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### RESEARCH ARTICLE

#### ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES AND ANTI-NUTRITIONAL FACTORS OF FLOUR FROM YAM (*DIOSCOREA BULBIFERA*) BULBILS IN SOUTHEAST CÔTE D'IVOIRE

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#### Abstract

In order to increase the value of aerial yam (*Dioscorea bulbifera*), studies about the physico-chemical properties and anti-nutritional factors on bulbils flour have been investigated. Samples were analyzed for proximate composition, mineral, organic acid content and levels of anti-nutritional factors using standard analytical methods. The moisture content of the bulbils flour were  $6.22 \pm 0.87$  % dw. The aerial yam (cultivar yellow) had low fat ( $2.36 \pm 0.87$  % dw), protein ( $8.12 \pm 0.02$  % dw) ash ( $3.44 \pm 0.05$  % dw) and cellulose ( $0.91 \pm 0.08$  % dw) but higher levels of carbohydrate ( $79.86 \pm 0.09$  % dw) and energy (373.16 kcal/100g). The most predominant mineral were potassium (847mg/100g). The major organic acids were oxalic acid ( $486 \pm 0.03$  mg/100g) and citric acid ( $365.4 \pm 0.5$  mg/100g). The high anti-nutritional factors (total phenol  $558 \pm 3.46$  mg/100g, oxalate  $320 \pm 2.65$  mg/100g, phytate  $469.33 \pm 2.08$  mg/100g) could pose a serious problem of public health. Therefore, it would be wise to cook bulbils before eating.

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#### Introduction:-

Roots and their tuber crops such as yams, cassava, cocoyam and sweet potatoes rank next in importance to the cereal grains in providing the major part of the daily caloric needs of people in the tropics (Ihekoronye and Ngoddy, 1985). Yams make a major contribution to the Nutrition of West Africans as a source of carbohydrate, before the introduction of cassava and sweet potatoes. They have been very important in times of famine (FAO, 1991). To fight against hunger and ensure food security of their population, most Africans living in south of Sahara countries have undertaken extensive development programs of food plant. Among them, yam is food of choice for millions of people because it represents about 12 % of their basic nutrition (Djèet *et al.*, 2010).

The genus *Dioscorea* contains a wide range of species used as food (about 600 species) (Coursey, 1967; Degras *et al.*, 1977) although the edible yams are derived from only about ten (FAO, 1991). Despite the diversity of species, only ten have been domesticated. She has given numerous cultivars (Degras, 1986; Hamonet *et al.*, 1995).

Yams are the edible tubers of various species of the genus *Dioscorea* and are important staple foods of many tropical countries including Côte d'Ivoire, Ghana, Togo, Burkina Faso and Nigeria (Kouakouet *et al.*, 2010; Amanzeet *et al.*, 2011). It is a major contributor to food security in West Africa (Zannou 2006), but out of the over 600 known yam species (Vernier *et al.*, 1998), only seven are mostly consumed (Jayakodyet *et al.*, 2007). These include *Dioscorea rotundata* Poir (White yam), *Dioscorea cayenensis* (Yellow yam), *Dioscorea alata* (Water yam),

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*Dioscorea esculenta* (Chinese yam), *Dioscorea praehensalis* (Bush yam), *Dioscorea dumetorum* (Bitter yam) and *Dioscorea bulbifera* (Aerial yam) (Otegbayo et al., 2001; Rely et al., 2006).

Yam in general are eaten boiled or fried or even roasted. The *Dioscorea bulbifera* is a vigorous climber plant native of West Africa (Hamon et al., 1995). The yam species produced aerial starchy bulbils. In Côte d'Ivoire, *Dioscorea bulbifera* comes in two varieties (wild and cultivated), is cultivated for their bulbils which are consumed once cooked like potatoes in water with oil and local ingredients. Aerial yam (*Dioscorea bulbifera*) is recorded to be an unpopular yam among the edible yam species which unlike the traditional yam produces aerial bulbils that look like potatoes hence the name aerial/air potatoes.

This species of yam is consumed by a small number of communities and is generally underutilized for a number of reasons (Igyoret et al., 2004). These include, it having a relatively bitter after-taste compared to other yam species, is unknown to most people, and much work has not been done on it to suggest uses to which it can be put to. However, there is a lot of potential for aerial yam in terms of its nutritional and functional properties that could be taken advantage of to produce diverse industrial products, not to mention its socio-economic importance (Sanful et Engmann, 2016). This bulbils-bearing yam which belongs to the Order *Dioscorea*, Family *Dioscoreaceae*, and Genus *Dioscorea* is unpopular species among the edible yam species (Nwosu, 2014). Aerial yam is grown for its bulbils and eaten during famine season (Sanful et al., 2013).

Therefore, investigation into the nutritional and other quality characteristics of the aerial yam is essential, with the ultimate aim being the promotion of its usage, and suggesting plausible products that it could be incorporated into. Since aerial yam has received very low attention by food processors and consumers. This study seeks to investigate the nutrient composition of flour aerial yam (*Dioscorea bulbifera*) yellow.

The aim of this study was therefore to characterise the flour of aerial yam (*Dioscorea bulbifera*) bulbils in order to identify appropriate uses it could be put to.

## **Material and Methods:-**

### **Raw Materials:-**

Bulbils of yam (*Dioscorea bulbifera*) used for this work were harvested at physiological maturity (6 month after planting) from the forest in Agou (South East of Côte d'Ivoire). They were immediately transported in a heap airtight store and stored in which the temperature and the relative humidity rate were  $28^{\circ}\text{C} \pm 3^{\circ}\text{C}$  and  $82 \pm 5\%$  respectively.

### **Production of flour from yam (*Dioscorea bulbifera*) bulbils:-**

At Six month of maturation just before they start falling due to senescence, bulbils were harvested and weighed. They were then peeled, washed and cut into slices (0.2 cm thickness). Five hundred of slices were dried at  $47^{\circ}\text{C}$  during 72 h. The dried slices were ground and pass through sieve ( $250\ \mu\text{m}$  size). The obtained flour was kept for analysis.

### **Proximate analysis:-**

Moisture content (on dry weight basis) was determined on fresh sliced samples after oven drying at  $105^{\circ}\text{C}$  for 24 h according to the procedure of AOAC (1990). Sugars were extracted from flours using 80% aqueous ethanol. Total sugars were determined using the method of phenol-sulfuric (Dubois et al., 1991). Reducing sugars were determined according to the method of Bernfeld (1955) using DNS. Crude fat was determined exhaustively extracting sample of flours in a Soxhlet apparatus using anhydrous hexane as solvent. Cellulose content was determined according to the gravimetric method of Van Soest (1963). Nitrogen was determined by the Kjeldahl method reported by AOAC (1990) and crude protein content was subsequently calculated by multiplying the nitrogen content by a factor of 6.25. Starch content was estimated by using the polarimetric method of BIPEA (1976). Ash content was determined by measurement of residues left after combustion in a furnace at  $550^{\circ}\text{C}$  for 8 h (AOAC, 1990). The organic matters were determined by the difference between the value of dry matter and total ash. Energy were obtained by the summation of multiplied mean values for protein, fat and carbohydrate by their respective Atwater factors, 4, 9 and 4 (Udosen, 1995).

**Determination of total carbohydrate:-**

Total carbohydrate was calculated by the difference between 100 and the sum of moisture, ash, crude fat, crude protein and crude fibre (Kirk and Sawyer, 1981): % CHO = 100 - (% moisture+ %protein % ash+ %fat content+ % Crude fiber).

**Mineral analysis:-**

Minerals were analyzed by the method reported by Oshodi (1992). The ash obtained from 1g of sample was dissolved in 10% HCl, filtered with filter paper and made up to standard volume with dionised water. Flame photometry method reported by AOAC (1990) was used to determine sodium and potassium contents of the sample. Calcium, Fe, Mg were determined using Atomic Absorption Spectrophotometer (AAS). The total phosphorus was estimated colorimetrically (UV-visible spectrophotometer, Model DR 2800/United States) (Tausky et Shorr, 1953).

**Organic acids analysis:-**

Liquid Chromatography High Performance (HPLC) was performed according to method of Ho *et al.* (1990). Fifty (50) mg of flour was dissolved in 75 ml of distilled water. The mixture was homogenized manually for 2 min and centrifuged at 4000 rpm/min for 30 min at 4°C in a centrifuge (Sigma Aldrich 2-PK). Supernatant obtained, was filtered on WATTMAN paper n°4 and then through millipore filter 0.45 µm. 20 µl of each solution obtained were analysed by an HPLC system (Schimadzu Corporation, Japon) equipped with a binary pump coupled to a UU-VS (SPD-6A) detector. Chromatographic separation of organics acids was performed on a column ISSep ICE ORH-801 at temperature set at 35°C. The flow rate of elution was 0.5 ml/min. The chromatogram obtained at 280 nm were compared to those standard of organics acids

**Total phenolic compounds analysis:-**

Total phenolic compounds were determined according to method of Julkunen-Titto (1985) using Folin-ciocalteu. A volume of 0.1; 0.2 or 0.3 ml of phenolic extract was diluted in 0.9; 0.8 or 0.7 ml of distilled water contained in the test tube. Consequently 0.5 ml of Folin-ciocalteu was added to this solution. The mixture was homogenized by manual stirring at room temperature (28°C), then leave rested on bench for 3 min. A volume of 2.5 ml of an aqueous solution of sodium (2 %, p/v) was added thereto after this reaction time. The new mixture was homogenized by manual stirring for 2 minutes and incubated on bench for 2 hours. The color intensity of the mixture was determined in a spectrophotometer at 760 nm against a controle which has not containing phenolic extract. The optical density were converted to mg of phenolic compound thanks to a calibration line prepared in the same conditions as the test and was used as the gallic acid standard phenolic compound.

**Anti-Nutritional factors analysis:-****Tannin analysis:-**

Total tannin content of yam *Dioscorea bulbifera* was determined by the spectrophotometric procedure described by Brainbridge *et al.* (1996).

**Phytate analysis:-**

The phytate was extracted with trichloacetic acid (TCA) and precipitated as ferric salt using the procedure outlined by Weeler and Ferrel (1979).

**Total oxalates analysis:-**

The level of total oxalates was determined by titration to warm of an aliquot acidified flour extract with a solution of sodium permanganate according to AOAC (1970). 0.75 g of flour was introduced into 100 ml of flask containing 76 ml of distilled water and 4 ml of hydrochloric acid. The mixture was homogenized by manual stirring for 2 min and then heated to boiling water bath for 1 hour. It was then cooled in an ice bath for 30 min and the volume was adjusted to the mark with distilled water. After filtration, first two aliquot of 40 ml each, were introduced separately in two beaker which had each received 20 ml of hydrochloric acid. The mixture was evaporated to half volume from the original and filtered on filter paper. The precipitate retained on the filter paper was washed several times with hot water until a volume about 60 ml was obtained. The resultant filtrate scored 3 drops of methyl red and ammonia until obtained pale yellow coloration. The solution was heated to boiling in a water bath for 20 min. It was cooled in an ice box for 10 min, then filtered to removed the precipitate of ferrous ion. The filtrate obtained was boiled for 10 min, then 5 ml of calcium chloride were added to it with constant stirring and let stand overnight. It was filtered on filter paper and calcium oxalate (5 %, p/v) precipitate retained by the filter paper was transferred to a beaker with distilled water and sulfuric acid until to obtain complete dissolution to precipitate heavy metals, 5 ml of

tungstophosphonate reagent were added to the acidified extract and the mixture was centrifuged at 5000 rpm/min for 15 min. The supernatant was titrated hot with constant stirring with solution of potassium permanganate.

#### **Inhibitor of alpha-amylase activity:-**

Anti-alpha amylase activity was determined according to method described by Lonstaff and Mc Nab (1991). 1 g of flour was dissolved in 10 ml of 100 mM acetate buffer. The mixture was homogenized and allowed to stand at 4°C for 12 hours and then centrifuged at 5000 rpm/min for 20 min. A volume of 0.25 ml of this extract was pre-incubated with 0.25 ml of a solution of alpha-amylase and 0.25 ml of 100 mM acetate for 15 min in buffer from 35°C. A volume of 0.5 ml of starch (1 %, p/v) was added. After 30 min of incubation, the reaction was screening halt by adding 2 ml of dinitrosalicylic acid (DNS) and heated in a bath-marie boiling for 5 min. The tuber was allowed to cool on the bench for 10 min, then 3 ml of water were added thereto. Staining intensity was determined in a spectrophotometer at 540 nm against a witness which was not contained happy enzyme extract.

#### **Inhibitor of trypsin activity:-**

Anti-trypsin activity was determined by the method described by Alonso *et al.* (1998). For extracting the inhibitor, 1 g of flour was dissolved in 10 ml of phosphate buffer at 4°C. The solution obtained was homogenized by manual stirring for 2 min and then left to stand overnight with mechanical stirring at 4°C. It was then centrifuged at 5000 rpm/min for the extract to be analysed. A volume of 20 µl of the extract was pre-incubated with 250 µl of trypsin solution (0.04 g/kg of trypsin in 0.025 M glycine-HCl buffer) and 1 ml of 0.15 M of phosphate buffer (pH 8.1) for 15 min at room temperature (28°C). Then a volume of 2.5 ml of benzyl-DL-Arginine p-nitroanilide hydrochloride (0.001 M) prepared in phosphate buffer (pH 8.1) was added quickly. After 30 min of incubation, the intensity of staining was determined in a spectro photometer at 410 nm against a control containing no enzyme extract.

#### **Statistical analysis:-**

All analyses reported in this study were carried out in triplicate. Statistical significance was established using Analysis of Variance (ANOVA) models. Mean comparison was carried out using Duncan's multiple range test ( $p < 0.05$ ), with the help of the software STATISCA 7.1 (StatSoftInc, Tulsa USA Headquarters).

### **Results and Discussion:-**

#### **Proximate analysis:-**

The proximate composition of flour from yam (*Dioscorea bulbifera*) bulbils are shown in Table 1. Moisture content estimates directly the water content and indirectly the dry matter content of the sample. It is also an index of storage stability of the flour. Flour with moisture content less than 14 % can resist microbial growth and thus has better storability (Colas, 1998 ; Okonkwo and Opara. 2010). The moisture content obtained in this study ( $6.22 \pm 0.11\%$ ) was lower than those found by Ogbuagu, (2008) and Abara, (2011) ( $7.029\%$  and  $9.20\%$  respectively). This slight difference could be associated to the level of maturity, environmental factors, experimental method of analysis, level of maturity of the tuber and type of cultivar used (Coursey, 1983 ; Abara *et al.*, 2003).

**Table 1:-** Proximate composition of flour from yam (*Dioscorea bulbifera*) bulbils.

Parameters	Composition (%)
Moisture	$6.22 \pm 0.11$
Ash	$3.44 \pm 0.05$
Protein	$8.12 \pm 0.02$
Fat	$2.36 \pm 0.02$
Cellulose	$0.91 \pm 0.03$
Total carbohydrates	$79.86 \pm 0.09$
Starch	$70.49 \pm 0.05$
Reducing sugars	$0.48 \pm 0.03$
Total sugars	$3.26 \pm 0.04$
Organic acids	$90.34 \pm 0.06$
Energy (Kcal)	$373.16 \pm 0.11$

The ash content of the yellow cultivar were found to be higher when compared with earlier report of Abara *et al.*, (2003) who reported an ash content of 2.24%. Ash content of bulbils of yam (*Dioscorea bulbifera*) ( $3.44 \pm 0.05\%$ ) is lower than that obtained in bètè-bètè (*Dioscorea alata*) yam tubers which is  $4.64 \pm 1.83\%$  (Assa *et al.*, 2014). The

percentage of ash obtained in this study shows that *D.bulbifera* will be rich in minerals. Ash content is a reflection of the mineral status, even though contamination can indicate a high concentration in a sample.

The protein content of flour from of yam (*Dioscoreabulbifera*) bulbils (8.12 ±0.02 %) is similar to that reported by Sahore and Amani (2013) but high in flours of the same specie (Libra et al., 2011).It appeared that protein content of flour from aerial yam (*D. bulbifera*) was higher than that reported on bananas (1.09%) (Mahapatraet al., 2012); white yam (5.15%) and sweet potato (3.64%) (Alaise and Linden, 1999) Thus, incorporating aerial yam flour in diet could contribute in amino acid balance.

Flour from yam (*Dioscoreabulbifera*) bulbils have low cellulose content which is 0.91 ± 0.03 %. That level is similar to that obtained in flour *Dioscoreabulbifera* purple cultivar after six months traning (Libra et al., 2011).

The fat content (2.36 ± 0.02 %) of flour from yam bulbils was quite reasonable as all root crops contain very low fat content (Ekpeyong, 1984). Thisfat content was comparably higher than that of white yam (*Dioscorearotundata*), 0.56% and sweet potato, 0.95% (Alaise and Linden,1999)butis lower than that obtained of flour of green cultivar of *Dioscoreabulbifera* which is 4.15 % (Princewill-Ogbonna and Ibeji, 2015). However, yams generally contain low levels of fat (Oyenuga, 1959; Shanthakumariet al., 2008).

The organics matter content of bulbils (93.34 ± 0.06 %) is close to that obtained in flour of kponan (*Dioscoreacayenensis-rotundata*) which is 91.23 ± 0.4 % (Konéet al., 2014).

The starch is the most important chemical component in the flours. Apart from its energy contribution, starch in most of the processed food systems is known to contribute to the texture, and as a result, to the organoleptic properties of food (Tharanathan and Mahadevamma, 2003). Flour from yam (*Dioscoreabulbifera*) bulbils have high starch content (70.49 ± 0.05 %) which. are lower than that repoted by Assaet al. (2014) in flour of bêtè-bêtè (*Dioscoreaalata*) yam tubers (74.87 ± 1.18 %).

The total and reducing sugar contents in flour from yam bulbils are respectively 0.48 ± 0.03 % and 3.26 ± 0.4 %. This is in accordance with the observation of Sahoré and Amani (2005) on of *Dioscoreaalata* tubers.

Flourfromyam (*Dioscoreabulbifera*) bulbils have high carbohydrates level (78.86 ± 0.09 %). High rate of carbohydrates shown that bulbils are energy food, that can contribute to food security in developing countries (FAO, 2001).These values are comparable to literature values 76.80 – 78.3% (Bell and Favier, 1981; Eka, 1985) and 81.31 – 87.64% (Udensiet al., 2008). The high carbohydrate and energy values of the flour yam recorded in this study make them reliable food security crops.The carbohydrate content of flour from aerial yam (76.570%) agrees with the work of Onyenuga (1968), which reported that the dry matter of most root and tuber crops is made up of about 60 to 90% carbohydrate.

Flour of yam (*Dioscoreabulbifera*) bulbils have high energy value level (373.16 ± 0.11 kcal/100 g). With this energy value, the flour of yam (*Dioscoreabulbifera*) could be used as energy in the flour poridge for infants and children (Butte, 1996).

#### Mineral analysis:-

Table 2 shows mineral content of flour of yam (*Dioscoreabulbifera*) bulbils.

**Table 2:-** Mineral content of flour from yam (*Dioscoreabulbifera*) bulbils.

Parameters	Composition (mg/100 g MS)
P	37.8 ± 1.21
Na	48.1 ± 2.29
Ca	77.1 ± 1.97
Fe	7.14 ± 0.03
K	847 ± 1
Mg	86.5 ± 1.32
K/Na	17.63 ± 0.85
Ca/P	2.03 ± 0.09

The phosphorus content of flour from yam (*Dioscorea bulbifera*) bulbils ( $37.8 \pm 1.21$  mg/100 g of dry matter) is lower than that obtained in *D. bulbifera* which is  $65.98 \pm 0.55$  mg/100 g of dry matter (Libra *et al.*, 2011). The phosphorus content of the flour is an indication that the flour products will help in the formation of teeth and bones in children and their proper development.

Sodium level of flour of yam (*Dioscorea bulbifera*) bulbils is  $48.1 \pm 6.55$  mg/100 g of dry matter). The daily sodium intake of an adult is 500 mg (NRC, 1989). With this low level in sodium, flour could be used as food without health risk for people with blood pressure.

Calcium level of flour from yam (*Dioscorea bulbifera*) bulbils ( $77.1 \pm 1.97$  mg/100 g of dry matter) is higher than that reported in plantain banana which is 7 mg/100 g of dry matter (FAO, 1999; Gayelord, 2000; Boukari *et al.*, 2001). The calcium is necessary for blood clotting. It regulates the acid-basic balance of blood, thus preventing the latter to be acids (Garcia-chuit and Boella, 2000).

The iron is the lowest mineral of flour from aerial yam (*Dioscorea bulbifera*). Its level is  $7.14 \pm 0.03$  mg/100 g of dry matter. Iron plays an important role in children development (Kordas and Stoolzfus, 2004).

The potassium the highest mineral of flour from yam (*Dioscorea bulbifera*) bulbils. Its level is  $847 \pm 1$  mg/100 g of dry matter. Potassium regulates the heartbeat and blood pressure, the water content of the body and neuromuscular excitability.

Magnesium rate of flour from yam (*Dioscorea bulbifera*) bulbils is low ( $86.5 \pm 1.32$  mg/100 g dw). Like magnesium rate relatively low, the flour would be used in a regimen to improve calcium absorption because magnesium is essential for calcium metabolism (Seeling, 1993; Kenney *et al.*, 1994).

The K/Na ratio (17.60) was close to the recommended 5.0 (Szentmihalyi *et al.*, 1998). Dietary changes leading to reduce consumption of potassium than sodium have health implications. Diets with higher ratio K/Na are recommended and these are found usually in whole foods (Arbeit *et al.*, 1992). Foods, naturally higher in potassium than sodium, may have a K/Na ratio of 4.0 or more (CIHFI, 2008).

The Ca/P ratio of flour of yam (*Dioscorea bulbifera*) bulbils is  $2.03 \pm 0.09$ . Food must have Ca/P of 1 or more. High consumption of flour of yam (*Dioscorea bulbifera*) bulbils could be recommended in diet to prevent osmotic and mineral imbalance in some sick (Appiah *et al.*, 2011).

#### Organic acid analysis:-

The organic acid content of yam (*Dioscorea bulbifera*) bulbils is resumed in table 3. Citric acid is the highest organic acid and sulfanilic acid the lowest of flour from yam (*Dioscorea bulbifera*) bulbils. Their rate are respectively  $365.4 \pm 0.5$  mg/100 g of dry matter and  $1.78 \pm 0.02$  mg/100 g of dry matter. Organic acids play an important role in food because they prevent the proliferation of microorganism (Smulder and Greer, 1998).

**Table 3:-** Organic acids composition of flour from yam (*Dioscorea bulbifera*) bulbils

Parameters	Composition (mg/100g)
Citric acid	$365.4 \pm 0.5$
Tannic acid	$4.08 \pm 0.02$
Oxalic acid	$486 \pm 0.03$
Sulfanilic acid	$1.78 \pm 0.02$
Tartaric acid	$3.26 \pm 0.01$

#### Anti-nutritional factors analysis:-

Anti-nutritional factors content are resumed in table 5. The determination of the anti-nutritional substances was of interest because of their toxicity in yams, negative effects on mineral bioavailability and their pharmacological effect. The anti-nutritional factors are substances of reserves of plants which complex some nutrients like rock salt, proteins and reduce their bioavailability during digestion. It is the case of oxalates, the phytate, tannins and total phenols, etc. These results of content of anti-nutritional factors were higher than those reported by other authors on the yam tubers.

**Table 4:-** Anti-nutritional factors composition of flour from yam (*Dioscorea bulbifera*) bulbils

Parameters	Composition (mg/100 g)
Total phenol	558 ± 3.46
Total oxalate	320 ± 2.65
Phytate	469.33 ± 2.08
Tannins	66 ± 1.73
α-amylase inhibitors	251 ± 2.65
Trypsin inhibitors	197 ± 1.73

Phenol content of 558 ± 3.46 mg/100g dw was identified in flour from aerial yam (*D. bulbifera*). The presence of phenols indicates that *Dioscorea* species could act as anti-inflammatory, anti clotting, antioxidant, immune enhancers and hormone modulators (Okwu and Omodamiro, 2005).

Tannin content of flour from yam (*Dioscorea bulbifera*) bulbils is 66 mg/100 g of dry matter was lower than those in wild yam tubers (*Dioscorea species*) (Sahorét *et al.*, 2006). The consumption of food rich in tannin can cause oesophageal cancer (Shilset *et al.*, 2006). Tannins have been reported to form complexes with proteins and reduce their digestibility and palatability (Eka, 1985). However, their contents in foods are known to reduce through cooking (Lewuet *et al.*, 2010). Tannin affects the nutritive value of food products by forming complex with protein (both substrate and enzyme) thereby inhibiting digestion and absorption (Osuntogunet *et al.*, 1989). They also bind iron, making it unavailable (Aletor and Adeogun, 1995). The phenolics and tannins are water soluble compounds (Uzogaraet *et al.*, 1990) and as such can be eliminated by soaking followed by cooking (Singh, 1988; Katariaet *et al.*, 1989; Murugesan and Ananthalakshmi, 1991; Singh and Singh, 1992; Shanthakumariet *et al.*, 2008).

Total oxalate content of yam (*Dioscorea bulbifera*) bulbils is 320 ± 2.65 mg/100 of dry matter. The lethal oxalate content in food is between 2 and 5 g (Oké, 1966). With this low lever, bulbils consumption would be safe humans.

Phytate content of yam (*Dioscorea bulbifera*) bulbils is 469.33 ± 2.08 mg/100 of dry matter. Knowledge of phytate levels in food is necessary because a high content can cause HARMFUL effects on digestibility (Nwokolo and Bragg, 1977). Phytate has been recognized as an anti-nutrient due to its adverse effects. It reduced the bioavailability of minerals and caused growth inhibition. The phytate contents of bulbils yams were higher, with values ranging from 0.89 mg/100g in *D. alata* (Akaba) to 4.16 mg/100g dry matter in *D. cayenensis* (Pure yellow flesh), compared to the 58.6 – 198 mg/100g on cultivars of *D. alata* reported by Wanasundera and Ravindran (1994). This phytate content of flour yam bulbils ranging from those of 400 to 2060 mg/100 g reported for cereals and grain legumes (Reddy *et al.*, 1982).

Phytates and oxalates are known to adversely affect mineral bioavailability (Bhandari and Kawabata, 2006).

α-amylase inhibitors content of yam (*Dioscorea bulbifera*) bulbils is 251 AUI/g of dry matter. Inhibitors delay the α-amylase hydrolysis of starch and thus reduce glucose uptake (Nickavaret *et al.*, 2008).

Trypsin inhibitors content of yam (*Dioscorea bulbifera*) bulbils is 197 TUI/g of dry matter. The inhibitors are protein which are able to inhibit serine proteases such as trypsin and chymotrypsin. Their act in formation of enzyme-trypsin are irreversible and this result cause hypertrophy of pancreas and hypersecretion of pancreatic enzymes (Besançon, 1994).

The values are very high compared to those ranged from 46.50±0.29 - 180±0.0033 obtained for *Mucunacochinchinensis* (7.47 TI unit/mg) mg/100g and *Mucunautilis* (13.00 TI unit/mg) by Ukachukwu and Obioha (1997) and Udensiet *et al.*, (2004), respectively. The presence of large quantity of trypsin inhibitor in the body disrupts the digestive process and may lead to complex formation. However, it is important to note that undesirable physiological reactions (Booth *et al.*, 1960).

### Conclusion:-

The study was carried to enhance the flour from yam (*Dioscorea bulbifera*) bulbils. The physico-chemical characterization of its flour shows their high dry matter, organic matter, total carbohydrates, energy value and potassium hence their interest in the use of human diet. The low moisture content which makes them store for a



long time. However, their high anti-nutritional factors (phenol, phytates, total oxalates, tannins,  $\alpha$ -amylase and trypsin inhibitors) can pose a serious problem of public health. Therefore, it would be wise to cook bulbils before eating.

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