Journal of Food Technology Research
2019 Vol. 6, No. 1, pp. 28-36
ISSN(e): 2312-3796
ISSN(p): 2312-6426
DOI: 10.18488/journal.58.2019.61.28.36

EFFECT OF TUBER SECTIONS, HEAT TREATMENT AND REHYDRATION WITH PROCESS CHEMICALS ON THE PHYSICOCHEMICAL PROPERTIES OF SWEET POTATO (*Ipomoea Batatas L.* (Lam)) FLOUR

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Article History
Received: 16 January 2019
Revised: 19 February 2019
Accepted: 27 March 2019
Published: 1 July 2019

Keywords
Sweet potato
Tuber sections
Physicochemical
Heat treatment
Rehydration
Flour.

ABSTRACT

The impact of tuber sections and some processing conditions on the physicochemical properties of sweet potato (*Ipomoea batatas* L. (Lam)) flour was investigated. Flour samples were generated as fresh, boiled and steamed from the head, middle, tail and the whole tuber. All the samples were subjected to some physicochemical analyses such as swelling index (SI), water absorption capacity (WAC), oil absorption capacity (OAC), total soluble solids (TSS), blue value index (BVI), gelling point temperature (GPT), boiling point temperature (BPT) and pH in order to assess the effect of tuber section, heat treatment and post-milling rehydration properties of flour in different steeping solution of varying concentrations. The result showed that the proximate composition of the flour from the tuber sections and the whole did not differ significantly ($p < 0.05$). The influence of steeping solution type (SST) was not significant ($p > 0.05$) on WAC, SI (boiled and steamed) and TSS (raw) while steeping solution concentration (SSC) effected significant variations ($p < 0.05$) in all the tested parameters of the flour. Also, the parameter analytical temperature (PAT) caused significant differences ($p < 0.05$) in all the test parameters.

Contribution/Originality: This study is one of the very few studies which have investigated the effect of tuber sections and processing conditions on the physicochemical properties of sweet potato (*Ipomoea batatas* L. (Lam)) flour. The investigation showed that the test variables had significant effects on the physicochemical properties of sweet potato flour.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L. (Lam)) is a very important crop in the developing world and a traditional but less important crop in some parts of the developed world. Apart from being a staple crop for some parts of the world, sweet potato can and does play a multitude of varied roles in the human diet being either supplemental or a luxury food. In the United States and other developed countries, the role of sweet potato is strictly as a luxury and in the other parts of the world, it plays it role as novel plant products and/or nutriceuticals (Sosinski *et al.*, 2001). Compositionally, sweet potato has very high moisture content resulting in relatively low dry matter content. The average composition of sweet potato dry matter is 70 % starch, 10% total sugars, 5% total protein (N × 6.25), 1% lipid, 3% ash, 10% fibre and 1% vitamins (Agbor-Egbe and Rickard, 1990; Woolfe, 1992; Takahata *et al.*, 1995). Sweet potato is a good source of high carbohydrate and a staple food in many tropical countries. It can be processed into many products for consumption (Iheagwara, 2012). Apart from domestic consumption, sweet potato has found greater utilization in the industry especially, food, textile and pharmaceutical industries (Iheagwara, 2013). One convenient form in which these industries can utilize sweet potato is the processed flour. It serves as a raw material base for industrial purposes, having good advantages of availability, storage stability, ease of handling and utilization and reduction in process time. Developing flour with good physicochemical characteristics will help to realize the vision of expandable utilization of sweet potato, reduce process time for industries using it as raw material, guarantee food security and enhance employment generation (Iwuoha and Nwakamma, 2002). Several studies have been carried out on sweet potato but little or no work has been conducted on the section by section analyses of the sweet potato tuber. In the light of this, this research priority is designed to evaluate the effect of tuber section, heat treatment and rehydration effect of steeping solution on the physicochemical properties of sweet potato flour.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Plant Materials

The produce utilized for this study is sweet potato (*Ipomoea batatas* L. (Lam)) tubers. They were obtained from National Root Crop Research, Umudike, Abia State, Nigeria.

2.2. Chemicals

The chemicals used are ANALAR grade of Sodium Carbonate, Sodium Chloride, Sodium Citrate and Sucrose for the steeping process as well as others for proximate analysis determination.

3. METHODS

The preparation of process reagents, generation and analysis of samples and data analysis were carried out following certain procedures.

3.1. Preparation of Process Reagents

The process reagents were prepared on dry matter basis at concentrations (% m/v, db) of 0.0, 5.0, 10.0, and 30.0. To accomplish this, an appropriate quantity of each of the process reagents (Sodium carbonate, Sodium chloride, Sodium citrate and Sucrose) were measured out, dissolved in some quantity of distilled water and made up to the requisite volumes.

3.2. Generation of Samples

For the generation of the sweet potato (*Ipomoea batatas* L. (Lam)) flour samples, the tubers were divided into three sections: the head section of the tuber (HST), middle section of the tuber (MST) and tail section of the tuber (TST) in the proportion of 30% (HST), 40% (MST) and 30% (TST) across the whole length of the tuber. The whole tuber serves as control. Subsequently, the tuber sections and the whole tuber (control) were subjected to three different treatment programmes.

3.3. Raw Sweet Potato Flour

For the raw sweet potato flour, each section of the tubers and the whole tuber (control) were pared off, washed, cut into slices (5mm thickness), dried and milled into flour. Subsequently, it was sifted through a 1 - mm mesh sieve and packaged.

3.4. Boiled Sweet Potato Flour

To obtain boiled sweet potato (*Ipomoea batatas* L. (Lam)) flour, each section of the tubers and the whole tuber (control) were pared off, washed and boiled at 0min, 30min and 60min time frame. Subsequently, they were cut into slices (5mm thickness), dried, milled and sifted through a 1- mm mesh sieve to generate flour samples of various section of the tuber at different levels of time.

3.5. Steamed Sweet Potato Flour

To obtain steamed sweet potato (*Ipomoea batatas* L. (Lam)) flour, each section of the tubers and the whole tuber (control) were pared off, washed, steamed at 0min, 30min and 60min levels of time, cut into slices (5mm thickness), dried, milled, sifted through a 1 - mm mesh sieve and packaged for further analysis.

3.6. Proximate Analysis

The proximate analysis was conducted in accordance with standard methods of AOAC (2010) and Nielsen (2010).

3.7. Functional Properties

The pH was determined according to the standard methods of AOAC (2010). Swelling index (SI), blue value index (BVI) and solubility were determined according to the method described by Iwuoha (2004). Water absorption capacity (WAC) and oil absorption capacity (OAC) were according to the method described by Mbofung *et al.* (2006) and gelling and boiling point temperatures (GPT and BPT) were determined according to the method described by Onwuka (2005).

3.8. Data Analysis

The results generated from the evaluation of the flour samples were analyzed by variance method and were fitted into multiple-factor designs to determine the effects due to section of the root tuber (SRT), tuber processing method (TPM), steeping solution type (SST), steeping solution concentration (SSC) and parameter analytical temperature (PAT). In situation where factors were found to be significant, Fishers least significant difference (LSD) multiple comparison test was used to separate the factor means at requisite level of confidence.

4. RESULTS AND DISCUSSION

4.1. Proximate Analysis

The result of proximate composition of sweet potato flour as affected by section of the root tuber is shown in Table 1. There is no significant difference ($p < 0.05$) in the tested parameters across the sections of the root tuber and the whole tuber. It may be that the distribution of these components across the tuber length follows a similar pattern. No section indicated an emerging sequence that could suggest it has predominant influence on the whole tuber. Hence the usual practice of processing the whole tuber into flour should continue.

Table-1. Mean values[a] of proximate composition of sweet potato flour obtained from different sections of the root tuber.

Tuber Section	Proximate Composition (%,db)					
	Moisture	**Protein**	**Fat**	**Fibre**	**Ash**	**Carbohydrate****
HEAD	13.84±1.16^{b}	5.19±0.68^{c}	3.82±0.30^{d}	2.70±0.30^{e}	1.05±0.03^{f}	73.39±4.37^{g}
MIDDLE	12.95±1.03^{b}	5.38±0.42^{c}	3.66±0.18^{d}	2.10±0.18^{e}	0.87±0.02^{f}	75.04±2.88^{g}
TAIL	14.35±1.05^{b}	5.59±0.33^{c}	4.05±0.32^{d}	2.40±0.32^{e}	0.79±0.02^{f}	72.80±3.39^{g}
WHOLE	14.27±1.14^{b}	5.58±0.51^{c}	4.07±0.35^{d}	2.50±0.35^{e}	0.73±0.03^{f}	72.85±2.85^{g}
LSD*	**1.6875**	**0.8220**	**0.6137**	**0.8166**	**0.4072**	**3.2203**

* Least significant difference
** Determined by difference
[a] Triplicate determinations
[b-g] Means with the same superscripts along the columns does not differ significantly at $p < 0.05$.

4.2. Effect of Steeping Solution Types (SST) On the Physicochemical Properties of Different Processed Sweet Potato Flour

Table 2 shows the mean values of physicochemical properties of sweet potato flour as affected by steeping solution types. For the swelling index (SI), there was significant variation ($p < 0.05$) among the chemicals for the raw samples. The highest swelling power (1.44cm^3/cm^3) was recorded with sodium carbonate and the least (1.41 cm^3/cm^3) was obtained with sodium chloride. This is in agreement with work by Lai *et al.* (2002) in which they reported that sodium carbonate (Na_2CO_3) exposes the food system to easy solvation and dissolution thereby promoting swelling. The latter case conforms with work by Kurtis *et al.* (2005) in which they reported that salts without a strong lyotropic effect (sodium and potassium chlorides) are effective swelling inhibitors. However, the boiled and steamed programmes did not differ significantly among the steeping solution chemicals. With regard to the three programmes, the boiled samples had a better swelling power compared to the raw and steamed samples. This is so because boiling opens up the network of the flour samples thereby facilitating enhanced swelling.

Table-2. Mean values on physicochemical properties of different processed sweet potato flour as affected by steeping solution type (SST).

Processing Method	Steeping Solution Type (SST)	Physicochemical Properties						
		SI	WAC (ml/g.db)	TSS (%,db)	BVI (ppm)	GPT (°C)	BPT (°C)	pH
RAW	SCB	1.44±0.22^a	1.72±0.05^a	6.83±1.43^a	215.50±76.14^a	64.83±4.09^a	74.75±4.09^a	11.12±2.69^a
	SCL	1.41±0.22^b	1.73±0.06^a	5.41±0.45^a	68.50±11.01^b	67.50±3.07^b	77.92±3.07^b	6.42±0.28^b
	SCT	1.42±0.23^c	1.72±0.05^a	5.38±0.43^a	70.75±9.83^b	66.25±2.75^{ab}	77.00±3.92^c	6.97±0.27^b
	SUC	1.43±0.21^d	1.71±0.06^a	5.81±0.74^a	83.25±10.40^c	66.00±3.41	76.08±4.58^d	8.48±2.44^c
	LSD*	**0.0086**	**0.0845**	**1.6387**	**3.7633**	**1.4126**	**0.5287**	**0.6532**
BOILED	SCB	2.99±0.61^a	2.24±0.26^a	9.75±1.21^a	222.92±80.52^a	60.58±3.59^a	69.92±3.04^a	11.52±2.79^a
	SCL	2.87±0.62^a	2.24±0.28^a	7.60±1.22^b	75.00±17.06^b	61.83±3.58^b	71.33±2.92^b	6.40±0.24^b
	SCT	2.90±0.59^a	2.25±0.26^a	7.88±1.26^b	73.92±17.15^b	61.42±3.71^c	70.58±3.12^c	7.07±0.25^c
	SUC	2.97±0.61^a	2.23±0.27^a	7.92±1.10^b	95.67±14.84^c	61.58±3.86^{bc}	70.92±3.25^c	7.55±0.59^d
	LSD*	**0.5492**	**0.0384**	**1.1978**	**2.9996**	**0.3739**	**0.5690**	**0.4601**
STEAMED	SCB	2.08±0.32^a	2.03±0.24^a	8.99±1.21^a	216.58±75.92^a	63.33±3.17^a	72.75±3.54^a	11.39±2.77^a
	SCL	1.99±0.48^a	2.07±0.22^a	7.33±1.30^b	72.00±14.44^b	65.08±3.28^b	74.83±3.62^b	6.47±0.27^b
	SCT	2.00±0.33^a	2.07±0.24^a	7.55±1.39^b	72.42±28.30^b	64.33±3.42^c	74.00±3.92^c	7.05±0.27^c
	SUC	2.02±0.33^a	2.03±0.24^a	7.57±1.38^b	87.50±14.13^c	64.33±3.54^c	73.75±4.28^c	7.22±0.59^d
	LSD*	**0.1213**	**0.0900**	**0.8831**	**4.2125**	**0.7237**	**0.3931**	**0.0086**

$^{a-e}$ Means not followed with the same superscripts along the columns for various factors differ significantly at $p < 0.05$
* Least significant difference
SI – Swelling Index, **WAC** – Water absorption capacity, **TSS** – Total soluble solids, **BVI** – Blue value index, **GPT** – Gelling point temperature and **BPT** – Boiling point temperature

The results of the water absorption capacity (WAC) obtained did not differ significantly among the process chemicals in all the processing methods. This indicates that the steeping solution chemicals had no effect on the WAC of the flour samples and as such any of them can be used in lieu of others depending on intended use.

For the solubility (TSS), there was no significant variation among the process chemicals for the raw samples but for the boiled and steamed samples, there were significant variation ($p < 0.05$) among the process chemicals. In relation with the boiled samples, the highest solubility (9.75%,db) was obtained with sodium carbonate and it differed significantly to sodium chloride, sodium citrate and sucrose that were statistically equivalent.

Similarly, for the steamed programme, the highest solubility (8.99%,db) was obtained with sodium carbonate and it differed significantly to sodium chloride, sodium citrate and sucrose that were statistically equivalent. This suggest that sodium carbonate being a softening agent increases hydration and tenderization of the sweet potato flour thus creating more hydrophilic sites which caused increase in solubility.

In relation to BVI, there were significant variation ($p < 0.05$) among the chemicals on the sweet potato flour samples. For the raw samples the highest BVI (215.50ppm) was obtained with sodium carbonate. Similarly, for the boiled samples, the highest BVI (222.92ppm) was obtained with sodium carbonate and for the steamed, the highest BVI (216.58ppm) was obtained with sodium carbonate too. These results shows that among the process chemicals, sodium carbonate has a higher cell/starch degradation due to its easy solvation and tenderizing actions and as such is a better choice compared to others.

For the gelling point temperature (GPT) and boiling point temperature (BPT), significant differences and equivalence existed among the process chemicals on the sweet potato flour samples. Among the salt, sodium chloride (NaCl) encouraged increased gelling and boiling point temperatures more than other salts while sodium carbonate (Na_2CO_3) favoured decreased gelling and boiling point temperatures. This suggests that Na_2CO_3 is a better gelling food additive than other salts and in terms of choice is more preferable because of its techno-economical potentials.

For the pH, there were significant variations ($p < 0.05$) among the process chemicals on the sweet potato flour samples. In all the processing methods, flour samples treated with sodium carbonate had the highest pH (alkalinity regime) values and those treated with sodium chloride had the least pH (slightly acidic regime) values. This shows that the steeping solution chemicals greatly affect the alkalinity and acidity of the sweet potato flour suspensions.

4.3. Effect of Steeping Solution Concentration (SSC) on the Physicochemical Properties of Different Processed Sweet Potato Flour

Table 3 shows the results of the effect of varying solute concentration on the physicochemical properties of sweet potato flour. The results obtained show that as the steeping concentration (SSC) increases, the swelling power of the flour samples decreases. For the raw sample, the highest swelling power (1.77cm^3/cm^3) was obtained at 5% concentration and the least value (1.25cm^3/cm^3) from 0% and 30% though statistically 0% and 30% SSC were equivalent. In relation to the boiled samples, two statistical equivalent classes emerged, that is (0%, 5% and 10%) and (10% and 30%). However, the highest swelling power (3.30cm^3/cm^3) was obtained from 5% SSC and the least swelling index (2.56cm^3/cm^3) was obtained from 30% SSC. Similarly, for the steamed programme, the highest value (2.20cm^3/cm^3) was obtained from 5% SSC and the least (1.84cm^3/cm^3) from 30% SSC though statistically, values obtained at 0% and 5% SSC were equivalent so also was 10% and 30% SSC. From these results, it reflects that it is better and economical to utilize 5% SSC in order to reduce cost and any health implications high concentration of the process chemicals may cause.

Table-3. Mean values on physicochemical properties of different processed sweet potato flour as affected by steeping solution concentration (SSC).

Processing Method	SSC (%m/v)	Physicochemical Properties						
		SI	WAC (ml/g.db)	TSS (%,db)	BVI (pmm)	GPT (°C)	BPT (°C)	pH
RAW	0	1.25±0.01[a]	1.80±0.01[a]	5.13±0.02[a]	87.00±22.45[a]	70.05±1.63[a]	82.33±2.05[a]	6.51±0.01[a]
	5	1.77±0.02[b]	1.66±0.01[b]	5.39±0.43[a]	105.72±74.77[b]	66.92±1.50[b]	76.08±2.40[b]	8.40±2.56[b]
	10	1.42±0.2[c]	1.68±0.01[b]	5.83±0.74[a]	118.03±82.48[c]	65.33±1.25[c]	74.83±1.62[c]	8.87±2.87[bc]
	30	1.25±0.02[a]	1.73±0.03[ab]	7.07±1.18[b]	127.25±89.02[d]	62.75±1.59[d]	72.50±1.55[d]	9.20±2.76[c]
	LSD*	**0.0086**	**0.0845**	**1.6387**	**3.7633**	**1.4126**	**0.5287**	**0.6532**
BOILED	0	3.08±0.14[a]	2.42±0.37[a]	7.25±1.52[a]	80.33±58.84[a]	65.02±2.94[a]	71.86±2.04[a]	6.68±0.01[a]
	5	3.30±0.56[a]	2.13±0.17[b]	7.58±1.28[a]	98.58±59.07[b]	62.33±2.13[b]	71.67±1.98[a]	8.21±2.76[b]
	10	2.80±0.63[b]	2.16±0.18[b]	8.01±1.25[a]	125.42±89.44[c]	60.92±2.29[c]	69.67±1.80[b]	8.52±2.70[bc]
	30	2.56±0.67[b]	2.25±0.19[c]	9.28±1.06[b]	140.17±99.77[d]	57.17±2.19[d]	67.42±1.93[c]	8.83±2.64[c]
	LSD*	**0.5492**	**0.0385**	**1.1978**	**2.9996**	**0.3739**	**0.5690**	**0.4601**
STEAMED	0	2.13±0.22[a]	2.21±0.31[a]	7.02±1.45[a]	96.00±62.16[a]	67.92±1.66[a]	75.75±1.96[a]	6.67±0.01[a]
	5	2.20±0.28[a]	1.94±0.17[b]	7.23±1.29[a]	98.58±65.87[a]	66.17±1.62[b]	73.21±2.45[b]	8.24±2.77[b]
	10	1. 89±0.30[b]	1.98±0.17[bc]	7.66±1.37[a]	116.00±0.73[b]	64.67±3.30[c]	72.24±2.81[c]	8.51±2.72[c]
	30	1.84±0.50[b]	2.07±0.19[c]	8.69±1.14[b]	129.58±89.21[c]	61.92±1.75[d]	70.67±2.09[d]	8.91±2.59[d]
	LSD*	**0.1213**	**0.0900**	**1.0127**	**4.2125**	**0.7237**	**0.3931**	**0.0086**

[a-e] Means not followed with the same superscripts along the columns for various factors differ significantly at $p < 0.05$

* Least significant difference

SI – Swelling Index, **WAC** – Water absorption capacity, **TSS** – Total soluble solids, **BVI** – Blue value index, **GPT** – Gelling point temperature and **BPT** – Boiling point temperature.

The results of the water absorption capacity (WAC) exhibited direct proportionally with the steeping solution concentration. However, in all the processing methods, it was observed that at 0% SSC (control), the values of WAC were significantly higher than those of 5%, 10% and 30% and this result is in agreement with report by Pawar and Ingle (1988).

Also, the solubility (TSS) increases as the steeping solution concentration increases. In all the processing methods, the highest solubility was obtained at 30% SSC and the least at 0% SSC. For t(he raw samples, statistically, the solubility of 0%, 5% and 10% SSC were equivalent ($p < 0.05$) and differ significantly from 30% SSC. Similarly, the boiled and steamed samples exhibited the same trend. This shows that as the SSC increases, it exposes the food system to easy solvation and dissolution thus creating more room for hydrophilic constituents which cause increase in solubility.

For the BVI, there were significant variations ($p < 0.05$) among the samples as the steeping concentration increases. In relation to the raw sample, the highest BVI (127.25ppm) was obtained at 30% SSC. Similarly, the boiled and steamed samples follow the same pattern with the highest BVI (140.17ppm) and (129.58ppm) obtained at 30% SSC for the boiled and steamed programmes, respectively. This suggests that as the SSC increases, it has a great effect on starch degradation.

The GPT and BPT were inversely proportional to the steeping solution concentration (SSC). As the SSC increases, the GPT and BPT decreases. For the raw samples, the highest GPT (70.05°C) and BPT (82.33°C) was obtained at 0% SSC (control) and the least GPT (62.75°C) and BPT (72.50°C) was obtained at 30% SSC. Similarly, the boiled and steamed sweet potato flour samples follow the same trend. For the boiled programme, the highest GPT (65.02°C) and BPT (71.86°C) was obtained at 0% SSC and the least GPT (57.17°C) and BPT (67.42°C) was obtained at 30% SSC. For the steaming programme, the highest GPT (67.92°C) and BPT (75.75°C) was obtained at 0% SSC and the least GPT (61.92°C) and BPT (70.67°C) was obtained at 30% SSC. These results are in line with reports of Lai *et al.* (2002); Roberts and Cameron (2002) and indicates that at 30% SSC, less thermal energy will be required to accomplished gelling and boiling of the samples than at 0% SSC.

The pH of the three processing methods were statistically significant. Similarly, as the SSC increases, the pH value also increases. Except for 0% SSC (control) that was acidic, all others were in the regime of alkalinity with 30% SSC exhibiting the highest value in all the processing methods.

4.4. Effect of Parameter Analytical Temperature (PAT) on the Physicochemical Properties of Different Processed Sweet Potato Flour

The results of the physicochemical properties of sweet potato flour as affected by PAT are shown on Table 4. Statistically, there were significant variations ($p < 0.05$) among the processing methods in all the test parameters. The results obtained showed that the swelling index (SI), total soluble solids (TSS), water absorption capacity (WAC) and oil absorption capacity (OAC) were temperature dependent. They increased as the rehydrating temperature increases. For the swelling index, the swelling of starch granules is the first stage in the initial changes in hydration related properties. The swelling index of the flour at different temperature profile was very pronounced at 80°C than at 30°C and 50°C in all the processing methods with the boiled samples having highest ($4.01cm^3/cm^3$) at 80°C and the raw sample the least ($1.25cm^3/cm^3$) at 30°C. This observation is in agreement with works by Lawal (2004); Hoover (2001); Adebowale and Lawal (2002) and Lawal *et al.* (2004). Also, it has been related to the associative binding within the starch granule and apparently the strength and character of the micellar network of the amylose content (Lindeboom *et al.*, 2004) thus low amylose content induces high swelling. Conversely, as the temperature of the aqueous solution increases, the starch molecules in the flour undergo structural reformation resulting in the disruption of the hydrogen bonds. Consequently, the water molecules become attached to the liberated hydroxyl groups causing the hydration of the starch moiety and corresponding swelling of the granules (Rickard *et al.*, 1991).

Table-4. Mean values on physicochemical properties of different processed sweet potato flour as affected by process application temperature (PAT).

Processing Method	PAT (°C)	Physicochemical Properties			
		SI	WAC (ml/g.db)	TSS (%,db)	OAC(ml/g,db)
RAW	30	1.25±0.01[a]	1.80±0.01[a]	5.13±0.02[a]	0.64±0.01[a]
	50	1.95±0.01[b]	2.13±0.08[b]	7.11±0.05[a]	0.84±0.01[b]
	80	2.31±0.01[c]	3.20±0.14[c]	9.11±0.07[b]	0.93±0.01[c]
	LSD*	**0.3530**	**03205**	**1.9923**	**0.0124**
BOILED	30	3.08±0.15[a]	2.42±0.41[a]	7.26±1.52[a]	0.89±0.10[a]
	50	3.52±0.15[b]	2.74±0.32[b]	9.10±1.09[b]	0.97±0.9[b]
	80	4.01±0.12[c]	3.90±0.51[c]	10.79±1.06[c]	1.08±0.7[cs]
	LSD*	**0.0392**	**0.0863**	**1.3490**	**0.0688**
STEAMED	30	2.13±0.22[a]	2.21±0.36[a]	7.02±1.45[a]	0.77±0.08[a]
	50	2.37±0.21[b]	2.42±0.36[b]	8.62±1.04[b]	0.90±0.04[b]
	80	2.63±0.13[c]	3.43±0.21[c]	10.26±0.92[c]	1.00±0.03[c]
	LSD*	**0.0165**	**0.1975**	**1.5141**	**0.0243**

[a-e] Means not followed with the same superscripts along the columns for various factors differ significantly at $p < 0.05$
* Least significant difference
SI – Swelling Index, **WAC** – Water absorption capacity, **TSS** – Total soluble solids, **BVI** – Blue value index, **GPT** – Gelling point temperature and **BPT** – Boiling point temperature.

For the water absorption capacity (WAC), a similar trend as observed in the swelling power occurs. This shows that hydrophilic tendency of the sweet potato flour improves as the rehydrating temperature increases with the highest WAC (3.90m1 H_2O/g,db) observed with the boiled samples at 80°C against (3.43m1 H_2O/g,db) and (3.20ml H_2O/g, db) recorded for the steamed and raw sweet potato flours, respectively, thus suggesting that the hydrophilic capacity of the boiled sweet potato was greatly enhanced. Also, it shows that as the temperature increases, there is disruption of the intragranular bonds of the starch in the flour leading to the liberation of the water binding sites-hydroxyl groups and inter-glucose oxygen atoms (Rickard *et al.*, 1991) and these water binding sites are more predominating in boiled sweet potato flour than the steamed and raw versions.

For the total soluble solids (TSS), there were significant variations ($p < 0.05$) among the samples as the temperature increases. The highest solubility was recorded at 80°C in all the processing methods. The boiled sweet potato flour had the highest solubility (10.79%,db) against (10.26%,db) and (9.11%,db) recorded for the steamed and raw versions, respectively. This shows that as the temperature of the aqueous solution increases, there is disruption of the hydrogen bonds and water molecules becomes attached to the liberated hydroxyl groups and as such the starch granules swell with consequent increase in solubility. This increase in solubility could be attributed to the amylose content since solublized amylose molecules leach from the swelled starch granules (Osundahunsi *et al.*, 2003).

Similarly, the oil absorption capacity (OAC) differ significantly ($p < 0.05$) among the samples as the rehydrating temperature increases. The OAC increased slightly over the temperature profile. The hydrophobic tendency was greater at 80°C than at 50°C and 30°C, respectively. In relation to the processing methods, the boiled sweet potato had a better hydrophobic effect than the steamed and raw samples. Conversely, at temperature of 50°C and above, the thermal effect on the component of the flour most especially the protein network undergoes conformational changes due to denaturation. This leads to the unfolding of the hydrophobic groups of the protein moiety which now binds with the oil. However, with the sweet potato samples, the hydrophobic ends exposed were very limited because of the low value of protein in sweet potato and this was responsible for the poor oil absorption capacity observed in Table 4.

5. CONCLUSION

On the basis of this investigation, it is evident that the usual practice of milling whole tuber remains preferential over section of the tuber. The heat treatment showed improvement in physicochemical properties of the flour over the fresh flour. Generally, the data obtained will provide baseline information for expandable utilization of sweet potato while characteristics of the physicochemical properties of the flours will guide/maximize the usage of the flour into suitable products.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study.

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