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EVALUATION OF THE CHEMICAL, FUNCTIONAL AND PASTING PROPERTIES OF STARCH FROM TRIFOLIATE YAM *(Dioscorea dumetorum)* LANDRACES

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ABSTRACT

This work was aimed at evaluating the chemical, functional and pasting properties of starches from fourteen trifoliate yam landraces using standard methods. Starch yield ranged from 10.965% (in Nwaonyeukwu) to 20.481% (in Umudike). High amylose content was observed in most of the landraces except in Irok. The starch of Una-aro had the highest swelling index (1.16%). Una-nkporo and Ochuli had the highest gelatinization temperature (82.50^{o}C) while Una-asaga and Ofuanya had the lowest (80.00^{o}C). Una-nkporo had the highest peak viscosity and set back (356.790BU and 153.960 respectively). The high starch yield observed in GRU, Ojiobi and Umudike indicates a potential source of starch for manufacturing industries. The high peak viscosity and setback observed in Una-nkporo implies that it may be suitable for products requiring high gel strength, thick paste, elasticity and cohesive pastes.

Keywords: Trifoliate yam, landraces, starch, functional and pasting properties.

INTRODUCTION

Yam is the common name for some plant species in the genus Dioscorea (family Dioscoreaceae) that form edible tubers. They are grown widely in tropical and subtropical regions of the world. They are plants yielding starchy roots and tubers which contain 70-80% of moisture, 16-24% of starch and trace quantities of proteins and lipids (Huang *et al.*, 2006). In the food domain, starch constitutes an essential tool for increasing the added-value of several foods, and may serve as texturizing, thickening, and stabilizing agent. Yam is a starchy tuber, that has not been processed to any significant extent commercially, but has been limited to preparation of local dishes such as pounded yam (yam dough), and porridges. (Amani *et al.*, 2002). Production of instant yam-flour, flakes and starch has been limited due to various constraints including high fresh market price (Onayemi and Potter, 1974, FAO, 2005). Some yam varieties are widely known and over-exploited as food in some communities in Nigeria because the physiochemical properties of these yams are well known and reported.

There is need to expand utilization of yam through industrial processing to minimize post harvest losses which in turn may lead to increased earnings from this crop. The starch content of the tuber presents prospects for the processing of yams into starches. Currently, yams are not listed among the most common sources of industrial starch which is principally provided by corn, potato, wheat, tapioca and rice (Woolfe, 1992, Alexander, 1996, and Ostertag, 1996) Starch is an important raw material for a number of industries including textiles, paper, adhesives, pharmaceuticals and food. As a country becomes more industrialized, demand for both native and modified starches increases but these demand are rather met through imports instead of locally made starch.

D. dumentorum spp is not a widely studied variety. The post harvest hardening phenomenon problem has an adverse effect on the productivity of the yam. Starch production and evaluation is therefore carried out in order to improve the utilization of trifoliate yam locally and industrially. This will reduce dependence on starch importation and thus increase the industrial utilization from locally available raw material. The result from this research will benefit the breeders, processors and other researchers.

The objective of this work therefore is to evaluate the chemical, functional and pasting properties of the starch from fourteen trifoliate yam land races.

LITERATURE REVIEW

Yam is the second most important tuber crop in Africa, after cassava root, with production reaching just under one third the level of cassava (FAO, 1997). The genus Dioscorea contains a wide range of yam species used as food. There are many varieties of yam species wide spread throughout the humid tropics, the most economically important species which are grown are white yam (*D. rotundata*), yellow yam (*D. caynensis*), water yam (*D alata*), Chinese yam (*D. esculenta*), aerial yam (*D. bulbifera*) and trifoliate yam (*D. dumentorum*) (Ike and Inoni, 2006). As with other crops, there are considerable variations in chemical composition of yam, not only between different species, but also within a single species. This is due to cultural and climatic factors under which yam is cultivated, its maturity stage at harvest and the method and duration in storage (Agbaja *et al*., 2005). Starch represents one of the most ubiquitous and accessible energy sources and may be used as a potential substrate for the production of fuels and chemicals by enzymatic and chemical processes (Vengadaramana, 2013). The methods of starch processing vary with the raw material and the intended use of the starch. As an additive for food processing, food starches are typically used as thickeners and stabilizers in foods such as puddings, custards, soups, sauces, gravies, pie fillings, and salad dressings, and to make noodles and pastas. Starch may be used in all traditional recipes in most cases giving better functionality.

METHODOLOGY

Fourteen trifoliate yam landraces (namely: GRU, Umudike, Oji-obi, Una-asaga, Una-aroDM6, Nwaonyeukwu, Una-okposi, Eleme, Una-nkporoDM$_3$, Ochuli, Una-nkporo$_2$DM$_7$, Ofu-anya, Una-ngwa and Irok) were obtained from the yam barn of National Root Crops Research Institute, Umudike, Nigeria.

Starch Isolation

The yam tubers were weighed, peeled, cut into smaller pieces, washed and wet-milled. Water was added to the milled paste and the resulting slurry was sieved with the aid of a muslin cloth. The sieved slurry was allowed to stand for sedimentation to take place. Then the supernatant was decanted off leaving the wet starch. The wet starch was then dried at 40^{o}C (oven dried). Then the starch was dry-milled after which it was sieved with a mesh to obtain the dried starch powder.

Determination of Chemical Properties

Amylose Content

Amylose content was determined using the method of Juliano (1971), Hoover and Ratnayake (2002). Exactly, 0.1g (100mg) of samples (starches) were weighed into a 10ml volumetric flask and 1ml of 99.7-100% (v/v) ethanol and 9ml of IN-sodium hydroxide (NaOH) were carefully added, the mouth of the flask was then covered with foil and the content mixed well. The samples were heated for 10min in a boiling water to gelatinize the starch (the timing started when the boiling began).

The samples were then removed from the water bath and allowed to cool very well. It was then filled up to the mark with distilled water and shaken well. About 5ml of the mixture was then pipette into another 100ml volumetric flask. Acetic acid (IN, 1.0ml), and 2ml of iodine solution were added and top to mark with distilled water. Absorbance (A) was read using spectrophotometer at 620nm wavelength.

The blank contained 1ml of ethanol, 9ml of NaOH, and then boiled and top up to the mark with distilled water. 5ml was then pipette into 100ml volumetric flask. Approximately, 1ml of acetic acid and 2ml of iodine solution was added and then filled to mark, this was used to standardize the spectrophotometer at 620nm. Amylose content was estimated thus:
Amylose content (%) = (3.06)(A)(20) = 61.20(A)
Amylopectin = 100 - Amylose

Determination of Functional Properties

Swelling Index

One gram of the starch was weighed into 10ml measuring cylinder and the volume it occupied was recorded (V_1). Distilled water was added until the 10ml mark was reached. The cylinder containing the sample and distilled water was left to stand for 45 minutes after which the new volume (V_2) was recorded. The swelling index was expressed as the ratio of the final over the initial volume (Ojinnaka, 2014)

Bulk Density

10ml capacity graduated measuring cylinder was weighed. The cylinder was gently filled with the sample, then the bottom of the cylinder was gently tapped on the laboratory bench several times until there is no further diminution of the sample level after filling to the 10ml mark. The bulk density was calculated as weight of sample (g) per volume of sample (ml). (Onwuka, 2005).

Gelatinization Temperature

The method of Onwuka (2005) was used. A 10% suspension of the starch sample was prepared in a test tube. The aqueous suspension was heated in a boiling water bath, with continuous stirring. Then the temperature was recorded 30 seconds after gelatinization was visually noticed as the gelatinization temperature.

Water and Oil Absorption Capacity

One gram (1g) of the sample was weighed into a conical graduated centrifuge tube. Using a Warring mixer, the samples were mixed thoroughly with 10ml distilled water for 30 seconds. The samples were removed and allowed to stand for 30mins at room temperature and centrifuged at 5000xg for 30mins. The volume of free water or oil (the supernatant) was read directly from the graduated centrifuge tube calculation: The amount of oil or water absorbed (total minus free) is multiplied by IPS density for conversion to grams (Onwuka, 2005)

Pasting Property Evaluation

The pasting property of starch was determined with the Rapid Visco Analyser (RVA). 3.5g of the starch sample was weighed and dispensed into the test canister. 25.0ml of distilled water was dispensed into the canister (14% moisture basis). The Visco Analyser was automatically recorded on the graduated sheet of the instrument. (Onayemi and Potter, 1994)

Statistical Analysis

All data obtained from the analysis of the *D. dumetorum* starch were subjected to analysis of variance (ANOVA) using SPSS software package. Means were separated using Duncan Multiple Range test to determine the significant difference at 5% probability.

RESULTS

The results of the chemical properties of starches extracted from trifoliate yam varieties are presented in Table 1. The starch yields of the trifoliate yam landraces varied significantly (P<0.05) and ranged from 10.965% (in Nwaonyeukwu) to 20.481% (in Umudike).

Table 1: Chemical Properties of *D. dumetorum* Landraces

Landraces	Starch	Amylose	Amylopectin
Gru	20.006 ± 0.815 ^{a}	18.941 ± 0.126 ^{j}	81.059 ± 0.216 ^{b}
Umudike	20.481 ± 0.030 ^{a}	28.060 ± 0.043 ^{a}	71.940 ± 0.043 ^{I}
Ojiobi	20.137 ± 0.777 ^{a}	26.772 ± 0.125 ^{b}	73.225 ± 0.130 ^{h}
Una-asaga	15.723 ± 0.419 ^{cd}	23.959 ± 0.043 ^{c}	76.035 ± 0.036 ^{g}
Una-aro$_{DM6}$	11.906 ± 0.347 ^{ef}	20.746 ± 0.173 ^{h}	79.253 ± 0.173 ^{c}
Nwaonyeukwu	10.965 ± 1.050 ^{f}	22.797 ± 0.130 ^{d}	77.203 ± 0.130 ^{f}
Una-okposi	16.813 ± 1.132 ^{bc}	21.206 ± 0.216 ^{g}	78.794 ± 0.216 ^{d}
Eleme	17.830 ± 0.919 ^{b}	22.613 ± 0.431 ^{de}	77.386 ± 0.043 ^{f}
Una-nkporo $_{DM3}$	16.211 ± 564 ^{bcd}	24.021 ± 0.438 ^{c}	75.979 ± 0.044 ^{g}
Ochuli	14.897 ± 1.263 ^{d}	21.756 ± 0.303 ^{f}	78.243 ± 0.303 ^{e}
Ofuanya	11.603 ± 0.472 ^{ef}	22.766 ± 0.000 ^{d}	77.478 ± 0.345 ^{f}
Una-nkporo2 dm$_{7}$	13.056 ± 0.857 ^{e}	22.277 ± 0.000 ^{e}	77.478 ± 0.345 ^{f}
Una-ngwa	15.727 ± 0.965 ^{cd}	22.577 ± 0.440 ^{de}	77.172 ± 0.860 ^{f}
Irok	14.762 ± 0.965 ^{d}	11.689 ± 0.086 ^{k}	88.311 ± 0.086 ^{a}

Mean ± S.d of duplicate determinations. Means followed by the same superscripts in a column denote values that are not significantly different at (p<0.05).

The functional properties of the trifoliate yam landraces are recorded in Table 2. The swelling index of the trifoliate yam landraces varied significantly (P<0.05) except in Umudike, Una-nkporo, Nwaonyeukwu, GRU, Ojiobi, Una-okposi, Una-Asaga and Eleme. Una-aro had the highest swelling index (1.16%) while Ochuli had the lowest (1.00%). There were significant differences in the bulk density of starches of the trifoliate yam landraces (P<0.05). Eleme had the highest bulk density (0.743 g/mol) while Ojiobi had the lowest (0.579 g/mol). There was significant difference (P<0.05) in the gelatinization temperature of the starches extracted from the trifoliate yams used for the study. Una-nkporoDM$_{7}$ and Ochuli had the highest gelatinization temperature (82.50^{0}C) while Una-asaga and Ofuanya had the lowest (80.00^{o}C). The oil absorption capacity of the starches extracted from the trifoliate yams differ significantly (P<0.05). Una-Asaga had the highest oil absorption capacity (10.795 g/mol) while the least oil absorption was observed in Una-ngwa (9.700 g/mol). Water absorption capacity of starches produced from the trifoliate yam landraces varied significantly (P<0.05). Irok had the highest water absorption 10.20% while Una-ngwa had the lowest (9.70%). There was no significant difference between the water absorption capacity of Eleme, Una-Asaga, Ofuanya, Una-okposi, Ojiobi, Una-nkporo and Ochuli.

Table 4.2: Functional Properties of *D. dumetorum* Landraces

Landraces	Swelling index	Bulk density	Gelatinization Temp	Oil Absorption	Water absorption
Gru	1.040 ± 0.000^{cd}	0.667 ± 0.134^{bc}	82.00 ± 0.000^{ab}	10.060 ± 0.240^{e}	10.150 ± 0.212^{a}
Umudike	1.015 ± 0.021^{cd}	0.702 ± 0.212^{ab}	81.00 ± 0.000^{abc}	10.340 ± 0.155^{cd}	10.100 ± 0.141^{ab}
Ojiobi	1.040 ± 0.000^{cd}	0.579 ± 0.000^{e}	82.00 ± 0.000^{ab}	10.340 ± 0.155^{cde}	10.050 ± 0.707^{abc}
Una-asaga	1.065 ± 0.035^{bcd}	0.650 ± 0.552^{bcd}	80.00 ± 0.000^{bc}	10.795 ± 0.162^{a}	9.850 ± 0.707^{bc}
Una-aro$_{DM6}$	1.160 ± 0.056^{a}	0.657 ± 0.555^{bcd}	81.50 ± 0.707^{abc}	10.455 ± 0.318^{bc}	10.100 ± 0.141^{ab}
Uwaonyeukwu	1.025 ± 0.021^{cd}	0.649 ± 0.000^{bcd}	81.00 ± 0.000^{abc}	10.625 ± 0.077^{ab}	10.100 ± 0.141^{ab}
Una-okposi	1.040 ± 0.000^{cd}	0.669 ± 0.304^{bcd}	81.50 ± 0.707^{abc}	10.295 ± 0.091^{de}	9.950 ± 0.707^{abc}
Eleme	1.065 ± 0.035^{bcd}	0.743 ± 0.155^{a}	81.50 ± 0.737^{a}	10.450 ± 0.000^{bcd}	9.900 ± 0.141^{abc}
Una-nkporo $_{DM3}$	1.020 ± 0.028^{cd}	0.613 ± 0.063^{de}	82.50 ± 0.747^{abc}	10.050 ± 0.707^{ab}	10.050 ± 0.707^{abc}
Ochuli	1.000 ± 0.000^{d}	0.634 ± 0.148^{cde}	82.50 ± 0.707^{c}	10.050 ± 0.707^{de}	10.050 ± 0.707^{abc}
Ofuanya	1.020 ± 0.000^{cd}	0.639 ± 0.360^{cd}	80.00 ± 1.414^{abc}	9.800 ± 0.000^{ab}	9.800 ± 0.000^{bc}
Una-nkporo2 dm$_7$	1.140 ± 0.028^{a}	0.634 ± 0.212^{cde}	82.50 ± 0.707^{a}	9.900 ± 0.141^{de}	9.900 ± 0.141^{abc}
Una-ngwa	1.130 ± 0.000^{ab}	0.635 ± 0.198^{cd}	81.00 ± 0.000^{abc}	9.700 ± 0.282^{e}	9.700 ± 0.282^{c}
Irok	1.090 ± 0.070^{abc}	0.688 ± 0.304^{bc}	82.00 ± 0.000^{ab}	10.200 ± 0.282^{a}	10.200 ± 0.282^{a}

Mean ± S.d of duplicate determinations. Means followed by the same superscripts in a column denote values that are not significantly different at ($p<0.05$)

The pasting properties of the extracted trifoliate yam starches are presented in Table 3. The pasting temperature of yam starches extracted for this study varied significantly ($P<0.05$). The pasting temperature of starches ranged from 85.70^0C - 88.92^0C with Umudike having the lowest and Ojiobi having the highest. Una-okposi had the lowest pasting time (4.50 mins) while the highest pasting time of 4.80 mins was recorded for Una-nkporo, Ofuanya, and Irok. Una-nkporo had the highest peak viscosity of 356.79 BU while Una-okposi was lowest (84.04 BU). Eleme and Ojiobi had the highest (228.50BU) and Lowest (140.37BU) breakdown viscosities respectively. There was no significant difference in the breakdown viscosity of Irok, Una-Asaga, Una-ngwa and Ochuli which had breakdown viscosity ranging from 210.250BU to 222.29BU. Setback values ranged from 153.96 BU (for Una-nkporo) to 46.00BU (for Una-okposi).

Table 3: Pasting Properties of Trifoliate yam (*D. dumetorum*) Landraces

Trifoliate yam landraces	**Pasting Temp(^{o}C)**	**Peak Time (mins)**	**Peak**	**Final visco (BU)**	**Breakdown Viscosities**	**Trough**	**Set Back**
Gru	86.500^{def}	4.600^{d}	269.960^{cd}	155.415^{f}	176.625^{c}	93.335^{f}	62.085^{e}
Umudike	85.700^{f}	4.565^{e}	269.295^{cd}	153.790^{f}	182.625^{c}	86.670^{f}	67.125^{e}
Ojiobi	88.925^{a}	4.700^{bc}	200.250^{e}	112.205^{g}	140.395^{e}	59.875^{g}	52.335^{f}
Una-asaga	86.075^{ef}	4.730^{b}	354.875^{b}	247.000^{d}	210.250^{b}	144.625^{d}	92.375^{c}
Una-aro$_{DM6}$	86.525^{def}	4.670^{c}	287.210^{c}	204.835^{e}	157.420^{d}	129.790^{e}	75.040^{d}
Nwaonyeukwu	85.750^{f}	4.670^{c}	262.960^{d}	163.585^{f}	176.710^{c}	86.250^{f}	77.335^{d}
Una-okposi	86.050^{f}	4.500^{e}	195.162^{e}	84.040^{h}	157.125^{d}	38.040^{h}	46.000^{g}
Eleme	85.725^{f}	4.600^{d}	386.710^{a}	247.830^{d}	228.500^{a}	158.205^{c}	89.625^{c}
Una-nkporo $_{DM3}$	88.525^{ab}	4.800^{a}	375.085^{b}	356.790^{a}	154.250^{d}	202.830^{a}	153.960^{a}
Ochuli	86.850^{de}	4.600^{d}	343.040^{b}	206.750^{e}	222.290^{ab}	120.750^{e}	86.000^{c}
Ofuanya	87.325^{cd}	4.800^{a}	361.500^{b}	283.040^{c}	179.955^{c}	181.545^{d}	101.500^{b}
Una-nkporo2 dm$_7$	87.750^{bc}	4.730^{b}	363.500^{b}	254.460^{d}	210.545^{b}	152.960^{d}	101.500^{b}
Una-ngwa	86.975^{cd}	4.800^{a}	399.580^{a}	296.625^{b}	210.250^{b}	190.790^{b}	101.835^{b}

Means followed by the same superscripts in a column denote values that are not significantly different ($p<0.05$)

DISCUSSION

Chemical Properties of Landraces of Trifoliate Yam (*Dioscorea dumentorum*)

The difference in the starch yields could be attributed to differences in the makeup of the different landraces. A similar observation was reported by Ezeocha *et al*, (2014) for *D. rotundata* cultivars. The starch yield obtained are within the range reported by Amoo *et al*., (2014) for 4 yam varieties ranging from 12.61% - 20.86%. The higher starch yields recorded for GRU, Ojiobi, and Umudike indicates a potential source of starch for commercial use in the manufacturing industries.

Amylose and amylopectin ratios are one of the important parameters reported to contribute to good textural attributes of root and tuber crops (Ikegwu *et al*., 2009). The general low content of amylose of the starch of trifoliate yam landraces (less than 50%) indicates that when these starches are incorporated into food products, swelling of starch will be enhanced (Testa and Morrisson, 1990). The difference in amylose content of the tubers could be attributed to differences in the cultivars. The amylose content is higher than that of cassava starch 17 %, while it is similar to that of corn starch 24-26 % (Ahmed *et al*., 2005). The high content of amylose in the trifoliate yam landraces may suggest possible use in the manufacture of noodles. It has been observed that boiled tubers (yam) are characterized by high amylose, dry matter and starch contents (Otebayo *et al*., 2001). The amylopectin content were higher than the result obtained by Amoo *et al*., (2014), who reported amylopectin content of 4 yam varieties ranging from 68.45-72%.

Functional Properties

The high swelling index as observed for Una-aro (1.16%) is indicative of the suitability of such starch for use as a disintegrant in the pharmaceutical industry (Omojola, 2013). The high bulk density of Eleme suggests that the starch polymers of this landrace have a loose structure (Plaami, 1997). Bulk density is important in determining package requirement, material handling and application in wet processing in the food industry (Kulkami *et al*., 1996).

The sequence of changes that occur when starch granules in the presence of water and heat form a paste is known as starch gelatinization. The temperature range where this process occurs is an important parameter in determining starch utilization in the industries (Omojola, 2013). The gelatiniation temperature of the trifoliate yam starches is high. Gelatinization changes the viscosity of starch mixture, causing it to thicken. It also improves the availability of starch for amylose hydrolysis which is an important step in the breakdown of the starch to form different products (GRIN, 2009). Gelatinization affects digestibility and texture of starch containing foods.

The oil absorption capacity of the trifoliate yam starches is similar to that of Eke-Ejiofor and Onwuno (2014), who obtained value ranges of 9.20-11.30 for cassava and potato. The water absorption capacity measures the volume occupied by the starch after swelling in excess water, and indicates the integrity of starch in aqueous dispersion (Leonel, 2009). The water absorption capacity is important in texture and quality of some foods since they stabilize starches against effects such as syneresis, which sometimes occur during retorting and freezing (Ellis *et al*., 2003; Baker *et al*., 1994). From the result obtained the higher water absorption capacity of Irok may influence its use in products that require high unit yield.

Pasting Properties of the Starches from Trifoliate Yam (*Dioscorea dumentorum*) Landraces

Pasting properties are important functional characteristics of starches. When an aqueous suspension of starch is heated above a critical temperature, granule swell irreversibly and amlyose leaches out into the aqueous phase, resulting into increased viscosity (pasting) (Brabet *et al*., 1998). The pasting temperature provides an indication of the minimum temperature required for sample cooking, energy cost involved and other component stability (Ikegwu *et al*., 2009). It also gives an indication of the gelatinization time during processing (Odedeji and Adeleke, 2010). Oguntunde (1987) reported that the associative bonding of the amylose fraction is responsible for the structure and pasting property of starch granule. The pasting temperature of the trifoliate yam starches used in this work is in line with results obtained by Amoo *et al*., (2014), who recorded pasting temperatures for starches obtained from 4 local yam varieties which ranged from 75.1 to 77.3°C. It can also be observed from the results (Table 3) that the higher the pasting temperature, the longer the pasting time. The pasting time of the trifoliate yam starches is low compared with the pasting time recorded by Amoo *et al*., (2014), who observed pasting time of 17.40-17.55 mins for yam varieties. The difference in the pasting time may be attributed to difference in cultivar. The starches with shorter pasting time such as that of Umudike and Una-okposi landraces maybe appropriate for the production of foods that require shorter processing time.

Peak viscosity is a measure of the ability of the starch to form a paste. It is also the ability of starch to swell freely before their physical breakdown (Sanni *et al*., 2001). Peak viscosity has been reported to be closely associated with the degree of starch damage. According to Sanni *et al*., (2001), high starch damage results in high viscosity. The peak viscosity obtained for D. *dumentorum* landraces are in line with the result obtained by Aviara *et al*. (2010), who reported peak viscosity ranging from 325-398 BU for starch extracted from sorghum, however, it is low as compared with the result obtained by Amoo *et al*., (2014), who recorded peak viscosity of 639-726 BU for yam starches.. The high peak viscosity observed in Una-nkporo implies that it may be suitable for products requiring high gel strength, thick paste and elasticity.

Breakdown measures the ability of starch to withstand collapse during cooling or the degree of disintegration of granules or paste stability (Jimoh *et al*., 2009; Oguntunde, 1987). Adebowale *et al*., (2005) reported that the higher the breakdown viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking. The breakdown viscosity of the trifoliate yam starches is within the range obtained by Aviara *et al*. (2010) (145-216 BU) for sorghum and Amoo *et al*. (2014) (15-385 BU) for yam starches.

Setback measure the re-association of starch (Jimoh *et al*., 2009). Kin *et al*., (1995) reported that a high setback value is associated with cohesive paste. The result obtained from this work agrees with the values obtained by Aviara *et al*. (2010) and Amoo *et al*., (2014) for sorghum (104-140BU) and yam (79-339 BU) respectively. Low setback values are useful for products like weaning foods which require low viscosity and paste stability at low temperature (Oduro *et al*., 2001). Hence, Una-okposi may be useful for such products. Conversely, starch from Una-nkporo may be useful for products such as pounded yam that require high cohesive pastes.

CONCLUSIONS

The high amylose content in umudike may contribute to good textural attributes. Una-okposi may be used industrially for products that require high unit yield as well as products such as weaning foods that require low viscosity and paste stability at low temperatures. Una-nkporo may also be suitable for production of noodles. Una-nkporo may have the highest ability to withstand heating and shear stress during cooking due to its high viscosity. Gru, Umudike, Ojiobi can be exploited for starch production because of their high starch yield. The extracted starch may be used in the industries or for food products that require thick paste, high gel strength and elasticity. Umudike and ojiobi may be used in the preparation of pounded yam and fufu. Starches from Umudike can also be employed in food preparations that require shorter processing time. ojiobi may be favourable for the preparation of weaning foods. Umudike, una-okposi and una-nkporo can also serve as alternate sources of starch based on their unique characteristics and thus, can be used for diverse products.

With the high starch yield obtained from *D. dumentorum* landraces as compared with cassava and corn, the industrial potential of the yams could be fully exploited for starch production. The available data on the industrial potentials of the yams and starch is adequate to encourage the commercial production of *D. dumentorum* landraces for commercial starch production.

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