INFLUENCE OF BLANCHING AND DRYING TEMPERATURES ON SELECTED PROPERTIES OF SWEET POTATO (*Ipomoea batatas*) FLOUR

Supported by tetfund TERTIARY EDUCATION TRUST FUND

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Received: November 18, 2018 **Accepted:** February 11, 2019

Abstract: Influence of blanching and drying temperatures on selected properties of sweet potato flour was investigated. Sweet potato samples were washed, peeled and sliced. They were then divided into five samples A, B, C, D and E. Samples A, B and C were treated by blanching at three different temperatures (55, 70 and 85ºC) for 5 min and dried at temperatures of 55, 70 and 85ºC. Sample D was sun dried slightly to reduce the moisture content while E was left in its fresh state. All the samples were milled and sieved. They were then analyzed for proximate and functional properties (water absorption, bulk density and swelling capacity). The study showed that both blanching and drying temperatures affected all the proximate properties of sweet potato except for crude fibre which was not significantly different ($p<0.05$) among treatments. Carbohydrate levels were generally higher for all the blanched samples compared to the untreated samples but values did not vary significantly among treatments. Moisture content of sweet potato flour, reduced with both drying and blanching temperatures, while protein content and fat increased with increase in blanching and drying temperatures. The effect of both parameters (blanching and drying temperatures) on the bulk density was also significant ($p<0.05$). The values of sweet potato flour samples varied significantly and positively from the untreated ones (fresh and sun dried). Thus, since the heat-treated samples had improved protein and carbohydrate contents and also better water absorption and swelling capacities, their flour have more desirable qualities.

Keywords: Sweet potato flour, blanching, functional properties, drying temperature

Introduction

Sweet potato (*Ipomoea batata*) is a dicotyledonous plant that belongs to the morning glory family *Convolvulacceae*. Its large, starchy, sweet-tasting tubers are a root vegetable (Woolfe and Jennifer, 1992). The plant is an herbaceous perennial vine, bearing ultimate heart shield or palmate loped leaves and medium-sized sympetalous flowers. The plant is believed to have originated and domesticated in Central or South America. About 5,000 years ago, it then spread to Mexico, China, Japan and Africa countries (Geneflow, 2009).

Sweet potato is widely grown throughout the world; the United Kingdom, France and the Netherlands being the major importing countries (Katan and De Roos, 2004). The USA is the largest exporter of sweet potato accounting for 35% of world trade. The other exporters are China (12%), Israel (9%), France (7%), and Indonesia (6%). Sweet potatoes are grown throughout the world and are consumed in large quantities. According to the Food and Agriculture Organization (FAO) statistics, world production in 2004 was 127 million tonnes. The majority comes from China, with a production of 105 million tonnes.

The leaves and tubers are the most important part of the potato plant. The young leaves and vine tips of sweet potato leaves are widely consumed as vegetable in West African countries such as Guinea, and Liberia, as well as in Northern Uganda (Abidin, 2004). According to FAO (1990), sweet potato leaves and shoot are good source of Vitamins A, C, and B_2 (riboflavin) and also an excellent source of lutein.

Sweet potato remains an underexploited root crop in the production of flour like other root crops such as cassava and yam. Sweet potato flour has not been fully accepted in some countries, especially in Nigeria, once Sweet potato flour is adopted, it will serve as good source of income for farmers and processors, as well as provide varieties of production item such as cakes, composite bread, sweetener for *kunnu* and snacks.

When potato tubers are processed, it yields about 30% for dried chips and 27% for flour. It has been observed that drying of blanched sweet potato slices or chips is a vital aspect of pre-treatment of processing and storage of sweet potato flour. Literature research has indicated different methods of pre-treatment (soaking, blanching and cooking); and drying of sweet potato chips which establishes safe moisture content level for storage. However, the effect of these various treatments, their temperatures and the temperatures of drying on the quality of the biomaterial has not been widely studied. Therefore, this study is focused on the influence of blanching and drying temperatures on some quality parameters of sweet potato flour.

Materials and Methods

Materials

Matured freshly harvested samples of sweet potato roots (*Ipomoea batatas)* used in this study were obtained from a farm in Gidan kwano village, Minna, Niger State, Nigeria (Plate I).

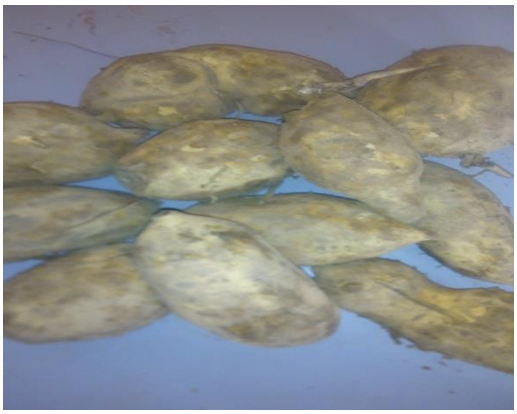

Plate I: Fresh samples of sweet potato

Methods

The methods that were used in the study are as follows:

Sample preparation

Sweet potato tubers were cleaned using tap water to remove dirt and dust. The materials were then peeled manually with a stainless-steel knife. The peeled sweet potato samples were washed thoroughly with tap water, and cut into chip size of constant thickness of 5 mm. 5724 g of the sliced sweet potato was weighed and divided into five samples A, B, C, D and E; weighing 1431, 1431, 1431, 715 and 715 g, respectively (Plate II) with D and E serving as the raw samples that were not subjected to any treatment.

Plate II: Sliced samples of sweet potato

Plate III: Oven drying of sweet potato samples

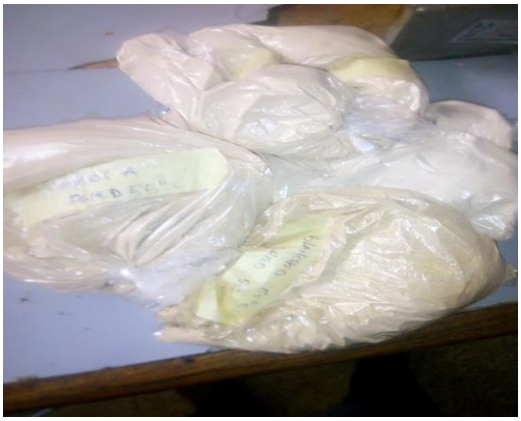

Plate IV: Milled sweet potato flour

The method described by Chinda *et al.* (2018) and Jangchud *et al.* (2003) with some modification was adopted. The experiments were carried out at three blanching temperatures of 55, 70 and 85ºC; and three drying temperatures of 55, 70 and 85ºC. Sample A was blanched at 55^0C and divided into three samples A_1, A_2 and A_3. Sample B was blanched at 70^0C and was divided into three samples B_1, B_2 and B_3. While Sample C was blanched at 80^0C and was divided into three samples C_1, C_2 and C_3. After the blanching process; Samples A_1, B_1 and C_1 were dried at 55^0C to 11% moisture content. Samples A_2, B_2 and C_2 were dried at 70^0C while samples A_3, B_3 and C_3 were oven dried at 85^0C to 11% moisture content (Plate III); sample D and E were not subjected to any treatment. The samples were then milled, sieved and packaged for further analysis (Plate IV).

Statistical analysis

The data obtained was analysed using Analysis of variance (ANOVA) which was carried out with the aid of Design Expert 7.0.0 software, in order to assess how the independent variables, blanching and drying temperatures interacted and affected the proximate and functional properties of the potato flour produced from the various treatments. The experimental design of the study is shown in Table 1.

Table 1: Experimental design of the study

Drying Temperatures (^{0}C)	Blanching Temperatures (^{0}C)		
	55 (B_1)	70 (B_2)	85 (B_3)
55 (T_1)	T_1B_1	T_1B_2	T_1B_3
70 (T_2)	T_2B_1	T_2B_2	T_2B_3
85 (T_3)	T_3B_1	T_3B_2	T_3B_3

Drying

The oven drying method was used to dry the sample. The samples were dried in an electric Oven dryer. The sliced chips were arranged on the drying tray and the trays were placed in the oven. The oven was set at 55, 70 and 85^0C to dry samples to 11% moisture content. After drying, the percentage weight loss was then calculated based on equation 1

$$\text{Percentage loss in weight} = \frac{Original\ weight - Weight\ after\ Drying}{Original\ Weight} \times 100 \quad \ldots\ldots\ldots 1$$

The samples were milled into flour using a milling machine, sieved and sealed in an air tight container for further analysis.

Laboratory analysis

The properties determined were proximate composition (Moisture content, crude fibre, ash content, fat content and carbohydrate) and functional properties (bulk density, swelling capacity and water absorption capacity).

Determination of proximate composition

The proximate composition of the samples was determined according to the method described by the Association of Official Analytical Chemists (AOAC, 2005).

Determination of moisture content

The moisture can was washed and dried in the oven and weighed using analytical weighing balance as W_1. Five grams (5 g) of the sample was put into previously weighed moisture can and recorded as W_2. The sample in the moisture can was put into the oven at 105°C for 3 h. The sample was removed and placed in the desiccator to cool and weighing was carried out afterwards. The sample was reheated and cooled intermittently until constant mass was obtained as W_3. The difference in mass as percent moisture was calculated as the percentage moisture content.

$$\%\ Moisture\ content = \frac{W2-W1}{W3-W2} \times 100 \quad \ldots\ldots\ldots 2$$

Determination of ash content

Three crucibles were thoroughly washed, heated, cooled in the desiccators and weigh using the electronic weighing balance. Their weights were recorded as W_1 with codes A, B and C. 5 grams of each sample was added to its corresponding crucible and the sample was recorded as W_2.

After this, the samples were heated in a muffle furnace at 550ºC for a period of time to ash. At the end of the ashing period, a light grey ash was observed. Removing the samples with the aid of tongs, the samples were taken to be cooled in a desiccator. After cooling, the samples were weighed and their respective weights were recorded as W_3. The percentage ash for each sample was calculated as;

$$\%\text{Ash (dry basis)} = \frac{\text{Weight of ash (W3−W1)}}{\text{Weight of Original sample (W2−W1)}} \times 100\% \quad \ldots\ldots\ldots 3$$

Determination of crude protein

The Kjeldahl apparatus was used for the determination of crude protein. About 0.5 g of the sample was weighed and put into a Kjeldahl digestion flask. A pinch of mixed catalyst was added into each of the flask moistened with distilled water and mixed with 12 ml of concentrated H_2SO_4. The mixture was

heated to red-hot temperature under a fume cupboard for 2 hours to obtain a clear solution. The digest was transferred quantitatively to 100 ml volume flask and diluted to mark with distilled water. A portion of the digest (10 ml) was mixed with equal volume of 40% NaOH solution in a semi-micro Kjeldahl distillation apparatus. The mixture was distilled and the distillate collected into 10 ml of 2% boric solution containing 3 drops of mixed indicator (methyl-orange). The distillate was collected and titrated against 0.1M of H_2SO_4 solution. A blank experiment was also set involving digestion of all the materials except the sample. The distillation was also carried out on the blank. The titre value of the blank was subtracted from that of the sample and the difference obtained was used to calculate the crude protein. The total nitrogen content of the sample was calculated using equation 4.

$$\%\ Protein = \frac{(A-B)\times Molarity\ of\ H2SO4\ \times 1.4007\ \times 6.25}{W} \times 100 \ldots\ldots 4$$

Where: A = titre value
B = blank titre value
W = weight of sample

Determination of crude fibre

5 g of each sample was weighed (and recorded as W_0) into a 500 ml conical flask and 100 ml of digestion reagent was added to the sample after which the entire solution in the conical flasks was brought to boiling and refluxed for 40 min. The flask was then removed from the heater, cooled a little then filtered through a filter paper. The residue was washed with hot water, stirred once with a spatula and transferred to a porcelain dish. The sample was then dried at 105°C. After drying, it was transferred to a desiccator and weighed as W_1. It was burnt in a muffle furnace at 500°C for 6 h, and was allowed to cool, and reweighed as W_2.

$$Percentage\ crude\ fibre = \frac{W1-W2}{W0} \times 100 \quad \ldots\ldots 5$$

Where: W_1= Weight of crucible + fiber + ash
W_2= Weight of crucible + ash
W_0= Dry weight of sample

Determination of fat content

2 g of sample wrapped in a filter paper was weighed using a chemical balance. It was then placed in an extraction thimble that was previously cleaned, dried in an oven, and cooled in the desiccator before weighing. Thereafter, about 25 ml of solvent was measured into the flask and the fat content was extracted. After extraction, the solvent was evaporated by drying in the oven. The flask and its contents were cooled in a desiccator and weighed. The percentage fat content was calculated using equation 6.

$$\%\ of\ fat\ content = \frac{weight\ of\ extracted}{weight\ of\ sample} \times 100 \ldots\ldots 6$$

Determination of carbohydrate

The carbohydrate content was determined by the method of difference where the mean values of other parameters were determined from one hundred (100).

$$\%\ Carbohydrate = 100\% - (\%MC + \%Fat + Crude\ fibre + \%\ Ash) \ldots\ldots 7$$

Determination of functional properties

The functional properties were determined according to the methods reported by Narayana and Narasinga-Rao (1984); Ukpabi and Ndumele (1996) Sosulski *et al.* (1976) for bulk density, swelling capacity and water absorption capacity, respectively.

Bulk density

2.5 g of sample was filled in a 10 ml graduated cylinder and its bottom tapped on the laboratory bench until there was no decrease in volume of the sample. The observed volume of the sample was then recorded as.

$$Bulk\ Density = \frac{Weight\ of\ sample(g)}{Volume\ of\ sample(ml)} \quad \ldots\ldots 8$$

Swelling capacity

0.1 g of sample was weighed into a test tube containing 10 ml distilled water and then it was heated in a water bath at temperature of 60°C for 30 min. This was continually shaken within the heating period. The test tube was then centrifuged at high speed for 15 min after heating in order to facilitate the removal of supernatant water which was then carefully decanted and the weight of the starch paste was taken.

$$Swelling\ capacity = \frac{weight\ of\ starch\ paste\ (g)}{weight\ of\ dry\ sample\ (g)} \quad \ldots\ldots\ldots 9$$

Water absorption capacity

1 g of sample mixed with 10 ml distilled water and allowed to stand at ambient temperature (30±2^{0}C) for 30 min.

$$Water\ absorption\ capacity = \frac{Volume\ of\ water - Volume\ of\ dry\ sample}{volume\ of\ dry\ sample} \quad \ldots\ldots\ldots\ldots 9$$

Results and Discussion

The results of the proximate composition and functional properties of the sweet potato flour blanched and dried at different temperatures are shown in Tables 2 to 3.

Table 2: Proximate composition of sweet potato flour

Samples	M.C (%)	Ash content (%)	Protein (%)	Crude fibre (%)	Fat (%)	Carbo-hydrate (%)
B_1D_1	8.66±0.24	1.5±0.26	2.4±0.20	0.8±0.05	18±1.34	74.2±0.69
B_1D_2	7.3±0.20	1.3±0.04	2.8±0.09	0.5±0.05	17.9±1.23	75.4±0.45
B_1D_3	6.7±0.11	0.9±0.06	3.1±0.67	0.3±0.02	18.2±0.92	75.7±0.49
B_2D_1	9.63±0.07	1.5±0.03	2.7±0.05	0.5±0.05	16.1±0.17	74.2±0.71
B_2D_2	7.96±0.06	1.25±0.01	3.2±0.19	0.5±0.05	16.6±0.36	74.2±0.63
B_2D_3	7.16±0.02	0.88±0.04	3.56±0.03	0.5±0.02	17.3±0.21	73±0.98
B_3D_1	11.03±0.05	1.5±0.26	3.6±0.44	0.6±0.1	14.5±0.36	73.9±1.73
B_3D_2	10.9±0.1	1.3±0.04	3.6±0.36	0.5±0.04	14.8±0.17	74.4±0.53
B_3D_3	10.6±0.26	1±0.18	3.8±0.04	0.5±0.07	15.1±0.62	74.7±0.81
Fresh	63.5±1.24	2±0.07	2.6±0.26	2.5±0.14	36.1±1.13	47.1±1.12
Sundried	11.58±0.31	2±0.21	2.5±0.61	2±0.06	30±0.74	56.2±0.84

Table 3: Functional properties of the sweet potato flour samples

Samples	Water absorption capacity	Bulk density	Swelling capacity
B_1D_1	9.9±0.07	0.72±0.03	10.21±0.09
B_1D_2	10.2±0.26	0.61±0.08	11.3±0.17
B_1D_3	9.97±0.06	0.4±0.01	10.22±0.1
B_2D_1	10.81±0.13	0.4±0.1	11.6±0.36
B_2D_2	10.85±0.28	0.4±0.02	11.52±0.18
B_2D_3	10.06±0.18	0.3±0.01	11.54±0.08
B_3D_1	12.8±0.26	0.4±0.02	11.81±0.79
B_3D_2	12.7±0.24	0.37±0.05	11.78±0.14
B_3D_3	12.83±0.14	0.32±0.03	11.83±0.07
Fresh	8.9±0.93	0.4±0.04	8.2±0.54
Sundried	9.2±1.04	0.4±0.02	9.72±1.04

Where;
B_1D_1 = Blanched at 55^0C, dried at 55^0C
B_1D_2 = Blanched at 55^0C, dried at 70^0C
B_1D_3 = Blanched at 55^0C, dried at 85^0C
B_2D_1 = Blanched at 70^0C, dried at 55^0C
B_2D_2 = Blanched at 70^0C, dried at 70^0C
B_2D_3 = Blanched at 70^0C, dried at 85^0C
B_3D_1 = Blanched at 85^0C, dried at 55^0C
B_3D_2 = Blanched at 85^0C, dried at 70^0C
B_3D_3 = Blanched at 85^0C, dried at 85^0C

Proximate composition of sweet potato flour

Moisture contents of potato flour generally reduced with an increase in drying temperatures (Table 2). The values of moisture contents of the materials blanched at 85ºC and dried at 55ºC (B_3D_1) had the highest value of 11.03±0.05%, while the lowest moisture content of 6.7±0.11% was obtained at blanching and drying temperatures of 55 and 85ºC (B_1D_3) respectively. A huge contrast in moisture content levels of fresh and sun-dried sweet potatoes was obtained. Moisture content values of 63.5% for fresh was obtained while 11.58 % was obtained for sun dried sweet potato which is higher compared to samples subjected to treatments. A value of 12.5% has been considered as the critical moisture content of flour within a locality with an ambient temperature of 27-29^{0}C and a value of 10% has been recommended for long term storage (Van Hal, 2000). The moisture levels obtained were within the acceptable limit of not more than 10% for long term storage of flour (Polycarp *et al.*, 2012). Falade and Solademi (2010) reported that sun-dried sweet potato flour had lower moisture range (8.36-12.78±1.26) than oven dried flour.

It was also observed that moisture content levels increased with increase in blanching temperature for each set of treatment ranging from 6.7±0.11 – 8.6±0.24% for materials blanched at 55ºC, 7.16±0.02 – 9.63±0.07% for those blanched at 70ºC and 10.6±0.26 -11.3±0.05% for samples blanched at 85ºC. This is attributable to the fact that higher blanching and drying temperatures results in higher gelatinization of starch, which probably might have reduced the rate of release of moisture during drying because of its binding or pasting property. However, observation shows further that even though moisture contents of potato flour decreased with drying temperatures in each set of treatment, the variation in moisture contents of the materials blanched at the highest temperature of 85ºC is small compared to those blanched at 55 and 70ºC. This could also be due to the high degree of starch gelatinization of starch in the samples at the 85ºC blanched temperatures.

Statistical analysis (Table 4) shows that blanching temperature and drying temperature both had significant ($P \leq 0.05$) effect on moisture content of the potato flour with p- values of 0.004 and 0.0546, respectively.

The ash content of the blanched and dried sweet potato flour decreased with increase in both blanching and drying temperatures for each set of treatments but did not vary between treatments as shown in Table 2. Ash content values of 1.5±0.26 and 0.9±0.06% were obtained for blanching and drying temperatures of 55 and 85ºC, respectively. Similarly, the ash content for the materials blanched at the highest temperature of 85ºC also ranged from 1.5±0.26 - 1.0±0.183% at corresponding drying temperatures of 55 - 85ºC. However, these values are lower compared to the two untreated samples of fresh and sun-dried sweet potatoes which were 2.0% for each. According to Van Hal (2000), flour from local varieties have generally low ash content. Jangchud *et al.* (2003) also reported that lower values of ash content observed with flour from some varieties used maybe due to the effect of some pre-treatments.

Table 4: Test of the significance of the influence of blanching and drying temperature on moisture contents

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-squared	
Model	22.08984	4	5.522461	17.87333	0.0081	0.9479	significant
A-Blanching Temp	18.03482	2	9.017411	29.18466	0.0041		
B-Drying Temp	4.055022	2	2.027511	6.561997	0.0546		
Residual	1.235911	4	0.308978				
Cor Total	23.32576	8					

Table 5: Test of the significance of the influence of blanching and drying temperature on ash contents

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-squared	
Model	0.507733	4	0.126933	100.210 5	0.0003	0.9901	Significant
A-Blanching Temp	0.004867	2	0.002433	1.921053	0.2602		
B-Drying Temp	0.502867	2	0.251433	198.5	< 0.0001		
Residual	0.005067	4	0.001267				
Cor Total	0.5128	8					

Drying temperature had significant ($P \leq 0.05$) effect on ash content of the sample with p- value of 0.0001 while the blanching temperature had insignificant ($P \leq 0.05$) effect on ash content of the sample with p- value of 0.2602 (Table 5).

A significant increase was noticed in the protein content of samples that were subjected to the treatments. Both blanching and drying temperatures affected protein content in sweet potato flour as shown in Table 2. Protein contents were higher for higher drying temperatures in each of the blanched treatments. However, samples blanched at temperature of 85ºC had higher protein contents compared to others blanched at 55 and 70ºC and dried at corresponding temperatures of 55 and 70ºC. Accordingly, the highest protein content of 3.8% was obtained at the highest blanching temperature of 85ºC and drying temperature of 85ºC while samples blanched at 55ºC and dried at 55ºC had the lowest value of 2.4±0.20. Comparatively, the fresh and sun-dried sweet potato flour had least protein contents of 2.6 and 2.5%, respectively. ILSI (2008) reported a range of 3.77-5.87% for protein content of sweet potato. Since protein is known for its importance in the building of bones, muscles, cartilage, skin and blood; and it is a macro-nutrient required for sustenance of life, blanching and drying of sweet potato is desirable. Sweet potato in both fresh and flour form have been reported to be of good biological value (Van Hal, 2000). According to Woolfe (1992), lower values of protein content observed with flour from some varieties may be due to varietal differences.

Both blanching and drying temperatures had significant effect on the protein contents of sweet potato flour (Table 6). As shown in Table 6; blanching temperature had significant ($P \leq 0.05$) effect on protein content of the sample with p- value of 0.0092 while the drying temperature had significant ($P \leq 0.05$) effect with p- value of 0.0405 with a high coefficient of correlation R- Squared value of 0.9304.

Crude fibre is a measure of the quantity of indigestible cellulose, pentosans and lignin in food. This content in blanched and dried sweet potato flour was unaltered by both blanching and drying temperatures. The crude fibre of the samples was only slightly higher at blanching and drying temperatures of 55 and 55ºC as indicated in Table 2. The crude fibre contents were higher (2.5%) in the fresh potato and sun dried (2.0%) samples.

Crude fibre is a measure of the quantity of indigestible cellulose, pentosans and lignin in food. This content in blanched and dried sweet potato flour was unaltered by both blanching and drying temperatures. The crude fibre of the samples was only slightly higher at blanching and drying temperatures of 55 and 55ºC as indicated in Table 2. The crude fibre contents were higher (2.5%) in the fresh potato and sun dried (2.0%) samples.

Table 6: Test of the significance of the influence of blanching and drying temperature on protein contents

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-Squared	
Model	1.739378	4	0.434844	13.37526	0.0138	0.9304	Significant
A-Blanching Temp	1.223022	2	0.611511	18.8093	0.0092		
B-Drying Temp	0.516356	2	0.258178	7.941217	0.0405		
Residual	0.130044	4	0.032511				
Cor Total	1.869422	8					

Table 7: Test of the significance of the influence of blanching and drying temperature on Crude fibre contents

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-Squared value	
Model	0.151111	4	0.037778	0.764045	0.5997	0.4331	not significant
A-Blanching Temp	0.015556	2	0.007778	0.157303	0.8595		
B-Drying Temp	0.135556	2	0.067778	1.370787	0.3520		
Residual	0.197778	4	0.049444				
Cor Total	0.348889	8					

Table 8: Test of the significance of the influence of blanching and drying temperature on fat contents

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-Squared value	
Model	16.49333	4	4.123333	61.85	0.0008	0.9841	Significant
A-BlanchingTemp	15.80667	2	7.903333	118.55	0.0003		
B-Drying Temp	0.686667	2	0.343333	5.15	0.0782		
Residual	0.266667	4	0.066667				
Cor Total	16.76	8					

Table 9: Test of the significance of the influence of blanching and drying temperature on Carbohydrate contents

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-Squared value	
Model	2155.947	4	538.9867	0.977189	0.5087	0.4942	not significant
A-Blanching Temp	1102.34	2	551.17	0.999278	0.4447		
B-Drying Temp	1053.607	2	526.8033	0.955101	0.4581		
Residual	2206.273	4	551.5683				
Cor Total	4362.22	8					

The result in Table 7 shows that both blanching temperature and drying temperature had insignificant ($P \leq 0.05$) effect on crude fibre content of the samples with p- values of 0.8595 and 0.3520, respectively. The corresponding low coefficient of correlation R-Squared value of 0.4331 means that both blanching and drying treatments slightly reduced the fibre content in the potato flours. Lower value of crude fibre observed with flour from some varieties used may be due to varietal differences (Woolfe 1992; Van Hal 2000).

The fat content was higher (18.0±0.34 - 18.20±0.10%) for flour from sweet potato blanched at lower temperatures of 55ºC, while the lowest values (14.5±0.36 – 15.10±0.62%) of fat were obtained at the highest blanching temperatures of 85ºC as presented in Table 2. However, for each block of treatment, the oil content is almost constant at 17.9±0.34 – 18.2±0.10%, 16.10±0.17 – 17.30±0.21% and 14.5±0.36 – 15.10±0.62%, obtained for potato flour blanched at 55, 70 and 85ºC before drying. In contrast, the fat content of the untreated potato samples (fresh and sun-dried samples) was higher (36.1 and 30.0%) than all the blanched samples. Although fats are back-up for energy production in the human body when carbohydrate is exhausted, its cholesterol content is unhealthy for humans as it increases the risk of heart disease. From this result, pre-heat treated sweet potato flour reduces this risk. The decrease of fat in sweet potato flour may be due to effects of some pre-treatments involving leaching such as blanching which decreases the content of fat with increase in blanching temperatures (Jangchud *et al*, 2003).

The result in Table 8 shows that both blanching temperature and drying temperature had significant ($P \leq 0.05$) effect on the fat content of the samples with p- values of 0.0003 and 0.0782, respectively.

The carbohydrate content of all the flour samples blanched at 55, 70 and 85ºC were higher than those of the two untreated samples (Table 2). The values were almost constant irrespective of the blanching and drying temperatures (74.2±0.69% - 75.5±0.45%) observed for the lowest blanching temperature of 55ºC and 73.9±1.73 – 74.7±0.82% observed for the highest blanching temperature of 85ºC; this agrees with the value of 74.9-76.4% for carbohydrate reported by Van Hal (2000). The untreated samples had lower carbohydrate contents of 47.1% for fresh potato and 56.2% for the sun-dried samples.

ANOVA for the carbohydrate content presented in Table 9, shows that both blanching temperature and drying temperature had insignificant ($P \leq 0.05$) effect on carbohydrate content of the samples with p-values of 0.4447 and 0.4581, respectively.

Functional properties of sweet potato flour

The water absorption capacity of the samples blanched at higher temperatures of 85ºC was higher than those that were blanched at 55 and 70ºC (Table 3). The water absorption capacity of the samples blanched at 55 and 70ºC ranged from 9.9±0.7 – 9.97±0.06 g/ml while the ones blanched at 85ºC had water absorption capacity ranging from 12.7 – 12.83±0.26 ml/g. In comparison, the value for the untreated samples were lower (8.9 mL/g for fresh and 9.2 mlLg for dried) than all the blanched samples. Both blanching and drying temperatures affected the water absorption capacity of sweet potato flour. Jangchud *et al. (*2003) reported that blanching increased the water absorption capacity of sweet potato flour at all temperatures investigated. Ahmed *et al.* (2010) reported that water absorption capacity was highest at 65^0C when treated with N_aHSO_3 (2.49 and 10.44 g/ml).

Statistical analysis (Table 10) revealed that blanching temperature and drying temperature had significant ($P \leq 0.05$) effect on water absorption capacity of the samples with p-values of 0.0041 and 0.0546 respectively. The coefficient of correlation R- Squared value of 0.9479 was also obtained.

Higher bulk density values of 0.40±0.02 – 0.72±0.026 kg/m^3 were obtained for the samples of flour blanched at 55ºC (Table 3). At this blanching temperature, the samples dried at 55ºC had the highest value of 0.72±0.0.026 kg/m^3. All the others blanched before drying had almost similar bulk densities of 0.3±0.02 – 0.4±0.017 kg/m^3 for blanching at 70ºC and 0.32 – 0.4 kg/m^3 for the ones blanched at 85ºC. These values are the same with the ones obtained for the fresh potato and dried potato which have 4.0 kg/m^3 each. The value obtained for bulk density of yam flour (0.64 – 0.76 g/cm^3) are comparable to that obtained for sweet potato flour 0.74 g/ml used as thickener or as a base in foods like yoghurt (USDA, 2009). It was observed that the increase in both blanching and drying temperatures affect the bulk density of sweet potato flour (Jangchud *et al.*, 2003).

Table 10: Regressional Analysis of water absorption of the samples

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-squared	
Model	22.08984	4	5.522461	17.87333	0.0081	0.9479	significant
A-Blanching Temp	18.03482	2	9.017411	29.18466	0.0041		
B-Drying Temp	4.055022	2	2.027511	6.561997	0.0546		
Residual	1.235911	4	0.308978				
Cor Total	23.32576	8					

Table 11: Test of the significance of the influence of blanching and drying temperature on Bulk density

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-Squared value	
Model	0.133978	4	0.033494	7.263855	0.0404	0.8790	Significant
A-Blanching Temp	0.089622	2	0.044811	9.718072	0.0291		
B-Drying Temp	0.044356	2	0.022178	4.809639	0.0863		
Residual	0.018444	4	0.004611				
Cor Total	0.152422	8					

Table 12: ANOVA of swelling capacity of the flour samples

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	R-Squared value	
Model	2.751111	4	0.687778	4.83122	0.0781	0.8285	not significant
A-Blanching Temp	2.530956	2	1.265478	8.88921	0.0337		
B-Drying Temp	0.220156	2	0.110078	0.773229	0.5201		
Residual	0.569444	4	0.142361				
Cor Total	3.320556	8					

Table 11 shows that the blanching temperature and drying temperature had significant ($P \leq 0.05$) effect on bulk density of the samples with p- values of 0.0291 and 0.0863, respectively.

Swelling capacity of the samples were generally higher for higher blanching temperatures of 70 and 85ºC and lowest at the lowest blanching temperature of 55ºC as presented in Table 3. The swelling capacity of the samples blanched and dried at 85 and 85ºC had constant values of 11.83±0.07 g/vol. irrespective of drying temperature variation. Similarly, those blanched at 70ºC had almost constant swelling capacity of 11.5 g/vol. However, the swelling capacity of the samples blanched and dried at 55 and 70ºC, respectively had higher values of 11.3 g/vol. which is higher than those blanched at the same temperature of 55ºC whose values ranged from 10.21 – 10.22 g/vol. In contrast, swelling capacity of the fresh, 8.2 g/vol and sun dried, 9.2 g/vol were both lower than all the blanched samples.

Blanching temperature had significant ($P \leq 0.05$) effect on swelling capacity of the sample with p- values of 0.0337 while the drying temperature had insignificant ($P \leq 0.05$) effect on swelling capacity of the sample with p- values of 0.5201 (Table 12).

According to Jangchud *et al.* (2003) blanching increases the swelling capacity in sweet potato flour. Swelling capacity of sweet potato flour increases as a result of processing which increased with increase in temperature (Yadav *et al.*, 2006)

Conclusions

Sweet potato flour was produced from blanched and dried potato at varying temperatures and the proximate and functional properties of the flour samples were investigated. Results obtained from the analyses indicated that both blanching and drying temperatures affected all the proximate properties of sweet potato except for crude fibre. The values of sweet potato flour samples vary from the untreated ones which were fresh and sun dried. Moisture content of sweet potato flour, reduced with both drying and blanching temperatures, while protein content and fat increased with increase in blanching and drying temperatures. The crude fibre contents were not significantly different among treatments while carbohydrate levels were generally higher for all the blanched samples compared to the untreated samples but values did not vary significantly among treatments. For the functional properties, both water absorption capacity and swelling capacity of the samples were higher for higher blanching and drying temperatures and also higher than the sun dried and fresh samples. From these results it was generally observed that the flour produced by blanching and drying of sweet potato gave better outcome as most of their proximate and functional properties increased compared to the untreated samples.

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