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# Functional and Pasting Properties of Lesser Known Nigerian Yams as a Function of Blanching Time and Particle Size

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**Abstract:** The Effects of blanching time and particle size on functional and pasting characteristics of some lesser known Nigerian yams were investigated. Two varieties of lesser known yam *Ighu* and *Ona* belonging to *Dioscorea dometorum* species and two varieties of commonly used yams *ozibo* and *okwanankata* belonging to the *D. rotunda* and *D. alata* sp., respectively. The yams were processed by peeling, cubing, and blanching at 100ºC for 5 or 10 min, drying at 50ºC and subsequently milled to flours and fractionated to 40, 60, or 80 mesh sizes. Another batch of the tubers were processed similarly, but they were not subjected to a blanching treatment. Swelling capacity, water absorption capacities, bulk density, solubility and pasting characteristics were evaluated. The result showed that the lesser known yam *Ighu* exhibited significantly higher ($p<0.05$) hot and cold paste viscosities, solubility, water absorption and swelling capacities than the common yam varieties. Hot and Cold paste viscosities, solubility, water absorption and swelling capacities of flour generally increased as particle size decreased in all the test samples. While the bulk density was not affected by the blanching treatment, it decreased with decrease in particle size. The yam starches generally showed weak stability,but starch of the lesser known variety *Ona* suffered the least share thinning . Rate of retrogradation was found to be high in all the yam varieties but more pronounced in the lesser known yams *Ighu* and *Ona*. *Ighu* starch which exhibited the highest cold and hot paste viscosity showed the highest setback and index of gelatinization values. Industrial and culinary applications of the test yam varieties were suggested.

**Key words:** Blanching, functional, Nigeria, particle size, pasting properties, yams

## INTRODUCTION

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, but has not been processed to any significant extent commercially. It's use has mainly 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 have been explored but industrial scale production has been limited due to various constraints including high fresh market price (FAO, 2005; Onayemi and Potter, 1974). Whereas some yam varieties are widely known and overexploited for food, many other varieties are known and exploited as food only in a few rural communities in Nigeria. Over dependence on the common yam varieties for food and industrial use account for the high market price of yams which indirectly limits industrial exploitation. Physicochemical properties of some of the widely exploited yam varieties have been reported. High swelling capacity has been reported for common variety of *D. rotundata* (Ayernor, 1976) and *D. alata* (Rasper and Coursey, 1967). The high swelling capacity of these yams were attributed to weak internal bonding, large starch granules (Oxford *et al*., 1987) and low amylose content (Aoakwa and Sefa-Dedeh, 2001). These factors are also known to affect water binding capacity of the yams (Ayernor, 1976) The rheological properties of common yam starches have also been shown to be dependent on cooking time and temperature (Sebio and Chung, 2006) as well as particle size of flour (FIIRO, 2005). No study has been reported on the physicochemical properties of flours of the test lesser known Nigerian yams. A study of the functional properties of the flour of these yams as well as the factors affecting these properties will help in determining their potential industrial and culinary applications. Hence this work aims at evaluating the functional and pasting characteristics of flour of some lesser known Nigerian yams as influenced by blanching time of tuber and particle size of flour.

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## MATERIALS AND METHODS

The four varieties of Nigerian yams studied are; "*Ozibo*" a variety of *D. rotunda*, *Ona* and "*Ighu*" are varieties of *D. dometorum* and "Okwanankata a variety of *D. alata*. The "*Ozibo*", "*Okwanankata*" and "*Ona*" were purchased from a village market in Izzi Ebonyi State, South East of Nigeria. Ighu was purchased from Oya-Agu, Udi in Enugu State. South East Nigeria (The location of purchase was based on availability). The *ozibo* variety is the popular white yam variety.

**Production of yam flour:** A set of unblanched yam flour was prepared from each of the four varieties of yams. The yam tubers were peeled, washed, diced and dried in a laboratory electric oven (Ambassador) at 45-50ºC for 48 h. The dried yam was milled in an attrition mill, The flour from the mill was fractionated to 40, 60 and 80 mesh sizes using the method described by Okaka *et al.* (1997). The samples were then stored in a freezer compartment.

To prepare blanched yam flour, The yam tubers were peeled, washed, diced and blanched. The first batch was blanched at 100ºC for 5 min, while the second was blanched 100ºC for 10 min. The samples were then dried at 45-50ºC for 48 h in an electric oven (Ambassador), milled in an attribution mill and the flour obtained were subsequently fractionated as described earlier and stored in a freezer compartment.

**Determination of amylose and amylopectin content:** The method described by Williams *et al*. (1970) was used to determine the amylose and amylopectin contents. The concentrations of the amylose in the samples were determined by reference to amylose standard curve. The amylopectin content were obtained by subtracting the amount of amylose from the total amount of starch and the values were expressed as percentage of starch content.

**Determination of solubility:** The solubility of the flour samples at 70ºC were determined by the method described by leach *et al.* (1959).

**Determination of swelling capacity:** The swelling capacity of the flour samples were determine using the method described by Onayemi and Potter (1974).

**Determination of water absorption capacity:** The water absorption capacity of the flour samples were determined as described by Okoli (1998).

**Determination of bulk density:** The bulk density was determined using the method described by Mao *et al.* (1965).

Table 1: Amylose and amylopectin content (%) of flours from different yam varieties

| Variety of yam | Amylose | Amylopectin | Amylose/amy Lopectin ratio |
|---|---|---|---|
| *Ozibo* | 20.95a | 79.05b | 0.265 |
| *Okwanankata* | 22.64a | 77.36b | 0.290 |
| *Ighu* | 20.80a | 79.20b | 0.262 |
| *Ona* | 21.41a | 78.59b | 0.272 |

Values are means of three replicate. Values with the same letter (a or b) are not significantly different at ($p \leq 0.05$).

Table 2: Variation of yam starch solubility with blanching time

| Yam variety | Unblanched | Blanching time 5 m | 10 m |
|---|---|---|---|
| *Ozibo* | 31.63a | 33.77b | 38.50c |
| *Okwanankata* | 29.26a | 32.33b | 35.42d |
| *Ighu* | 30.60a | 41.50a | 48.10a |
| *Ona* | 30.70a | 39.00a | 45.30b |

Along the same rows values followed by the same letters are not significantly different (p>00.05)

**Evaluation of pasting properties:** Rapid Visco-Analyzer was used to evaluate the pasting properties of the yams. The instrument was used to access the pasting temperature, peak viscosity, stability, cold paste viscosity, set back and index of gelatinization

## RESULTS AND DISCUSSION

**Amylose and amylopectin:** The Amylose and Amylopectin contents of the yam varieties are presented in Table 1. The results showed that the amylose fraction in the yam varieties ranges from 20.8-22.64%. Flour derived from *Okwanankata* had the highest amylose fraction (22.64%) while the *Ighu* had the least (20.8%). Statistically there was no significant difference($p \geq 0.05$) in the amylose and amylopectin contents of the yam varieties.

**Solubility:** Table 2 shows the solubility of the starch of the yam varieties as affected by the blanching time .The results showed that solubility of the starches of the test yam varieties were not significantly different (p>0.05)in un blanched samples. Solubilities of the samples were significantly affected by blanching time at 100ºC.

The flours from unblanched samples had an average solubility value of (30.6%) which was significantly lower ($p \leq 0.05$) than solubility of yam starch blanched for 5 min (36.6%). Yam samples blanched for 10 min on the average yielded starch which was more soluble (41.8%) than the 5 min treatment by 14.1%. In general, the *ighu* variety was most soluble at both blanching times.

Particle size significantly affected the solubility of the yam starches studied (Table 3). Solubility was lowest in flour samples of 40 mesh particle size and highest in samples with 80 mesh size. 60 mesh size samples had intermediate solubility relative to other samples. This trend was observed in both blanched and un blanched samples.

Table 3: Effect of particles size on solubility of yam starch

| | Unblanched | | | Blanched | | |
|---|---|---|---|---|---|---|
| Yam variety | 40 Mesh | 60 Mesh | 80 Mesh | 40 Mesh | 60 Mesh | 80 Mesh |
| *Ozibo* | 28.2a | 30.4b | 36.3c | 32a | 34.0c | 34.6f |
| *Okwanankata* | 27.9a | 29.2b | 30.7c | 36b | 33.0c | 34.0f |
| *Ighu* | 28.0a | 30.0b | 34.0c | 38b | 41.2d | 45.3g |
| *Ona* | 28.4a | 31.0b | 32.8c | 36b | 39.4d | 42.0h |

Along the same rows values followed by the same letters are not significantly different (p >0.05)

Table 4: Effect of blanching on bulky density of yam flour

| | | Blanching time (m) | |
|---|---|---|---|
| Yam variety | Unblanched | 5 min | 10 min |
| *Ozibo* | 0.52a | 0.53a | 0.54a |
| *Okwanankata* | 0.46c | 0.48c | 0.49c |
| *Ighu* | 0.41a | 0.42a | 0.43a |
| *Ona* | 0.38d | 0.35d | 0.40d |

Along the same rows values are not significantly different(p>0.05)

Blanching for 5 and 10 min, respectively produced 6.7 and 21% increase in solubility in *Ozibo.* 10.4 and 21% increase in *Okwanankata*, 35.4 and 56.8% increase *Ighu* and 27 and 47.5% increase in *Ona.* These results suggest that increase in blanching time produced more significant increase in solubility in *Ighu* and *Ona* than in *Ozibo* and *Okwanakata*. In all cases the *Ighu* and Ona varieties showed greater response to increase in solubility with decrease in particle size. However, it is worthy to note that the increase in solubility observed with decreases in flour particle size was more pronounced in unbalanced samples .

The range of applications of flour as food ingredients is dependent on their solubility since their interactions with water determines to what extent they can impact their desired functionality. The present investigation show that the starch of the lesser known yam varieties especially the *Ighu a*nd *Ona* are highly soluble when blanched at $100^0$C. These varieties of yam will find good applications in food system where solubility of starch is needed.

**Bulk density (g/mL):** The bulk densities of the yam flours are presented in Table 4 and 5. The results showed that blanching time had no effect on bulk density of flour. Bulk density was however significantly ($p \leq 0.05$) affected by the particle size of the flour as well as the variety of yam. On the average, the flour derived from *Ozibo* has the highest bulk density (0.53 g/mL) followed by *Okwankata* (0.49 g/mL) and *Ighu* (0.425 g/mL). Ona flour was the least bulky with an average value of 0.39 g/mL. The bulk density showed consistent decline with decrease in particle size (Table 5).

This is in agreement with the report of Okaka *et al*. (1997) which suggested that bulk density of flour is not affected by factors such as blanching time and temperature, but is affected by factors such as particle size. The significantly low bulk density of *Ona* will make this variety usefully in food formulations where low bulk is desired such as in baby foods.

**Swelling capacity:** Swelling capacities (%) of the flours from the test yam varieties yam are shown on Table 6 and 7. The results showed that the test flours showed moderate swelling power, and that particle size of the flour affect the swelling capacity. (Table 6 and 7) Swelling capacity was generally highest in flour with particle size of 80 mesh and decreased as the particle size increased to 40 mesh. *Ozibo* for instant in unbalanced form had the swelling capacity of 86, 87 and 88% for 40, 60 and 80 mesh particle size respectively showing 2.2% increase in swelling capacity as the particle size decreased from 40 to 80 mesh. This trend was similar in the other 3 varieties.

Blanching given to tuber affected the swelling capacity of the yam flours. In unblanched samples, *Ighu* had the highest mean swelling capacity of (95%) while *Ozibo* had the least (87%) *Okwanankata* and *Ona* had the swelling capacity 90 and 93.3%, respectively. Blanching of the tuber for ten minutes increased the swelling capacity of Ozibo flour by 10% and that of *Okwanakata*, *Ighu* and *Ona* by 6.2, 4.2 and 5.2%, respectively. The flour from lesser known vars *Ighu* and *Ona* had significantly higher (p<0.05) swelling power than the

Table 5: Effect of partizle size on bulk density (g/mg) of yam

| | Unblanched | | | Blanched | | |
|---|---|---|---|---|---|---|
| Yam variety | 40 mesh | 60 mesh | 80 mesh | 40 mesh | 60 mesh | 80 mesh |
| *Ozibo* | 0.53a | 0.52e | 0.50i | 0.57n | 0.53s | 0.51t |
| *Okwanankata* | 0.49b | 0.46f | 0.44j | 0.49p | 0.47v | 0.47w |
| *Ighu* | 0.44c | 0.42g | 0.39m | 0.44q | 0.43x | 0.42u |
| *Ona* | 0.40d | 0.39h | 40 mesh | 0.41r | 0.40y | 0.39k |

Along the same rows values followed by the same letter are not significantly different (p>0.05)

Table 6: Variation in swelling capacity (%) of yam

| | Unblanched particle size | | | Blanched particle size | | |
|---|---|---|---|---|---|---|
| Yam variety | 40 mesh | 60 mesh | 80 mesh | 40 mesh | 60 mesh | 80 mesh |
| *Ozibo* | 86.0a | 87d | 88h | 92.2e | 95.2s | 97.9u |
| *Okwanankata* | 89.4b | 90e | 91k | 89.4f | 94.4x | 97.6u |
| *Ighu* | 93.0c | 94f | 98l | 96.4v | 97.6j | 99.3y |
| *Ona* | 90.0c | 93g | 97m | 94.0t | 97.2j | 99.0y |

Along the same rows values followed by the same letter are not significantly different (p>0.05)

Table 7: Variation in swelling capacity (%) of yam flour with blanching time

| | | Blanched | |
|---|---|---|---|
| Yam variety | Unblanched | 5 m | 10 m |
| *Ozibo* | 87.0a | 95.1r | 96.2s |
| *Okwanankata* | 90.0b | 93.9d | 95.6g |
| *Ighu* | 95.0c | 97.8h | 99.0p |
| *Ona* | 93.3d | 96.7q | 98.2m |

Along the same rows values followed by the same letter are not significantly different (p>0.05)

Table 8: Effect of blanching on water absorption capacity of yam

| | | Blanched | |
|---|---|---|---|
| Yam variety | Unblanched | 5 m | 10 m |
| *Ozibo* | 127.9a | 131.7b | 135c |
| *Okwanankate* | 127.7a | 129.3b | 132k |
| *Ighu* | 131.0b | 136.0e | 136d |
| *Ona* | 130.7b | 134.0d | 138h |

Along the same rows values followed by the same letter are not significantly different (p>0.05)

Table 9: Variation in water absorption capecity with particle size of yam flour

| | Particle Size | | |
|---|---|---|---|
| Yam variety | 40 mesh | 60 mesh | 80 mesh |
| *Ozibo* | 127.7a | 132.7r | 136g |
| *Okwanankate* | 127.0a | 130.3e | 132t |
| *Ighu* | 129.0b | 134.0f | 138h |

Along the same rows values followed by the same letter are not significantly different (p>0.05)

Table 10: Variation in peak viscosity (RVA) with blanching time

| | | Blanched | |
|---|---|---|---|
| Yam variety | Unblanched | 5 m | 10 m |
| *Ozibo* | 154.0b | 166e | 173.0f |
| *Okwanankate* | 117.0d | 129s | 145.0g |
| *Ighu* | 251.0a | 254x | 291.0k |
| *Ona* | 139.6c | 154h | 175.6j |

Along the same rows values followed by the same letter are not significantly different (p>0.05)

commonly used yam vars. *Ozibo* and *Okwanankata*. Moderate to high swelling power enhances the functionality of flours in such food system like breakfast cereals, baby foods and *fufu.* (Okoli, 1998). These results indicate that flour and starch derived from *Ighu* and *Ona* could be useful in breakfast cereals, baby foods and other food formulations where high swelling capacity is required.

**Water absorption capacity:** Variation in water absorption capacities of the yam varieties with blanching time is presented in Table 8. The data show that water absorption capacities of the yams vary significantly with blanching time .In the unblanched samples, *Ighu* had the highest water absorption capacity(131%)while *Okwanankata* had the least (127.7%) *Ozib* 29.7% and 1307% water absorption capacities, respectively. In all the varieties, blanching increased the water absorption capacity. Blanching at 100ºC for 10 min increased water absorption capacity by 4, 3.4, 3.8 and 5.4%, in *Ozibo, Okwanankata*, *Ighu* and *Ona* , respectively. These results showed that *Ona* responded more than other yam varieties to increase in blanching time with respect to water absorption capacity. While *Okwanankata* responded least to the influence of blanching time.

The results also showed that water absorption increased with decrease in particle size of the sample (Table 9). For *Ozibo*, it decreased from 136 to 127.7% as the particle size increased from 80 to 40 mesh, showing a percentage decrease of 8.3%. For *Okwanankata* the water absorption decreased from 131.7% in 80 mesh to 127% in 40 mesh showing 4.7% decrease. Water absorption capacity of *Ighu* decreased from 140 to 129% when the particle size of flour is varied from 80 to 40 mesh. This amounts to 7.9% decrease in water absorption capacity. In *Ona*, the water absorption capacity decreased from 137 to 131% with decrease of particle size from 80 to 40 mesh. This amount to 6% decrease. These results suggest that *Ighu* responded more to particle size change than other yam varieties with respect to water absorption capacity.

Water absorption capacity may be an advantage in applications of the lesser known yam flours in such food systems as baby food formulations ,fufu production and bread making where increase water absorption of the flour will increase product yield (Okoli, 1998).

**Pasting characteristic:** Peak viscosity of flours derived from blanched and un-blanched tubers is shown in Table 10. The results showed that in un-blanched samples, *Ighu* had the highest peak viscosity (Average of 251 RVA) followed by *Ozibo* (154RVA) and *Ona* (139.6 RVA) while *Okwanankata* had the least (117RVA). In all cases, blanching increased the peak viscosity of the yam flour. Blanching the yam at 100ºC for 5 min increased the peak viscosity by 19 RVA, 28RVA, 40RVA and 36 RVA

Table 11: Variation in pasting characteristics of yam flour with particle size

| Yam variety | Particle size | Peak viscosity | Viscosity after 15 minutes heating at peak | Final viscosity | Set back value | Index of gelatinization | Starch stability |
|---|---|---|---|---|---|---|---|
| Ozibo | 40 mesh | 137 | 122 | 153 | 16 | 31 | - |
| | 60 mesh | 165 | 153 | 168 | 3 | 15 | 12 |
| | 80 mesh | 182.2 | 171 | 190 | 8 | 19 | 11 |
| Okwanankata | 40 mesh | 108.9 | 97.1 | 125 | 16 | 28 | 11.8 |
| | 60 mesh | 127 | 96 | 140 | 13 | 44 | 31 |
| | 80 mesh | 165 | 99 | 175 | 10 | 71 | 66 |
| Ighu | 40 mesh | 192 | 140 | 260 | 60 | 120 | 52 |
| | 60 mesh | 300 | 127.5 | 360 | 60 | 240 | 172.5 |
| | 80 mesh | 314 | 110 | 370 | 56 | 209 | 204 |
| Ona | 40 mesh | 147 | 140 | 166 | 19 | 26 | 7 |
| | 60 mesh | 150 | 145 | 168 | 18 | 23 | 5 |
| | 80 mesh | 173.2 | 161 | 189 | 16 | 28 | 12 |

* value are Means of three replications

in Ozibo, Ighu and Ona respectively. Increasing the blanching time to 10 min increased the viscosity more. The peak viscosity of the flour increased as the particle size of flour decreased irrespective of the variety of yam (Table 11).

The viscosity after 15 min heating at the peak as well as final Viscosity increased with decrease in the particle size. Starch Stability, which defines the change in viscosity of the starch paste after heating and stirring at maximum temperature for 15 min measures the ability of the swollen starch granules to resist deformation and bursting during a constant heating and stirring process. These results (Table 11) show that the yam starches have very low stability (weak) and the starch paste breaks down rapidly when subjected to intense sharing force. The *ighu* starch paste which exhibited the highest Peak Viscosity, swelling and water absorption capacity was the most unstable whereas the *ona* starch paste which had moderate peakviscosity, water absorption and swelling indices was the most stable. Starch stability is important in determining the application of starch in many food systems. Ona starch with moderate swelling capacity and relatively higher starch stability will be useful as filler in meat canning industry on account of low shear thinning characteristics.

The Final viscosity, Setback value as well as the Index of gelatinization values measure the rate of re-crystallization of gelatinized starch (retro gradation) .In this study, the final viscosity of the test yam pastes were found to increase with blanching time and decrease in particle size irrespective of the variety (Table 11). *Ighu* on the average recorded the highest set back values and index of gelatinization while *Ozibo* recorded the least set back and index of gelatinization at the condition of the studied. *Okwanankata* and *Ona* gave moderate values (Table 11). The low cold paste viscosities, setback and index of gelatinization values of the test yam varieties may have implications on their application in many industrial and traditional food systems. In the use of yams for the production of instant pounded yam flour, where a gel of high rigidity is desired from a pre-gelatinized yam flour, the lesser known yam , *Ighu* , will produce a better paste than the commonly used yam, *Ozibo,* on account of high setback and index of gelatinization values. *Ozibo and Okwanankata* on account of their low retro- gradation rate may be useful in the production of the traditional pounded yam where the gelatinized starch is further texturized by a pounding process. They may also find good use in wheat/yam composite flour bread making where they can contribute to low bread stalling.

## CONCLUSION AND RECOMMENDATION

The results of this study show that the lesser known yams *Ona and Ighu* contain amylase and amylopectins in ratios similar to that in common varieties *Ozibo and Okwanakata* . However, the lesser known varieties exhibit significantly higher starch solubility, water absorption and swelling capacities than the regularly used yams. Flours derived from the lesser known varieties (*Ona and Ighu*) also exhibit lower bulk density that the better known yams (*Ozibo* and *Okwanakata*). Water absorption and swelling capacity of tested yam flours generally increased with decrease in particle size and increase in blanching time.

Hot and cold paste viscosities as well as Viscosity after 15 min heating followed the trend already highlighted for starch solubility, water absorption and swelling capacity, but *Ona* starch paste suffer the least shear thinning, and was the most stable thus suggesting that this lesser known yam starch may be useful as a filler or binder in meat canning and other industries . In addition, the low bulk density exhibited by *Ona* flour may also make it useful in baby food production. On the other hand, the flours derived from blanched *Ighu* (lesser known yam) which showed significantly higher hot and cold paste viscosities as well as high set back and index of gelatinization values will function optimally in the production of instant pounded yam flour.

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