Effect of drying techniques on some quality properties of yellow-fleshed sweet potato flour

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Abstract: The study determined the effect of drying techniques on some quality properties of yellow-fleshed sweet potato (YFSP). YFSP tubers were weighed, sorted, washed, peeled, pretreated, and diced (oven-dried) or wet milled into slurry for drum-dried samples. Dried samples were milled, sifted, weighed, and packaged. The pretreatments and drying conditions were blanching (85 ℃, 3min 30secs), steam cooking (120 ℃, 2min), sun drying (27 ± 2 ℃), oven drying (70 ℃, 8 h) and drum drying (150 ℃, 10 rpm, 84.05%). The mineral content, rehydration capacity (RC), and sensory evaluation of samples were determined using standard methods. The results showed that the RC of sun oven-dried samples were not significantly different ($p > 0.05$) while the RC of the samples (oven and sun drying) increased as the rehydration temperatures increased, contrary to that of drum-dried samples. Drum-dried samples had the highest RC of 524.5%. The mineral contents: calcium, iron, potassium, and magnesium decreased with pretreatment and processing operations. Sun oven-dried samples were the most acceptable reconstituted dough based on their sensorial attributes. The study concluded that acceptable YFSP flour could be produced by any of the drying methods depending on the end use.

Keywords: sweet potato, rehydration capacities, sensory properties, sun drying, oven drying, drum drying.

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1 Introduction

Sweet potatoes (*Ipomoea batatas*) are rich sources of simple starches and are abundant in complex carbohydrates. The tuber contains functional components like polyphenols, anthocyanin, and beta-carotene (a pro-vitamin A carotenoid) with small amounts of vitamins and minerals (Kumar et al., 2016). Sweet potato is normally consumed boiled, fried, or mashed for pottage in Nigeria but it is not commercially available in Nigeria in flour or flakes form. Sweet potato contains a high percentage of moisture content usually greater than 70%, making it highly perishable after harvest (Morakinyo and Taiwo, 2016). The availability of sweet potato roots in the dried form will extend the shelf life making it easy for reconstitution. Processing sweet potato tuber into the powdered form will offer an exceptional prospect of offering the product in a stable form (Olatunde et al., 2016).

Drying is an ancient method of keeping food safe. Different drying techniques (sun, solar, oven, vacuum, drum drying, etc.) affect the quality of the products differently. Conventional dehydration of food materials led to changes in product colour, texture, and loss of

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nutritive values. However, pretreatment before drying is important in minimizing the variations that happen in the tissue for the period of production (Deng et al., 2017). Bao et al. (2021) reported that drying techniques affected the top and internal structure of starch granules resulting in a change in their functional attributes. These properties include starch gelatinization, retrogradation, and pasting profile of the flour products (Bao et al., 2021).

Natumanya et al. (2021) reported that drying can lead to a considerable loss of nutrients depending on drying methods and temperature conditions. Borad et al. (2017) also specified that the result of unit operations on nutritive composition relies on the nutrient sensitivity to several conditions predominantly during production. The drying techniques can have a significant influence on the quality attributes of food products, starting from the noticeable color and texture to the undetectable nutrient standards (Mohammad et al., 2020). Drying significantly has impact the sensory and nutritional properties of food final products (Olatunde et al., 2016).

Rehydrated foods are progressively used as parts of industrial foods and their rehydration properties rely directly on the drying properties. Water absorption by dry materials is a complex technique influenced by many causes amongst which temperature plays a significant role in the water absorption capacity and the product's quality attributes. Several pre-drying treatments and additives with improved packaging have contributed to the enhanced rehydration characteristics of many dried products. Soaking at high temperatures decreased the required time to attain maximum water absorption capacity in blueberries (Reque et al., 2015).

Sweet potato tubers have been reported to contain micronutrients like potassium, iron, calcium, sodium, and phosphorus (Odunlade et al., 2017). The tuber contains trace elements that help to regulate the muscles, heart, and nerves, preserve the body fluid and maintain strong bones and teeth (Muhammed et al., 2022). Potassium is an indispensable nutrient that is vital for amino acids and protein synthesis (Akindele et al., 2017). To reduce anaemia and other related diseases, there is a need for childbearing (pregnant and nursing) women, babies, convulsing patients, and the aged to eat food containing iron because of its importance in red blood cell formation (Abbaspour et al., 2014). Zinc is also a micronutrient that is required in a very small amount which helps ingestion and improves organ functions by preventing the liver from harm (Akindele et al., 2017).

Due to the need to increase the use of sweet potato flour for human consumption, reduce yearly losses of the harvested sweet potato tuber and increase the availability of the flour products throughout the year, thus there is a need to determine the effect of different processing techniques (drying methods) and pretreatment on the quality properties of the flour product. Hence, this study aims to compare the effect of different drying techniques on the quality (rehydration capacities (RC), mineral contents, and sensory) properties of the flour. The results of this work will make available valuable information for the production of yellow-fleshed sweet potato flour.

2 Materials and methods

2.1 Experimental site

Sweet potato tubers (*Ipomoea batatas*) were obtained from Oja Tuntun in Ile – Ife, Osun State, Nigeria which is located at the latitude of 7.490462 and longitude 4.552127. The tuber was characterized in the Department of Botany, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria which is located at the latitude of 7.520767 and longitude of 4.530315. All the chemicals used were of analytical grades.

2.2 Sample preparations

Yellow fleshed sweet potato tubers were weighed, sorted, and washed in a vat. The YFSP tubers were processed by the modified method of Chittrakorn and Bora (2021). The washed YFSP cultivars were manually peeled using a manual peeler and diced into smaller pieces of 1.5 mm thickness using a dicing machine (AB Hallde Maskiner Sweden RG – Z – PAT No: 8900) (Jangchud et al., 2003; Afolabi et al., 2021). The diced samples were pretreated and oven or sun-dried as depicted in Table 1.

Table 1 Sample Description of YFSP flour samples

Sample Code	Drying Methods	Conditions
SU	Sun-dried	unblanched, 3 – 4 days at 27 ±2 ℃
OU	Oven-dried	unblanched at 70 ℃ for 8 h
SB	Sun-dried	0.02% sulphite, 85 ℃ blanched for 3 min 30 s dried for 3 – 4 days at 27 ±2 ℃
OB	Oven-dried	0.02% sulphite, 85 ℃ blanched for 3 min 30 s oven-dried at 70 ℃ for 8 h
SS	Sun-dried	0.02% sulphite, steam cooked for 2 min sun-dried for 3 – 4 days at 27 ±2 ℃
OS	Oven-dried	0.02% sulphite, steam cooked for 2 min oven dried at 70 ℃ for 8 h
DD	Drum-dried	150 ℃, 10 rpm, 100 ml (84.05%)

The drum-dried flour samples were produced using the modified techniques of Yadav (2007). The YFSP tubers were wet milled into a slurry using a Premier attrition mill (2726.29 g of tubers with 2000 ml of water). The drum drier was heated to 150 °C using indirect heat contact transfer through the superheated steam generated from the boiler discharged inside the drum of the drum drier. The drum drier speed was at 10 rpm and the slurry was diluted to 84.05% moisture content (MC). The dried flakes were milled using a Premier attrition mill and packaged in Ziploc bags. The pictures of the milled flour samples are shown in Plate 1.

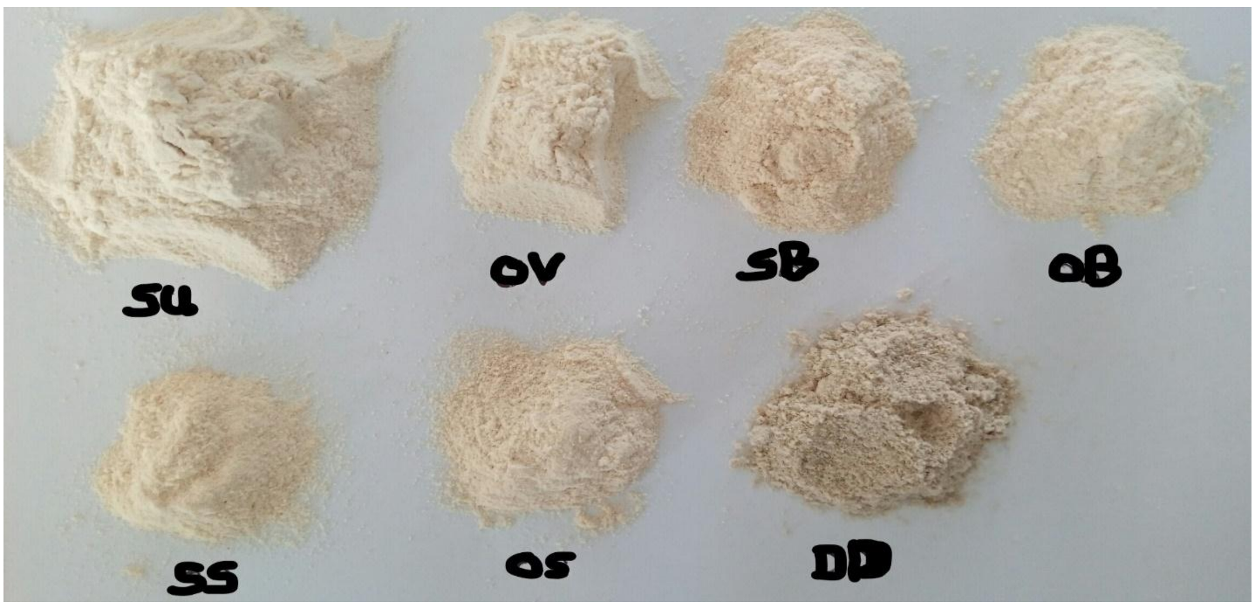

Plate 1: Pictures of YFSP flour samples

2.3 Rehydration capacity of the YFSP flour samples

The rehydration capacity (RC) of the flour samples was carried out. A 1 g flour sample was poured inside a 10 ml tube containing distilled water and mixed. The mixture was mixed with vortexed for 10 mins and kept in a water bath at room temperature, 60, 70, 80, and 90 °C, then centrifuged at 2000 g for 10 mins. The liquid from the centrifuge was removed and the remaining supernatant was removed by slanting the tube. The supernatant was carefully decanted and the contents in the tube were allowed to drain at 45 °.

2.4 Mineral contents of the YFSP flour samples

AOAC (2005) defined the technique to analyze the mineral content of all the YFSP flour samples. The samples were ashed at 550 ℃. The ash was boiled with 10 ml of 20% hydrochloric acid in a beaker and then filtered into a 100 ml standard flask. This mixture was topped up to the mark with deionized water. The minerals (iron, sodium, potassium, and magnesium) were analyzed from the resulting solution using an Atomic Absorption Spectrophotometer (AAS PG Instrument Model 990 FG) while calcium was determined spectrophotometrically using an ultra-violent wavelength of Spectrophotometer Model 752N.

2.5 Sensory properties of the YFSP flour samples

Sensory properties were evaluated by 20 semi-trained panelists from the Department of Food Science and Technology, Obafemi Awolowo University, Ile – Ife, Nigeria (Babalola and Taiwo, 2019). Reconstituted sweet potato dough was prepared in a ratio of 200 g of flour to 100 ml of water. 100 ml of water was boiled and 200 g was added to the boiled water and turned for 15 mins until smooth and cooked. The smooth dough was wrapped in nylon and kept in a cooler. *Ewedu* (Jute leaves) soup served with the dough was plucked, rinsed, and blended. The blended leaves were cooked with spice (locust beans, salts, and seasoning) for 5 mins. No stew or other soup was added to the *ewedu* soup. Reconstituted sweet potato dough (in swallow form) was served with *ewedu* soup to the 20 semi-panelists from the Department of Food Science and Technology who were given a questionnaire to rate each sample on a 9 - point hedonic scale where 1 and 9 denote dislike extremely and like extremely respectively. Each dough sample was evaluated based on sensory attributes like colour, aroma, texture, taste, mouthfeel, and overall acceptability.

2.6 Statistical analysis using one-way analysis of variance (ANOVA)

Experimental points were chosen guided by the literature and preliminary studies (using the randomized blocked design). All analyses were made in three replicates and the data obtained was subjected to a one-way Analysis of Variance (ANOVA) at a 5% level of significance using SPSS 20.0 for Windows. Means were separated by Duncan’s multiple range tests. Descriptive and inferential tests were also used where applicable.

3 Results and discussions

3.1 Flour rehydration capacities (RC)

The RC of YFSP flour samples at different temperatures is shown in Figure 1. At room temperature (RT), the RC of all the YFSP flour samples ranged from 107 to 524.5%. Unblanched samples had the lowest RC of 107% while drum-dried samples had the highest RC of 524.5%.

From Figure 1, as the temperature increased the RC of the flour samples increased. As for the drum dried samples, the RC was highest at RT while there was a decrease in RC as the rehydration temperature increased. The increase in the RC of other sun and oven-dried samples may be due to the swelling of the starch components (amylose or amylopectin) present in YFSP flour that caused the particle size to swell until it reached its maximum capacity which agrees with the study of Agunbiade et al. (2006). The reduction in the RC of drum-dried samples as the temperature increase may be the due effect of the drum-drying method on the sample. The drum-dried samples were probably gelatinized during drying (as a result of high heat), which caused the surface area of the flour to increase due to flaking and this could cause the sample to have the highest RC at RT compared to other samples that had smaller particle size and surface area. The diameter of the drum was 0.46 m and at the speed of 10 rpm, it took the sample 0.498 m^2 to travel around the drum from the feeding of the drum to scrapping of the flakes. The drum makes a three-quarter rotation by the time the product is scrapped which implied that the period of area contact of the product at 10 rpm can cause an increase in starch gelatinization of the drum-dried flour sample (Wadchararat et al., 2006). RC of the YFSP flour is an intricate property that is affected by the physical, chemical, and structural changes that occurred during the pretreatment, processing, and drying methods of the samples (Feng and Tang, 1998). SB, SS, and SU samples had higher values of RC while oven-dried samples had lower values. Processing conditions, sample preparation composition, and the level of structural and chemical composition brought on by the different drying methods before milling into flour are all variables that could have an impact on the degree of rehydration. The lower rehydration values of oven-dried samples show insufficient product shrinkage due to prolonged drying, which could lead to the product's irreversible physicochemical alterations (Taiwo and

Babalola, 2018).

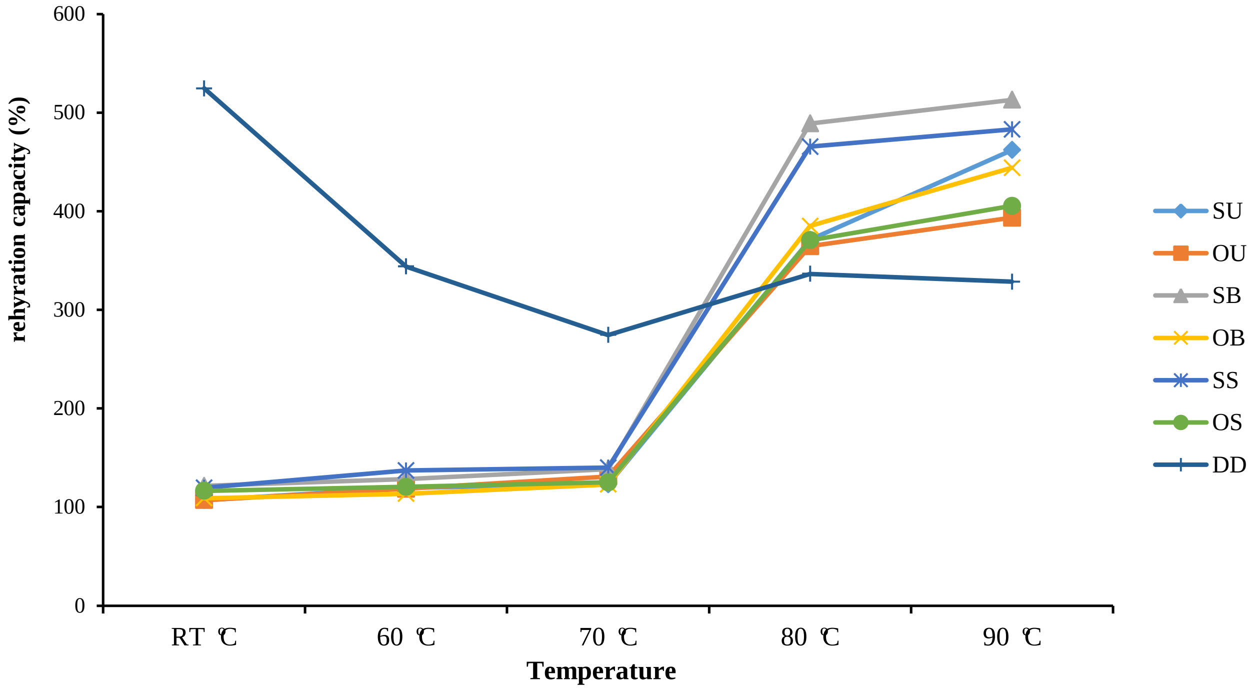

Figure 1 Rehydration capacity of YFSP flour samples at different temperatures

The results shown in Table 2 indicated the percentage (%) difference between the RC of YFSP samples at RT compared to the RC at different temperatures and SU (control). At RT, the RC of unblanched oven-dried samples (OU) was 0.01 while drum-dried samples had the highest RC of 390.19%. This means that the RC of SU and OU were similar at RT. The RC of other samples at RT was significantly different ($p > 0.05$) from each other. This suggests that the pretreatments employed did influence the RC at RT. Oven-dried samples had lower RC of the samples compared to the sundried samples and this can be due to the effect of oven drying on the yellow-fleshed sweet potato flakes. Of the three methods, drum-dried samples had the highest RC, followed by sundried samples and oven-dried samples.

The negative values imply a loss in RC i.e., the amount of water taken up by sample OB at 60 ℃ is less than that of sample SU at the same temperature. At each temperature, there was a significant difference ($p < 0.05$) in the RC of the samples except for the drum dried using unblanched sun-dried as reference samples. The RC of the samples increased with an increase in temperature.

Table 2 Percentage (%) difference between the RC of YFSP flour samples at different temperatures

Samples	Room Temperature (℃)	60 °C	70 °C	80 °C	90 ℃
SU	-	-	-	-	-
OU	0.01±0.01[b]	-0.85±0.85[b]	6.51±0.01[a]	-1.75±0.01[c]	-17.42±0.01[d]
SB	13.55±0.01[b]	7.52±0.01[e]	12.60±0.01[c]	31.81±0.01[a]	11.04±0.01[d]
OB	1.87±0.01[b]	-5.28±0.01[e]	0.01±0.01[c]	3.77±0.01[a]	-3.90±0.01[d]
SS	11.6±0.01[d]	14.65±0.01[b]	13.82±0.01[c]	25.47±0.01[a]	4.55±0.01[e]
OS	8.89±0.01[a]	0.84±0.01[c]	1.64±0.01[b]	-0.12±0.01[d]	-12.22±0.01[e]
DD	390.19±0.01[a]	187.88±0.01[c]	188.22±0.01[b]	-9.31±0.01[d]	-28.90±0.01[e]

Table 3 Percentage (%) difference across the RC of YFSP flour samples of different temperatures

Samples	Room Temperature (°C)	60 °C	70 °C	80 °C	90 °C
SU	-	12.18±0.50^{d}	15.45±0.50^{c}	247.23±0.50^{b}	332.26±0.50^{a}
OU	-	11.25±0.50^{d}	22.90±0.50^{c}	241.15±0.50^{b}	268.26±0.50^{a}
SB	-	6.26±0.50^{d}	14.49±0.50^{c}	302.97±0.50^{b}	322.72±0.50^{a}
OB	-	4.63±0.50^{d}	13.34±0.50^{c}	253.71±0.50^{b}	307.84±0.50^{a}
SS	-	15.14±0.50^{d}	17.65±0.50^{c}	290.04±0.50^{b}	304.68±0.50^{a}
OS	-	3.93±0.50^{d}	7.80±0.50^{c}	218.53±0.50^{b}	248.57±0.50^{a}
DD	-	-34.91±0.50^{b}	-32.91±0.50^{a}	-35.34±0.50^{b}	-36.87±0.50^{b}

Data in Table 3 compared the RC of samples at different temperatures with those at RT. There was a significant difference ($p > 0.05$) between all the samples at different temperatures except for the drum-dried samples. This is because the RC of the drum-dried samples was negative and fluctuated between -32.91 and -36.87. This suggests that the amount of water absorbed decreased as temperature increased, The RC of drum-dried samples reduced at higher rehydration temperatures compared to the RC of samples at RT. For non-drum dried samples at 60 and 70 °C, the percentage (%) difference in RC increase was between 3.93 and 22.9 while between 80 and 90 °C, the percentage (%) difference in RC was 218.53 and 332.26 respectively. For drum-dried samples, RC did not increase with temperature increase. When YFSP rehydrates at 80 and 90 °C, it means that the dried product has good quality because the pores allow water to reenter the cells thereby causing the RC capacity to largely increase (Okpala and Ekechi, 2014). As the temperature increases after 70 °C, it was found that the initial rate of RC increased at 80 - 90 °C. This shows that when the water is hot, fast rehydration is possible or RC is largely increased (Okpala and Ekechi, 2014).

Table 4 shows the regression relationships between the percentage (%) RC of YFSP flour samples at different temperatures from 60 to 90 °C. Linear, logarithm, polynomial and power equations were used to relate the RC at different temperatures of the samples. The effects of different processing (blanched and unblanched) parameters on the regression coefficient of the (%) RC of YFSP flour samples at different temperatures were not significant ($P > 0.05$) but the effect of processing method (drum-dried) parameters on the regression coefficient of the (%) RC of YFSP was significant ($P < 0.05$) compared to other samples. The influence of drying methods, pretreatment, and blanching was significant ($P < 0.05$) (Allen et al., 2016). Using linear equation ($y = ax$) to relate percentage (%) RC at different temperatures gave a good correlation for most of the sample points except for the drum-dried sample which did not have a good correlation point. The correlation coefficient (r^2) for all the samples ranged from (-5.386 to 0.8129) at different temperatures of 60 to 90 °C. The lowest correlation coefficient (r^2) among all the samples was – 5.386 for drum-dried samples and the highest correlation coefficient (r^2) was 0.8129 for unblanched oven-dried samples. The correlation coefficient (r^2) between blanched and unblanched ranged from 0.7644 to 0.8129 which exhibited a good correction point while that of the drum-dried sample was negative (-5.386) meaning that it did not have a good correction point. Using a logarithmic equation to describe the relationship between percentage (%) RC and temperature, the correlation coefficient ranged from 0.6339 to 0.6689 for all the samples which indicates a good fit. Steam cook oven dried samples had the lowest r^2 of 0.6339 while unblanched oven dried samples had the highest r^2 of 0.6339 (Chan et al., 1997). A polynomial equation of the second order ($y = ax^2 + bx + c$) enhanced the correlation coefficient of all the samples from -2.224 to 0.8830. Drum Dried had the least correlation coefficient of -2.224 while unblanched samples had the highest correlation coefficient of 0.8830. The correlation coefficient (r^2) between blanched and unblanched ranged from 0.8263 to 0.8330 which exhibited a good correction point while that of the drum-dried sample was negative (-2.224) meaning that it did not have a good correction point. For the power equation, the correlation coefficient of all the samples ranged from 0.6127 to 0.7126. Drum dried samples had the least correlation coefficient of 0.6127 while unblanched oven dried samples had the highest correlation coefficient of 0.7126. The correlation coefficient (r^2) between blanched and unblanched samples ranged from 0.6477 to 0.7126 and they exhibited a good correction point while that of drum-dried samples was negative (0.6127) meaning that it had the least correction point. Using exponential and moving average equation, the correlation coefficient of all the samples were not a good fit. The correlation coefficient (r^2) of all the samples for the exponential equation was negative while only unblanched sun-dried samples were negative and other samples did not have any correlation (Allen et al., 2016). The regression analysis for all the temperature ranges was fitted and show a significant correlation as their coefficient of determination (r^2) was greater than 0.8129 (Singh and Pandey, 2011).

Table 4 Regression relationships percentage (%) across the RC of YFSP flour samples at different temperatures

Samples	Linear equation	R^2	Logarithmic equation	R^2	Polynomial equation	R^2	Power equation	R^2
SU	$y = 81.982x$	0.8015	$y = 212.69\ln(x) + 32.852$	0.6508	$y = 12.505x^2 + 30.826x$	0.8830	$y = 80.517x^{0.9144}$	0.6858
OU	$y = 75.682x$	0.8129	$y = 184.18\ln(x) + 46.547$	0.6689	$y = 6.8509x^2 + 47.655x$	0.8464	$y = 83.402x^{0.8518}$	0.7126
SB	$y = 96.636x$	0.7644	$y = 255.88\ln(x) + 33.099$	0.6370	$y = 13.457x^2 + 41.587x$	0.8282	$y = 89.233x^{0.9531}$	0.6641
OB	$y = 81.182x$	0.7917	$y = 208.94\ln(x) + 34.844$	0.6448	$y = 11.343x^2 + 34.778x$	0.8606	$y = 80.617x^{0.9057}$	0.6685
SS	$y = 92.555x$	0.7765	$y = 237.46\ln(x) + 41.635$	0.6468	$y = 10.688x^2 + 48.831x$	0.8280	$y = 91.515x^{0.916}$	0.6842
OS	$y = 77.127x$	0.7889	$y = 184.13\ln(x) + 51.292$	0.6339	$y = 7.4363x^2 +46.706x$	0.8263	$y = 88.499x^{0.817}$	0.6477
DD	$y = 91.355x$	- 5.386	$y = -121.3\ln(x) + 477.74$	0.6574	$y = -44.19x^2 + 272.14x$	-2.224	$y= 467.74x^{0.294}$	0.6127

The R^2 coefficient for polynomial, linear, power, and logarithm equations decreased for non-drum-dried samples. For drum-dried samples, the best coefficient of fit is greater from the logarithm equations than power equations. Linear and polynomial equations were not suitable for mathematically relating RC and temperature for drum-dried samples.

3.2 Mineral contents of the YFSP flour samples

The mineral contents of YFSP flour samples are shown in Table 5. The Ca content in YFSP flour samples ranged from 0.47 ± 0.01 to 1.34 ± 0.18 mg/100 g. The results were lower than the values reported by Afolabi et al. (2021) whose values ranged from 3.92 to 6.68 mg/100 g for yellow-fleshed sweet potato cultivar. Sundried samples had the least Ca contents and oven-dried samples had the highest Ca values.

Table 5 Mineral contents of YFSP flour samples

Samples	Ca (mg/100g)	Fe (mg/100g)	K (mg/100g)	Mg (mg/100g)	Na (mg/100g)
SU	0.93 ±0.01^{b}	0.31 ±0.02^{d}	0.44 ±0.01^{c}	6.51 ±0.01^{c}	14.03 ±0.01^{b}
OU	1.34 ±0.18^{b}	0.22 ±0.01^{e}	0.47 ±0.01^{a}	6.60 ±0.01^{a}	14.26 ±0.01^{ab}
SB	1.03 ±0.01^{a}	0.32 ±0.01^{d}	0.46 ±0.01^{f}	6.40 ±0.04^{d}	14.51 ±0.01^{a}
OB	1.03 ±0.01^{b}	0.36 ±0.01^{c}	0.40 ±0.01^{e}	6.51 ±0.01^{c}	13.46 ±0.01^{c}
SS	0.47 ±0.01^{c}	0.37 ±0.01^{c}	0.42 ±0.01^{d}	6.22 ±0.01^{e}	13.48 ±0.01^{c}
OS	1.10 ±0.01^{b}	0.40 ±0.01^{b}	0.43 ±0.01^{c}	6.58 ±0.01^{b}	13.66 ±0.26^{c}
DD	0.86 ±0.01^{b}	1.66 ±0.01^{a}	0.37 ±0.01^{b}	6.18 ±0.06^{f}	12.47 ±0.04^{d}

Mean values with the same superscript in a column are not significant ($p > 0.05$).

Ca is essential in the body for its importance in plasma coagulation, muscle contraction, neurological purpose, bone and teeth development, or repairs. The Fe content of all the samples ranged from 0.22 ± 0.01 to 1.66 ± 0.01 mg/100 g. This followed the trend of Lyimo et al. (2010) which reported the Fe content of sweet potato flour in the range of 0.59 - 0.60 mg/100 g. The results (1.61 mg/100 g) of Olayiwola et al. (2009) also correspond with the values of drum-dried samples. There was no significant difference ($p > 0.05$) between the Fe content of SU and SB; OB and SS while the samples were significantly different $p < 0.05$. Fe was lower in non-drum-dried samples. The higher Fe values in drum-dried samples may be due to contact with the drum-drying surface. Fe is important to produce hemoglobin, the formation of red blood cells, and the oxygenation of red blood cells which also enhance circulation, digestion, elimination, and respiration in the body (Bamishaiye et al., 2011). From Table 5, the potassium (K) content present in YFSP flour samples ranged from 0.37 ± 0.01 to 0.47 ± 0.01 mg/100 g. K content in the samples is slightly lower than the results obtained by Olatunde et al. (2016) that reported the K content present in sweet potato flour ranged from 0.76 – 1.22%. K plays an important role in physiological processes which include the transmission of nerve impulses, and contraction of cardiac, smooth, and skeletal muscles. It also helps the blood pressure to be stable and supports electrochemical transmissions. It was reported that K intake helps to avert strokes which work with sodium to conserve a suitable water balance in the body (Shahnaz et al., 2003). Magnesium (Mg) content present in YFSP flour samples ranged from 6.18 ± 0.06 to 6.60 ± 0.01 mg/100 g. The values obtained are lower than the results of Sanoussi et al. (2016) which reported the Mg contents of YFSP to range from 22.50 – 23.10 mg/100 g. Mg is a co-factor in some enzyme systems that are involved in neurochemical transmission and muscular excitability along with Ca and vitamin C (Bamishaiye et al., 2011). More than three hundred metabolic reactions need Mg as a cofactor (Carolyn, 1998). The Na content of the YFSP flour samples ranged from 12.47 ± 0.04 to 14.51 ± 0.01 mg/100 g. There were differences ($P<0.05$) between all the samples implying that pretreatment influenced the Na content. Na in YFSP flour is known for providing body fluid strength because the quantity of water in the extracellular fluid is usually controlled by the quantum of Na in circulation, acid-base balance, and nerve and muscle function (Afolabi et al., 2021).3.3 Sensory properties of the reconstituted dough produced from the flour samples

The sensory properties (SP) of reconstituted YFSP dough are presented in Table 6 and Plate 2**.** The SP was carried out to determine or evaluate the quality attributes of reconstituted YFSP dough. The mean score for the color of reconstituted YFSP dough produced from the flour samples ranged from 4.55 ± 0.53 to 7.40 ± 0.26 (table 6). The result obtained is similar to the values obtained by Afolabi et al. (2021) who reported the mean sensory score for colour ranging from 4.66 to 7.86 for sweet potato dough. The difference between the mean scores of the entire colours may be attributed to the pretreatment methods. The effect of blanching and drying techniques had an impact on the colour of each sample – the samples were bright. YFSP tuber when wet-milled into a fine slurry, it was observed that the slurry turned green (army green) during processing.

Table 6 Sensory properties of reconstituted YFSP dough

Samples	Color	Aroma	Taste	Texture	Mouthfeel	Overall Acceptability
SU	7.40±0.26^{a}	6.45±0.28^{a}	6.10±0.38^{a}	5.90±0.35^{a}	5.95±0.37^{ab}	6.50±0.32^{a}
OU	6.90±0.40^{a}	6.25±0.32^{a}	6.35±0.27^{a}	6.55±0.38^{a}	6.35±0.35^{a}	6.40±0.36^{a}
SB	6.60±0.30^{a}	5.85±0.27^{ab}	5.85±0.31^{a}	6.35±0.40^{a}	6.65±0.30^{a}	6.25±0.34^{a}
OB	6.55±0.29^{a}	5.90±0.32^{ab}	5.75±0.27^{a}	6.35±0.42^{a}	6.20±0.31^{a}	6.15±0.24^{a}
SS	6.65±0.36^{a}	6.20±0.30^{a}	6.35±0.35^{a}	6.65±0.29^{a}	6.40±0.34^{a}	6.80±0.32^{a}
OS	7.10±0.25^{a}	6.60±0.23^{a}	5.95±0.29^{a}	6.10±0.32^{a}	6.25±0.29^{a}	6.40±0.31^{a}
DD	4.55±0.53^{b}	5.05±0.34^{b}	4.80±0.41^{b}	4.90±0.31^{b}	5.05±0.45^{b}	4.95±0.39^{b}

Mean values with the same superscript in a column are not significant ($p > 0.05$)

The colour change in the slurry may probably be a result of increased surface area which enhanced browning reactions after grinding (Ruttarattanamongkol et al., 2015). This may also contribute to the darker colour of the reconstituted drum-dried dough samples as presented in plate 2. Drum-dried flour in Plate 1 also had the darkest colour. Colour, undoubtedly is an indispensable sensorial attribute for characterizing food and judging its quality (van Hal, 2000). The colour change in the drum-dried samples may also be due to the caramelization of sugar during drum drying because of the high temperature used (150 ℃) compared to 40 - 70 ℃ for drying the other samples. A similar observation was made by Olatunde et al. (2016) when 10 different varieties of sweet potatoes were processed.

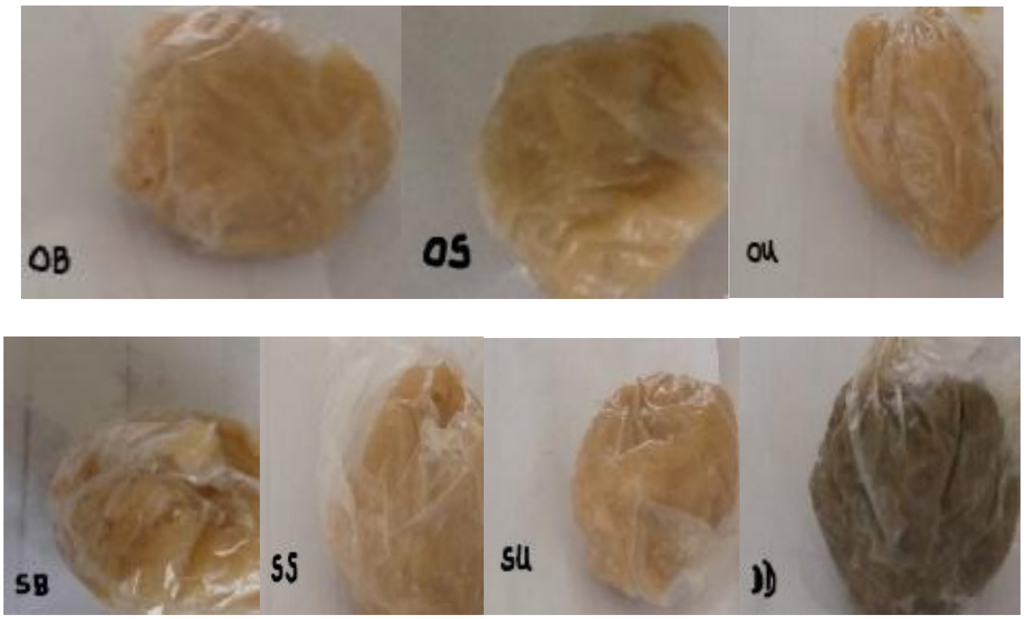

Plate 2 Reconstituted YFSP dough

The mean score for the aroma of reconstituted YFSP dough produced from the flour samples ranged from 5.05 ± 0.34 to 6.60 ± 0.23 (Table 6). There was no significant difference ($p > 0.05$) between the mean scores for all the aromas of reconstituted YFSP dough produced from oven and sun-dried samples compared to drum-dried samples suggesting that pretreatment used in this study did not influence the aroma of the samples. The mean score for the taste of reconstituted YFSP dough produced ranged from 4.80 ± 0.41 to 6.35 ±0.27. There was no significant difference ($p > 0.05$) between the mean score for the taste of reconstituted YFSP dough produced from oven and sun drying compared to drum-dried samples. Each sample (dough) had a varying degree of sweetness. Drum-dried samples had the highest degree of sweetness, followed by blanched samples. Unblanched samples had the least degree of sugar sweetness compared to other samples (the sweetness is probably due to the caramelization of sugar under high heat). This could be a result of the carbohydrate content of the flour samples. The mean score of the taste of reconstituted YFSP dough obtained in this study was slightly similar to the mean score values (4.93 - 7.40) obtained by Afolabi et al. (2021). The difference in the taste of the reconstituted YFSP bolus could be a result of the pretreatment during processing and the drying method used (Okoronkwo et al., 2019). The mean score for the texture of reconstituted YFSP dough produced from the samples ranged from 4.90 to 6.65. There was no significant difference ($p > 0.05$) between the mean score of the texture of reconstituted YFSP dough produced from oven and sun-dried samples. The sweet potato dough produced from sun and oven-dried samples was easy to reconstitute compared to the drum-dried samples which formed lumps during reconstitution with hot water. Drum-dried flour when reconstituted using the same quantity of water flour (200g of flour to 100 ml of water) as the other samples gave a softer dough. It required less volume of water to reconstitute. This is probably because the starch content in the flour samples had almost gelatinized during the drum drying operation even before reconstitution so minimal water (volume) was required. The mean score for the mouthfeel of reconstituted YFSP dough samples ranged from 5.05 to 6.65 (Table 6). There was no significant difference ($p > 0.05$) between the mean scores for the mouthfeel of reconstituted YFSP dough produced from oven and sun-dried samples except for drum-dried samples. This may be related to the amount of water used for reconstitution. Although the same quantity of water was used (200g of flour to 100 ml of boiling water), this allowed the flour of other samples (oven and sun-dried) to mix well and smoothen out but for drum-dried samples - the flour formed lumps and did not form a smooth dough.

The mean scores for the overall acceptability of reconstituted YFSP dough samples ranged from 4.95 to 6.80. Drum-dried samples had the least sensory scores in all attributes. Oven and sun-dried samples were the most acceptable reconstituted YFSP dough compared to the drum-dried samples because of their dark colour, mouthfeel, and texture. The dark color of drum-dried samples could be attributed to the gelatinization of the starch granules during processing (Iheagwara et al., 2019). The aroma and taste of all the samples were good which could be ascribed to the composition or variety of the tuber itself. Each sample (dough) had a varying degree of sweetness of dough while the bolus produced from oven and sun-dried samples were accepted due to the brightness of colour. Comparing the mouthfeel and taste of the bolus of the reconstituted YFSP dough, drum-dried samples had the least mean score while unblanched and blanched samples had higher mean score values. The colour and mouthfeel of the flour samples were tolerated by some panelists while taste and aroma were not acceptable. Some of the panelists agreed that the aroma, taste, and mouthfeel of all the samples were good while some were average. Hence, the acceptability of the reconstituted YFSP dough was dependent on the pretreatment and drying methods (sun >> oven >> drum drying) with color, taste, aroma, and an increased amount of brightness being the most important quality attribute, with its consumers (Afolabi et al., 2021).

4 Conclusion

The study concluded that rehydration temperature had a significant effect on the RC (80 and 90 °C) and gave the highest RC. Drum-dried samples had the highest RC at RT. Using higher temperatures resulted in product disintegration. The drying method had a strong influence on the rehydration capacity of the flour. Mathematical relationships between RC and temperature were best described using polynomial equations for sun or oven-dried samples. For drum-dried samples, logarithmic equations gave the highest R^2 values. Sun-dried and oven-dried samples had higher mineral content (Ca, K, Mg, P) than drum-dried samples. The sensory scores for the reconstituted dough of drum-dried flour were low and unacceptable. The dough of reconstituted sun/oven-dried flour had high scores indicating acceptance.

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