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EFFECT OF DRYING METHODS AND PRETREATMENTS ON FUNCTIONAL PROPERTIES OF SWEET POTATO FLOUR

Ogunlakin, G. O., *Olajire, A. S., Ajiboye, T. S. and Fagbohun, M. A.

Department of Food Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State Nigeria.

***Corresponding author Email address: olajiresola@yahoo.com**

ABSTRACT

Sweet potato (*Ipomoea batatas L*) is rich in calories and biologically active phytochemicals such as beta-carotene, polyphenols, ascorbic acid and dietary fibre, meanwhile it is highly perishable crop. Drying is one of the oldest methods of preservation and has been translated into technology recently which helps in extending the self-life of food material by reducing the moisture content to a safe level. This study was therefore conducted to evaluate the effect of pretreatments and drying methods on functional and pasting properties of sweet potato flour. Three drying methods (sun, solar and cabinet drying) were used to dry freshly harvested sweet potato tuber pretreated with blanching, potassium methabisulphate, ascorbic acid and sodium chloride. Functional (water absorption capacity, oil absorption capacity, bulk density, swelling capacity and solubility index) and pasting (peak, trough breakdown, final viscosity, set back, peak time and pasting temperature) properties were determined. The result for functional properties for all the drying methods and the pretreatment used were 127-198 g/g, 87.99-119.00 g/g, 0.63-0.86 g/cm^3 4.42-8.76 g/g and 9.88-18.42 g/g for water absorption capacity, oil absorption capacity, bulk density, swelling capacity and solubility index, respectively. The results of pasting properties ranged from 352 to 1565 RVU, 214 to 589 RVU, 29 to 539 RVU, 390 to 1656 RVU, 99 to 630 RVU, 1.22 to 6.87 min and 50.1 min to 82.2 ºC for the peak, trough, breakdown, final viscosity, setback, peak time and pasting temperature, respectively and for both the drying methods and the pretreatment used. The result shows that pretreatments and drying methods affected the functional and pasting properties of the flour. The sample dried using cabinet dryers had the highest value compare to other drying methods in term of water absorption capacity, bulk density and swelling

power. Pasting properties of cabinet drying provided a better alternative to sun drying and solar drying.

Keywords: Sweet potato, drying, pretreatment, functional and pasting properties

INTRODUCTION

Sweet potato (*Ipomoea batatas L*) is one of the staple foods in many of the developing countries of the tropics and sub-tropics with different varieties and differences in skin and flesh colour which ranges from white to yellow-orange and deep purple (Woolfe, 1992; CIP, 2013). Sweet potato helps in improving household and national food security, health, and livelihoods of poor families in sub-Saharan Africa (Bovell-Benjamin, 2007). Different varieties exist in African which ranges from white, cream or yellow flesh (low in pro-vitamin A) and orange flesh (high in pro-vitamin A) (Oloniyo *et al*., 2021). Sweet potato roots have a number of physicochemical properties. The crop consists mainly of carbohydrates, with starch forming the larger part of the root dry matter (Engoru *et al*., 2005). It is majorly use in food industry in making different kinds of commercial products due to its high starch content (Engoru *et al*., 2005).

It can be processed into other products or dry into flour that can be used as a starting material for production of juice, bread, candy, noodles, snacks, alcohol and *amala*. Some food products are usually subjected to some forms of pre-treatments, which include hot water blanching and sulphiting before drying. Blanching helps to inactivate active enzymes that resulted into quality degradation (Moreno-Perez *et al.,* 1996) and to improve the acceptability and the quality of the final product (Babajide *et al.* 2006). Blanching also help in softening structural tissues of food products and increase the rate of moisture diffusivity (Senadeera *et al.,* 2000).

Storing potato crop has been a challenge and it can hardly stay for more than a week due to soft skin that is easily damaged by cuts and abrasion during harvesting, transportation or distribution (Rees *et al.,* 2003). This resulted into huge losses especially during on-seasons (Teye *et al.,* 2011). Due to this fact, it is consumed within a few days after harvest and makes it unavailable throughout the year. In developing countries like Nigeria, research carried out shows that processed sweet potato roots into flour offers an opportunity of presenting the commodity in a more stable form (Van-Hal, 2000). One of the methods that can give stable product to sweet potato is drying. Drying process involves moisture removal as a result of simultaneous heat and mass transfer phenomena (Ertekin and Yaldiz, 2004; Olajire *el al*., 2018). This method gives longer shelf- life, lighter weight for essay transportation and smaller space for storage (Igbal *et al*., 2019). Although, series of works has been done on effect of pretreatment on the drying of sweet potato into flour (Ahmed *et al*., 2010; Dinrifo, 2012; Haile *et al*., 2015 and Lagnika *et al*., 2021) but there is little information on the pretreatments used (blanching, potassium metabisulphite, ascorbic acid and sodium chloride) in relation to drying of sweet potato. Hence, this work aimed at evaluates the effect of processing methods on the functional properties of sweet potato flour.

MATERIALS AND METHODS

Materials

The sweet potato tubers used for this research work was procured from a farmer in Ogbomoso, Oyo State, Nigeria. This sample was brought to Ladoke Akintola University of Technology (LAUTECH), Teaching and Research Farm Agronomic Section for proper identification of the variety. The equipment used includes weighing balance, cabinet dryer, solar dryer, milling machine, sieves. Other apparatuses used are knife, water, and bowls which were obtained in Food Processing Laboratory, Ladoke Akintola University of Technology, LAUTECH, Ogbomoso. The reagents used were of analytical grade, obtained in the Food Chemistry Laboratory, LAUTECH, Ogbomoso.

Sample Preparation

The method of Adeleke and Odedeji (2010) was used to prepare potato flour. The sweet potato tubers were firstly sorted and washed thoroughly in clean water to remove some extraneous material from it. The tubers peeled with a sharp knife in water to prevent browning and sliced into thickness of approximately 3 - 5 mm. The sliced tubers were divided into five equal portions. The first portion was blanched in hot water at temperature of 60 °C for 5 min (Ariahu *et al*., 2011). The second portion was treated with potassium metabisulphite solution at a concentration of 0.01% for 2 min (Oduro *et al.,* 2001). The third portion was treated with ascorbic acid solution at a concentration of 0.5% for 3 min. The fourth portion was treated with sodium chloride (NaCl) solution at 1% concentration for 20 min (Emmanuel, 2012), while the fifth portion was not treated and save as control sample.

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Drying and Milling Procedures

The pretreated and the control samples (500 g) each was placed in a drying try and dry using three different drying methods (sun, solar and cabinet at 50 °C). For each drying methods, measurement was taking at 1 h interval until three consecutive weights were constant, and drying was done in triplicate for all the three different drying methods employed. The dried samples obtained (both pretreated and control samples) were properly milled using plate attrition mill and sieve using a sieve of diameter 250 µm. The milled samples were packed in a high density polyethylene bag to prevent rehydration of the samples.

Determination of Functional Properties

Water Absorption Capacity: Water absorption capacity was determined according to the method described by Oyeyinka *et al*. (2015). This was determined by weighing 1.5 g of the flour into a centrifuge tube and 10 cm^3 of distill water was added, with the aid of laboratory centrifuge, it was centrifuged at 3225 rpm for 25 min and the supernatant was decanted. The residue was air dried and weighed. The values are expressed as grams of water absorbed by 1 g of sweet potatoes flour.

Oil Absorption Capacity: The method described by Lin (2004) was used for the determination of fat absorption capacity. One gram of each of the samples was weighed into a conical graduated centrifuge tube, and then a warring whirl mixer was used to thoroughly mixed the sample with 10 cm^3 of distilled water for 30 min. The mixture was allowed to stand for 30 min at room temperature and then centrifuged at 5000 rpm for 30 min. The volume of free water was read directly from the graduated centrifuge tube. The values are expressed as grams of oil absorbed by 1 g of sweet potatoes flour.

The bulk density: Bulk density of the samples was determined using the method described by Onwuka (2005). The sample was filled into 10 cm^3 measuring cylinder. The bottom of the cylinder was gently tapped on a laboratory bench until there was no further diminution of the sample after filling to 10 cm^3 mark. Bulk density was estimated as mass per unit volume of the sample (g/ cm^3).

$$Bulk\ Density = \frac{mass\ of\ the\ Samples}{Volume\ Occupy} \quad (1)$$

Swelling capacity: The method described by Ukpabi and Ndimele (1990) will be used. Ten gram of the sample was measured into a 300 cm^3 measuring cylinder. Follow by 150 cm^3 of distilled water was added to the sample and allowed to stand for four hours. The final volume after swelling will be recorded. The percentage swelling will be calculated as:

$$\% \text{ Swelling Capacity} = \frac{Final\ volume - initial\ volume}{initial\ volume} \times \frac{100}{1} \qquad (2)$$

Solubility Index: The solubility was determined using method described by Akpata and Miachi (2001). Five gram of the sample was weighed into 250 cm^3 graduated flask. It was made up with distilled water to a graduation mark; it was shaken frequently and allowed to stand overnight. It was filtered through 54 grade filter paper, 25 cm^3 clear liquor pipetted and evaporated to dryness in a weighed dry stainless steel. The residue was dried in an oven and held for 3 h at 105 ºC and weighed. It was returned to the oven and held for another 30 min at 105 ºC, it was then cool and weighed.

Pasting Properties of Sweet Potato

Pasting properties was determined with a Rapid Visco Analyzer (RVA TECMASTER, Perten Instrument), using the method reported by Adebowale *et al.* (2005). At a temperature of 30 – 90 ºC and at a rate of 2.5 ºC/min, flour slurry which contain 12% solid was heated and held at 95 ºC for 15 min and allow to cool according to Chinma *et al*. (2013). The values of pasting properties were recorded on the calibrating sheet of amylogram, properties such as peak viscosity, trough viscosity, breakdown viscosity, final viscosity, set back viscosity, pick time and pasting temperature were obtained on the amylogram scale. All the experimental works were performed in triplicate.

Statistical analysis

The data were analyzed by one-way analysis of variance (ANOVA) using SPSS version 21.0. Mean separations were performed by Duncan's multiple range test, to find out whether there is any significant variation of the means ($p<0.05$).

RESULTS AND DISCUSSION

Functional Properties of Flour

The functional properties water absorption capacity, oil absorption capacity, bulk density, swelling capacity and solubility index (Table 1). Functional properties are important parameters in food industry because sample with good functional properties can be easily be incorporated into other food sample and resulted into food of good quality (Ocheme *et al.*, 2018).

The water absorption capacity (WAC) of the flour ranged from 127 to 198 g/g for control sample sun dried had the lowest value while sample pretreated with NaCl solution using cabinet dryer had the highest value. There is a significant difference ($p<0.05$) in the values of WAC for all the pretreatment and the drying methods considered. The higher values of WAC obtained is in harmony with the finding of Chandra *et al.* (2015). The higher values of WAC may be due to increase in the amylose leaching and solubility and loss of starch crystalline structure in sweet potato flour (Chandra *et al*., 2015). As compared to the value reported by Odoemelam (2003) for processed cassava flour, The range of values obtained in this study was found higher than that of Odoemelam (2003) for the processed cassava flour.

Oil absorption capacity (OAC) of the samples ranged from 87.99 to 119.00 g/g with sample pretreated with potassium metabisulphite and solar dried had the lowest value while sample pretreated with NaCl solution and sun dried had the highest value. There is a significant difference ($p<0.05$) in the values of OAC for all the pretreatments and the drying methods considered. It was observed that all the samples sundried with different pretreatments had the highest OAC. Oil absorption is attributed to physical entrapment of oil and is important for flavour retention and mouth feel of foods.

The bulk density of the flour ranged from 0.63 to 0.86 g/cm^3 with sample pretreated with blanching and sun dried had the lowest value while sample pretreated with blanching and dried with cabinet dryer had the highest value. There is a significant difference ($p<0.05$) in the values of bulk density for all the pretreatment and the drying methods considered. Bulk density has implication in the packaging and transportation of food materials; higher bulk density products are known to exhibit better packaging properties than those with low bulk density. Fagbemi (1999) reported that high bulk density is desirable in that it offers greater packaging advantage as greater quantity may be packaged within a constant volume. The result obtained was similar to that of Ochema *et al*. (2018) for wheat and groundnut flour blends.

The swelling power of the flour ranged from 4.42 to 8.76 g/g with sample pretreated using NaCl which was sun dried had the lowest value while sample pretreated with potassium metabisulphite with cabinet dried sample had the highest value of swelling power. There is a significant difference ($p<0.05$) in the values of swelling power for all the pretreatment and the drying methods. Sample dried using cabinet dryer had the highest value of swelling

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power compare to all other drying methods and different pretreatment used. Swelling power is based on size of the particle, type of the variety and the processing method employed (Chandra *et al*., 2015). A low swelling power was observed in sun-dried flour, this may be due to stronger bonding force in its starch granules (Table 4.1). It was observed that the swelling power obtained in this research work was found to be higher than the one obtained by Kusumatanti *et al*. (2015) which ranged from 3.40 to 3.67 g/g and Torte *et al*. (2017) which ranged from 4.60 – 5.90 g/g.

The solubility index of the flour ranged from 9.88 to 18.42 g/g with control sample dried with cabinet dryer had the lowest value while sample pretreated with NaCl solution and sun dried had the highest value. There is a significant difference ($p<0.05$) in the values of solubility for all the pretreatment and the drying methods used. Sample dried using sun had the highest solubility compare to other drying method (solar and cabinet) using different pretreatment methods. Drying methods do not have any significant effect on the solubility index on the samples investigated. A higher solubility index was observed among the sun-dried flour samples compared to solar and cabinet dried flour samples. Soni *et al.* (1993) attributed high solubility indices in starches to the easy solubility of the linear fraction (amylose) which is linked loosely with the rest of the macro molecular structure, and leached out during the swelling process.

Pasting Properties of sweet potato Flour

The pasting properties considered in this study include peak, trough, breakdown, final viscosity, set back, peak time and pasting temperature as presented in Table 4.2. pasting properties help in determined the efficiency of a flour in a baked food or brewing (Dereje *et al*., 2020). It is also used in assessing the suitability of its application as functional ingredient in food and other industrial products (Odongo *et al*., 2015).

The peak viscosity values for the samples range from 352 to 1565 RVU. The highest value was obtained from sample pretreated with NaCl solution using sun dried while the lowest value was obtained from pretreated by blanching using sun dried method. There was a significant difference ($p<0.05$) between the values for all the pretreatment and the drying methods used the peak value is the highest value attained by gelatinized starch during heating in water (Ojo *et al*., 2017) and it also indicates the easy cooking of a sample (Erikssos *et al*., 2014).

The trough viscosity value for all the pretreatment and the drying methods ranged from 214 to 589 RVU. Cabinet dried sample using NaCl solution as pretreatment has the lowest values while sample dried using cabinet and pretreated with NaOH solution has the highest value. There was a significant difference ($p<0.05$) in all the values. The trough helps in measure the ability of paste to withstand breakdown when cooling (Ojo *et al*., 2017). The result obtained was higher than the one obtained by Fetuga *et al.* (2014) who reported a range of 4.33-139.96 RVU for trough viscosity using different drying methods.

The breakdown viscosity of the potato flour ranged from 29 to 539 RVU with the sample pretreated with NaCl solution dried with cabinet had the lowest breakdown viscosity while the sample pretreated with NaCl solution which was sun dried had the highest breakdown viscosity. There was a significant difference ($p<0.005$) in the values of breakdown viscosity for all the pretreatment and the drying methods employed. Breakdown viscosity measures the resistance to disintegrate in response to heat and shear (Aina *et al*., 2009). Adebowale *et al.* (2005) reported that the higher the break down viscosity, the lower the ability of the sample to withstand heating and shear stress during processing. The result was higher than the one obtained by Olatunde *et al*. (2016) who reported a range of breakdown viscosity of 11.00 to 125.33 RVU.

The final viscosity is the capability of a material to gel (paste) after cooking Tortoe *et al.* (2017) and it determine the quality of a particular starch containing food (Osungbaro *et al*., 2010). It also to determine the resistance of the paste to shear force during stirring (Adebowale and Lawal 2003). The final viscosity values ranged from 390 to 1656 RVU. The lowest value was obtained from sample that was blanched and dried using cabinet dryer while the sample that was pretreated with NaCl solution and sun dried gave the highest values of final viscosity. There was a significant difference ($p<0.05$) in all the pretreatment and the drying methods. The result obtained was higher than the one obtained by Olatunde *et al.* (2016).

The setback viscosity which indicates the tendency of the dough to undergo retrogradation has a phenomenon that causes the dough to become firmer and increasingly resistant to enzyme attack (Li *et al*., 2017). The setback viscosity of the flour from the result ranged from 99 to 630 RVU with the sample pretreated with potassium metabisulphite dried with cabinet dryer had the lowest back viscosity while sample pretreated using NaCl which was sun dried had the highest setback viscosity. There was a significant difference ($P<0.05$) in all the pretreated values and drying methods used. Fetuga *et al.* (2014) had a lower range of value of setback for sweet potato flour (1.90 to 80.13 RVU) when compared with the values obtained in this study.

The peak time provides an indication of minimum time required by the flour to reach their respective peak velocity (Fetuga *et al*., 2014; Nabubuya *et al*., 2012). The peak time is a measure of the cooking time (Adebowale *et al.* 2005). The peak time of the sample ranged from 1.22 to 6.87 min with the control sample dried with solar dryer had the lowest peak time while the sample pretreated with ascorbic acid which was sun dried had the highest peak time. There was a significant difference ($p<0.05$) in the value of the peak time for all the pretreatment used and the drying methods. According to Jangchud *et al*. (2003) the peak time was reported to fall within the range of 3.30 – 9.76 min, this shows that the result obtained in this work for peak time fall within the range.

The pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu *et al.,* 2007), it can have implications for the stability of other components in a formula and also indicate energy costs (Newport Scientific, 1998). The pasting temperature ranges from 50.1 to 82.2 ºC with sample pretreated with ascorbic acid which was had the lowest pasting temperature while sample pretreated with potassium metabisulphite which was dried with cabinet had the highest pasting temperature.

The pasting temperature of the potato flour extracted from the result varied significantly ($p<0.05$) for all the pretreatment and the drying methods. The result obtained is in harmony with the finding of Aina *et al*. (2009) who reported that the pasting temperature of sweet potato ranges from 78.3 – 93 ºC. Also, the result was also in line with the finding of Olatunde *et al*. (2016) who reported that pasting temperature of different sweet potato cultivars obtained from different pretreatments ant drying methods ranged from 69.78 to 81.25 ºC

Table 1: Functional Properties of Flour

Sample	WAC (g/g)	OAC (g/g)	Bulk Density (g/cm³)	Swelling Power (g/g)	Solubility index (g/g)
A_{su}	150.000^{bcde}	109.000^{cd}	0.630^{a}	5.350^{bc}	15.230^{efg}
A_{so}	157.000^{cde}	92.850^{ab}	0.660^{ab}	5.900^{cd}	14.350^{def}
A_{ca}	198.000^{f}	96.310^{abc}	0.840^{b}	6.100^{cd}	14.050^{def}
B_{su}	150.000^{bcde}	92.290^{ab}	0.715^{b}	7.040^{ef}	13.000^{abcde}

B_{so}	191.000[f]	87.990[a]	0.770[b]	7.610[f]	12.110[abcde]
B_{ca}	246.000[g]	89.200[ab]	0.850[b]	8.760[g]	10.630[abc]
C_{su}	186.000[f]	116.000[d]	0.740[b]	6.480[de]	17.520[fg]
C_{so}	188.000[f]	92.290[ab]	0.850[b]	6.970[ef]	1 4.720[deg]
C_{ca}	190.000[f]	109.000[cd]	0.850[g]	7.150[ef]	12.330[abcd]
D_{su}	138.000[abc]	119.000[d]	0.740[b]	4.420[a]	18.420[g]
D_{so}	142.000[abcd]	104.000[abcd]	0.850[b]	5.760[cd]	13.700[bcde]
D_{ca}	158.000[de]	105.000[bcd]	0.850[b]	6.450[de]	11.500[abcd]
E_{su}	127.000[a]	98.770[abc]	0.660[b]	6.180[de]	10.400[ab]
E_{so}	137.000[ab]	94.890[abc]	0.810[b]	6.280[de]	10.390[ab]
E_{ca}	162.000[e]	99.150[abc]	0.840[b]	6.410[de]	9.88[a]

Values represent means of triplicate reading, follow by different lowercase letter
Means within the same row with different alphabets are significantly different ($p \leq 0.05$)

A,B,C and D are samples pretreated using blanching, potassium metabisulphite, ascorbic acid and sodium chloride solution, respectively. E is the untreated sample (control). Subscript su, so and ca stand for sun, solar and cabinet drying methods, respectively.

Table 2: Pasting Properties of Flour

Sample	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Set back (RVU)	Peak time (min)	Pasting temperature (°C)
A_{su}	352.000[a]	299.000[e]	55.000[b]	659.000[e]	360.000[j]	5.530[de]	50.450[a]
A_{so}	702.000[g]	220.000[a]	482.000[g]	601.000[d]	381.000[k]	4.200[c]	50.150[a]
A_{ca}	372.000[bc]	214.000[a]	158.000[e]	390.000[b]	170.000[c]	4.730[cd]	50.200a
B_{su}	1251.000[i]	867.000[k]	384.000[f]	1220.000[i]	353.000[ij]	4.400[c]	81.600[d]
B_{so}	553.000[e]	564.000[i]	49.000[b]	798.000[h]	294.000[h]	6.670[fg]	53.700[b]
B_{ca}	360.000[bc]	259.000[d]	101.000[c]	358.000[a]	99.000[a]	4.200[c]	82.200[d]
C_{su}	429.000[d]	398.000[g]	31.000[a]	736.000[f]	338.000[i]	6.870[g]	50.100[a]

C_{so}	603.000^{f}	500.000^{h}	103.000^{c}	748.000^{fg}	248.000^{ef}	4.400^{c}	54.600^{b}
C_{ca}	392.000^{cd}	360.000^{f}	32.500^{a}	602.000^{d}	242.000^{e}	5.830^{ef}	76.600^{c}
D_{su}	1565.000^{j}	103.000^{a}	539.000^{h}	1656.000^{j}	630.000^{l}	4.400^{c}	81.500^{d}
D_{so}	339.000^{ab}	245.000^{c}	94.000^{c}	445.000^{c}	200.000^{d}	1.530^{a}	51.800^{a}
D_{ca}	889.000^{h}	589.000^{j}	29.000^{a}	788.000^{h}	1990.000^{d}	4.400^{e}	81.500^{d}
E_{su}	531.000^{e}	394.000^{g}	137.000^{d}	670.000^{e}	276.000^{g}	2.470^{b}	51.000^{a}
E_{so}	885.000^{h}	504.000^{h}	381.000^{f}	765.000^{g}	261.000^{fg}	1.220^{a}	51.000^{a}
E_{ca}	405.000^{cd}	249.000^{cd}	156.000^{e}	387.000^{b}	137.000^{b}	2.000^{a}	50.400^{a}

Values represent means of triplicate reading, follow by different lowercase letter
Means within the same row with different alphabets are significantly different ($p \leq 0.05$)

A,B,C and D are samples pretreated using blanching, potassium metabisulphite, ascorbic acid and sodium chloride solution, respectively. E is the untreated sample (control). Subscript su, so and ca stand for sun, solar and cabinet drying methods, respectively.

CONCLUSION

Functional and pasting properties of sweet potato examined in this study give clear information to food processor. This study has showed that sample dried using cabinet dryer had the highest value compare to other drying method in term of bulk density, water absorption capacity and swelling power while sun drying had the highest value for both solubility and least gelation capacity while the oil absorption capacity varies. The value of solubility index for sun dried sample was higher compare to all other pretreatment and the drying methods considered.

The pasting properties (peak viscosity, trough viscosity and final viscosity) were generally high when compared with other previous works without pretreatment due to pretreatment used, which indicate that pretreatment has effect on the pasting properties. For peak time and pasting temperature, pretreatment and drying methods have no effect on the result obtained. Results obtained from this study shows that this flour should be recommended for the food industries (confectionary industries) as a fortifier in other to increase the nutrients of products and to serve as food security especially in developing countries.

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