12.67^{b}±0.58	6.25^{c}±0.02	40.25^{b}±0.02	28.27^{a}±0.05

Results are mean± standard deviation of triplicate determinations expressed on dry weight basis. Values along the same column with different superscripts are significantly different (P <0.05).
Where **A** = untreated *A. differmis* rhizome sample, **B** = treated *A. differmis* rhizome sample,
As = starch from untreated *A. differmis* rhizome sample And **Bs** = starch from treated A. difformis rhizome sample

3.4.Mineral content of the flours and starch

The mineral analysis result in table.3 reveals that the rhizome of *A. differmis* appears to be rich sources of potassium when compared with the Recommended Dietary Allowances (RDA) of NRC/NAS (1989) for infants and children. Robinson (1987) reported that a diet that meets two thirds of the Recommended Dietary Allowances (RDA) values is considered to be adequate for an individual. The high content of Potassium can be utilized beneficially in diets of people who take diuretics to control hypertension and suffer from excretion of potassium through the body fluid (Siddhuraju et al., 2001) well-cooked of earlier shoot had been recommended for human consumption (Oyetayo, 2007) The calcium and Iron content in the rhizome of *A. differmis* is found to be higher than an earlier study in the corms of Colocasia esculenta and Alocasiam acrorrhiza(Aggarwal et al. 1999); tubers of Dioscorea spp. (Rajyalakshmi and Geervani, 1994; Shanthakumariet al.,2008; Murugesan and Ananthalakshmi, 1991). Iron content was higher compared to infants, children and adults RDA's of NRC/NAS (1980). The copper content, in the *Anchomanes differmis* appears to be lower when compared with the other wild yam as reported by

Shanthakumari et al. (2008). Cadmium, Chromium, Lead and Nickel were not present in both rhizome and starch of forest Anchomanes.

Steeping has significant effect on antinutrients as show by phytate and cyanide . it had been reported that physical and chemical process such as soaking, cooking germination, fermentation, selective extraction and enzyme treatment are capable of reduce antinutrients content in food. (Friedman et al., 2003; González et al., 2002). Cyanide content in these research falls below the lethal dose of free HCN for an adult; that is 50-60 mg/100g but the toxicity of bound HCN is less clearly understood.

Table 3 Minerals composition (mg/kg) of sample from Anchomanes differmis rhizome

Sample	Ca	Mg	Fe	Mn	Cu	Zn	Cd	Cr	Pb	Ni	Na	K	Sulphate	Phosphorus
A	3519.2 ^{a}±4.8	1981.76^{a} ±0.6	133.48^{a} ±1.3	39.52^{a} ±0.4	11.63^{c} ±3	18.46^{b} ±0.5	Nd	Nd	Nd	Nd	1729.69^{b} ±0.9	4185.93^{b} ±0.7	72.29a ±0.4	100.48^{b} ±0.5
B	3237.2 ^{b}±6.9	868.98^{b} ±2.6	133.51^{a} ±1.1	10.39^{b} ±0.5	3.62^{a} ±0.7	29.34^{d} ±0.5	Nd	Nd	Nd	Nd	2426.56^{a} ±1.0	6113.22^{a} ±0.0	50.51^{c} ±0.4	54.61^{c} ±0.2
As	428.65 ^{d}±2.5	68.96^{d} ±1.0	16.0^{b} ±0.0	35.16^{c} ±0.6	8.37^{b} ±0.0	5.82^{a} ±0.1	Nd	Nd	Nd	Nd	287.33^{d} ±4.0	310.29^{d} ±0.6	61.08^{b} ±0.9	112.80^{a} ±0.1
Bs	941.09 ^{c}±1.9	73.48^{c} ±0.3	11.47^{c} ±0.3	6.94^{a} ±0.1	3.56^{a} ±0.1	23.87^{c} ±0.1	Nd	Nd	Nd	Nd	827.33^{c} ±1.9	717.64^{c} ±5.1	61.08^{b} ±0.9	57.94^{b} ±1.0

Results are mean± standard deviation of triplicate determinations expressed on dry weight basis. Values along the same column with differen superscripts are significantly different (P <0.05).
Where **A** = untreated *A. differmis* rhizome sample, **B** = treated *A. differmis* rhizome sample, As = starch from untreated *A. differmis* rhizome sample And **Bs** = starch from treated *A. differmis* rhizome sample. Nd = not detected

3.5. Phytochemical properties of *A. differmis*

The glycosides are hydrolysed to HCN by the endogenous enzyme linamarase, which is present in the human digestive tract. All the traditional food processing methods reduce or remove the toxicity by releasing HCN from the glycosides. Since HCN is soluble in water and has a boiling point of 25°C it can be removed by soaking.

Tannin content are between 1.00 -1.67g/100g which is higher than Dioscorea spp (Shanthakumari et al., 2008). Recent reports show that tannins may have potential value as cytotoxic and/or antineoplastic agents (Aguinaldo et al., 2005) Improved ferment ability of meal nitrogen in the rumen has also been reported by Mathieu and Jouany (1993). while low dosages tannin (0.15–0.2 %) in the diet can be beneficial because it have positive effects on silage quality in the round bale silages, in particular, reducing NPNs (non -protein nitrogen) in the lowest wilting level (Tabacco et al., 2006) aside from the use of tannins as antimicrobial agents or prevention of dental caries; they are

Table 4. Phytochemical level of samples from Anchomanes differmis rhizome (mg/100g)

Parameter/ Sample	Phytate	Tannin	Oxalate content	Cyanide content	Cardiac Glycoside	Flavonoid	Alkaloid	Saponin
A	0.40^{b}±0.01	1.67^{a}±0.06	2.21^{b}±0.01	0.02^{a}±0.01	0.10^{a}±0.07	7.61^{c}±0.05	15.23^{c}±0.03	6.88^{b}±0.01
B	0.33^{a}±0.02	1.67^{a}±0.06	2.32^{c}±0.04	0.01^{a}±0.01	0.16^{a}±0.03	8.76^{d}±0.08	19.26^{d}±0.18	7.20^{c}±0.02
As	0.11^{c}±0.01	1.00^{a}±0.00	1.97^{a}±0.03	0.01^{a}±0.01	0.48^{b}±0.04	0.84^{b}±0.03	1.40^{a}±0.01	11.76^{d}±0.01
Bs	0.08^{c}±0.01	1.33^{a}±0.06	1.94^{a}±0.01	0.01^{a}±0.01	0.55^{c}±0.12	0.56^{a}±0.06	2.79^{b}±0.04	5.36^{a}±0.01

Results are mean± standard deviation of triplicate determinations expressed on dry weight basis. Values along the same column with different superscripts are significantly different (P <0.05).

Where **A** = untreated *A. difformis* rhizome sample, **B** = treated *A. difformis* rhizome sample, **As** = starch from untreated *A. difformis* rhizome sample And **Bs** = starch from treated *A. difformis* rhizome sample
now being used in the manufacture of plastics, paints, ceramics and water softening agents (Bandarayanake, 2002).

The presence of tannins in all of the crude extracts examined may justify their therapeutic use as astringent (*A. difformis* rhizome) to cure dysentery which is mainly due to enteric infection by Oyetayo (2007). The present offlavonoids, (a large group of naturally occurring plant phenol compounds including flavones, flavonols, isoflavones, flavononesand chalcones) in forest anchomanes is of great importance since it had been known as nature's tender drugs, possess numerous biological/ pharmacological activities. Recent reports of antiviral, anti-fungal, antioxidant, anti-inflammatory, antiallergenic, antithrombic, anticarcenogenic, hepatoprotective, and cytotoxic activities of flavonoids have generated interest in studies of flavonoid-containing plants. Of these biological activities, the anti-inflammatory capacity of flavonoids has long been utilized in Chinese medicine and the cosmetic industry as a form of crude plant extracts (Aguinaldo et al. 2005; Moon et al, 2006; Jiang et al. 2008; Kim et al. 2004; Wu et al. 2008). The presence of flavonoids in all crude plant extracts may confirm their folkloric use in treating rheumatism Akah and Njike (1990).

3.6. Pasting properties of starches from A. difformis

The result of amylograph of starches was as show in the table 4. The peaks time, pasting temperature are very close to each other indicating that both starches from the A. difformis rhizome were thermo-resistant with relatively opaque and less viscous gels, these was similar to the result obtained by Saahore et al (2005) for six different wide yam but higher than those obtained by Aprianita(2010) for Taro (72. 89), yam (72. 32) and Sweet potato (64. 48).Their aqueous suspensions contained less amylose and showed a slight tendency to retrogradation. Such properties are positive quality factors for the potential use of starches from these lesser known rhizome species.

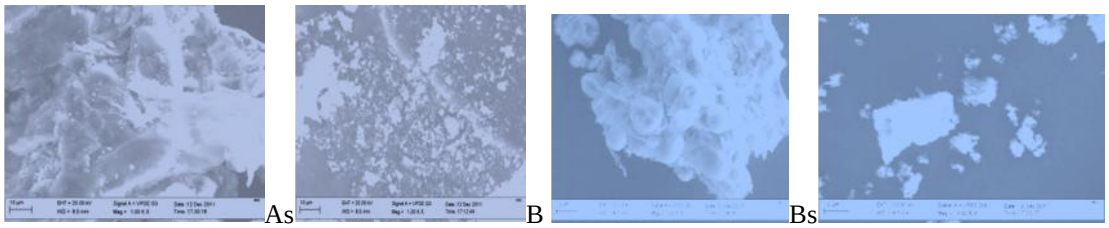
Table5. Result from amylograph of *A. difformis*

	Peak viscosity	Trough 1	Breakdown	Final Visc	Setback	Peak Time	Pasting Temp
As	254.17	245.92	10.75	377.17	131.25	4.22	81.65
Bs	245.75	216.17	29.58	327.17	111.00	4.38	82.46

Where **As** = starch from untreated *A. difformis* rhizome sample, **Bs** = starch from treated *A. difformis* rhizome sample

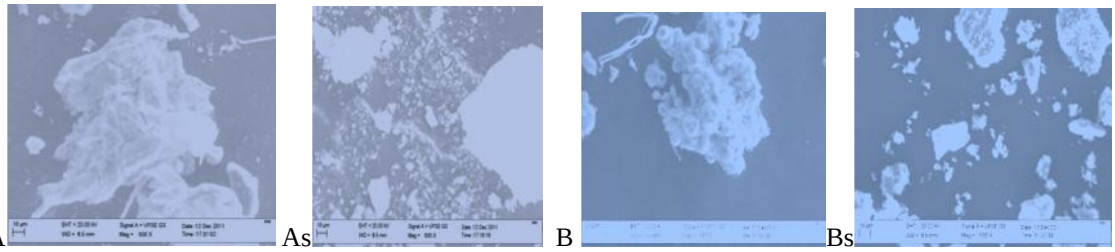
3.7. Photomicrograph of anchomanes starch at different magnifications.

Plate 1 shows the photomicrograph of anchomanes starch at various magnifications using a scanning electron microscope. The starch granules are very small sized, haxagonal in shape and show aggregation forming lumps which is the reason why the starch suspension does not settle even when left over night. It has a particle size that ranges between 1 – 1.5 μm; this is due to the fact that a light microscope was used then as against the present work that employed a scanning electron microscope. The granule size is comparable to that of amaranth starch (Bandhari and Singhal, 2002) and such small sized starches are more reactive than starches with larger granule size (,Trubiano 1987). Generally, small and medium sized starch granules have been reported to have varied utilization in the food and pharmaceutical industries (Omojola et al., 2010) which gives credence to the industrial potentials of the starch.



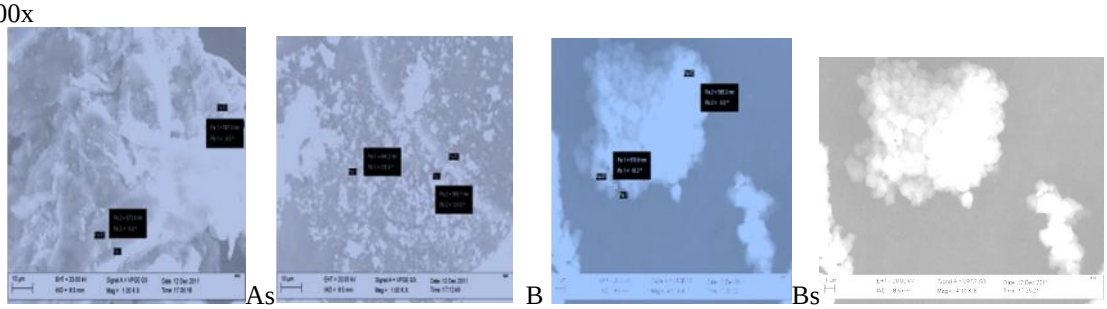
A As B Bs

Mag : 100 x



A As B Bs

Mag: 500x



A As B Bs

Mag: 1000x

Plate 1: Photomicrograph of anchomanes flour and their starch sample at 0.1 KX, 0.5 KX and 1 KX respectively

Where **A** = untreated *A. difformis* rhizome sample, **B** = treated *A. difformis* rhizome sample, **As** = starch from untreated *A. difformis* rhizome sample, **Bs** = starch from treated *A. difformis* rhizome sample.

IV. Conclusion

Some physicochemical properties of anchomanes difformis starch have been examined and these properties compare favourably with other starches. The study has therefore shown anchomanes difformis as potential source of industrial starch. This will help to reduce the burden on starch from other well-known sources such as corn, potato and cassava and make starch available at low cost; also the reduction in antinutrients as a result of the steeping in hot water enhance the nutritive value of the *Anchomanes difformis* flour thus could be fed by the animal.

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