Influence of Various Drying Methods on the Proximate Composition, Mineral Content, and Functional Properties of Cream-Fleshed Sweet Potatoes (*Ipomoea Batatas*)

Riyang Zakka[1*] Solomon Samuel Choji[2], Bobby Shekarau Luka[3] Nimram Dindam Pius[2], Gayus Sale Dafur[4] and Christiana Godiya Yilleng[5]

[1]Department of Food Science and Technology, Federal university Wukari, Taraba State

[2]Department of Biochemistry, Plateau State University Bokkos, Plateau State

[3]Department of Agricultural Engineering, Federal University Wukari, Taraba State

[4]Department of Biology, Federal University of Education, Pankshin, Plateau State, Nigeria

[5]Department of Community Health, Plateau State College of Health Technology Zawan, Plateau State, Nigeria

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ABSTRACT

This study investigates the impact of various drying methods (shade, oven, microwave, and open sun) on the proximate composition, mineral content, and functional properties of cream-flesh sweet potato flour (CFSP). The proximate analysis, mineral content, and functional properties were assessed using standard analytical techniques. The results indicated that the moisture content, protein, crude fiber, ash, fat, and carbohydrate contents of CFSP ranged from 5.65 to 12.53%, 8.99 to 11.67%, 3.43 to 3.87%, 2.48 to 3.23%, 2.33 to 2.87%, and 69.48 to 73.67%, respectively. The mineral content, including iron, calcium, sodium, and potassium, varied between 2.42 to 2.88 mg/100g, 137.53 to 164.34 mg/100g, 187.44 to 209.53 mg/100g, and 236.16 to 285.43 mg/100g, respectively. Functional properties such as bulk density, water absorption, oil absorption, and swelling capacity ranged from 1.69 to 2.59 g/cm³, 18.67 to 32.67%, 9.00 to 13.00%, and 5.34 to 5.98%, respectively. The results of this study demonstrated that shade drying was the most effective method, as it retained the highest concentrations of key minerals (calcium, potassium, iron, and sodium) and exhibited superior levels of protein, ash, and crude fiber. Furthermore, shade-dried CFSP showed the lowest moisture content, which reduces its susceptibility to deterioration, spoilage, and microbial growth during storage. This makes shade drying the most optimal method for preserving the nutritional and functional quality of sweet potato flour.

Keywords: Sweet Potatoes, Drying methods, Proximate, Mineral and functional properties.

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) ranks as the sixth most important food crop globally, prized for its nutritional value and versatility in various culinary applications. As of 2009, global production of sweet potatoes reached 107.6 million tons, with major producers including China, Uganda, Indonesia, India, and Japan (FAO, 2010). This adaptable crop is consumed in a variety of forms, from fresh produce to processed goods such as noodles, Chinese-style French fries, and canned products (Antonio et al., 2008). However, despite its widespread popularity and nutritional benefits, sweet potatoes are highly perishable due to their high moisture content, making them vulnerable to microbial spoilage even under refrigeration (Xiao et al., 2009). As a result, fresh sweet potatoes must either be consumed soon after harvest or processed into more stable forms, such as flour, to prolong shelf life and reduce waste.

One widely used method for preserving sweet potatoes is drying, which effectively reduces moisture content, thereby limiting the potential for microbial growth and chemical deterioration (Mujumdar and Law, 2010). Typically, the preservation process involves peeling, sometimes slicing, blanching in hot water, and sun-drying to produce dried sweet potato flour (Akissoé et al., 2003). This flour is a versatile ingredient used in a range of culinary applications. However, while drying extends shelf life, it can alter the nutritional and functional properties of the product. The drying technique employed plays a pivotal role in shaping the quality of the final product, impacting its proximate composition, mineral content, and functional properties. These factors are particularly crucial for sweet potato flour, which is valued not only for its culinary uses but also for its health-promoting qualities.

The nutritional value of sweet potato flour can be influenced by several factors, including the cultivar of sweet potato, pre-treatment methods, the specific drying technique, and the temperature used during dehydration. These variables can significantly affect the retention of essential nutrients, including vitamins and minerals (Olatunde et al., 2016). The proximate composition of sweet potato flour, which includes key macronutrients such as fiber, fat, protein, and ash, can also vary widely depending on the drying method used. Additionally, the mineral content—particularly elements like calcium (Ca), potassium (K), sodium (Na), and iron (Fe)—is critical in determining the overall nutritional quality of the flour.

Drying is an energy-intensive process that removes moisture from agricultural products until the moisture content stabilizes in equilibrium with the surrounding air (Agoreyo et al., 2011). This process involves the simultaneous transfer of heat and moisture and is designed to reduce moisture levels to a point that prevents microbial growth and slows the product's deterioration (Carsky, 2008; Dincer and Sahin, 2004; Shi et al., 2008). Beyond extending shelf life, drying reduces the weight and volume of the product, making it more convenient for storage and transportation, while also preserving the appearance and original flavor. However, depending on the method used, drying can both positively and negatively affect the nutritional integrity of the food.

Among the most common drying techniques are open sun drying (OSD), solar drying, and oven drying. Open sun drying, a traditional and widely practiced method, involves spreading the product under direct sunlight, often on mats or drying floors. Although it is cost-effective and harnesses natural energy, this method has significant drawbacks, including nutrient degradation, particularly of heat-sensitive vitamins such as Vitamin C, and exposure to environmental contaminants like dust and insects (Sharma et al., 2009). Furthermore, the drying rate can be slow and unpredictable, complicating the maintenance of product quality. Prolonged sun exposure can lead to the breakdown of essential nutrients, diminishing the final product's nutritional value.

Another limitation of open sun drying is its dependence on favorable weather conditions. In areas with inconsistent or unfavorable weather, the drying process may be prolonged, exacerbating nutrient degradation and increasing the risk of microbial contamination. Moreover, direct sunlight exposure can be damaging to bioactive compounds in food, leading to the loss of antioxidants and other beneficial phytochemicals (Tiwari, 2016). While open sun drying remains a popular method due to its low cost, the concerns over nutrient retention and quality control have led researchers to explore alternative drying methods.

In response to these limitations, shade drying has emerged as a potential alternative. This technique involves drying the food in a shaded area, reducing exposure to direct sunlight and excessive heat while still allowing sufficient air circulation to facilitate moisture removal. Shade drying is gentler on food, potentially preserving more nutrients and bioactive compounds that are sensitive to heat and sunlight. This method has been suggested as a viable alternative to open sun drying, offering better control over the drying rate and yielding a higher-quality product with improved nutrient retention (Oliveira et al., 2015). However, despite its nutritional advantages, shade drying often requires more time and may be less efficient in terms of energy use and drying speed compared to sun drying.

Despite the potential benefits of shade drying, there remains a lack of comprehensive research comparing the effects of various drying methods on the proximate composition, mineral content, and functional properties of sweet potatoes. Existing studies tend to focus on individual drying techniques or broad comparisons between traditional and modern methods. Therefore, there is a clear need for more detailed research on how specific drying methods affect the nutritional and functional properties of sweet potato flour, particularly in terms of its fiber, fat, protein, and ash content, as well as the retention of essential minerals like calcium, potassium, sodium, and iron. This gap in the literature underscores the importance of this study, which aims to assess the impact of different drying methods on the quality of cream-flesh sweet potatoes.

The findings of this research will provide valuable insights into the most effective drying techniques for preserving the nutritional and functional properties of sweet potatoes, with potential benefits for improving storage and shelf life. By comparing the effects of sun drying, shade drying, and possibly other methods, this study aims to identify the technique that best maintains the nutritional quality of sweet potatoes while minimizing nutrient degradation. The results will be important not only for food producers, processors, and consumers seeking to improve the quality of dried sweet potato products but also for developing more efficient and sustainable drying methods for sweet potatoes and similar crops. Ultimately, this research could contribute to enhancing food security and reducing post-harvest losses.

Sweet potatoes offer considerable nutritional benefits, their susceptibility to spoilage due to high moisture content presents significant challenges. Drying serves as an effective solution to extend their shelf life and preserve their nutritional quality, yet the choice of drying method is crucial in maintaining the integrity of key nutrients and bioactive compounds. This study will shed light on how different drying methods impact the proximate composition, mineral content, and functional properties of cream-flesh sweet potatoes, advancing our understanding of how these techniques influence the overall quality of dried sweet potato flour.

MATERIALS AND METHODS

Procurement and Preparation of Raw Materials

Cream flesh sweet potato (CFSP) (*Ipomoea bataus*) cultivar between 25-30kg, harvested within a week and was purchased at wukari new market, Taraba state. The choice of the cream flesh sweet potato (CFSP) is based on its availability in the region, it was sorted, cleaned, washed and pealed. The cream sweet potato was cut into flat shape of 2mm thickness and divided into four portions for the four different drying methods (oven, shade, microwave and sun), (Fisher scientific model 230, U.S.A.) oven was used at 60^{o}C, digital Microwave (400 watts, NGM-25D2, JAC, Egypt) for 10minutes, shade dryer in the department of Food science and technology, Federal University Wukari was used for drying and mill and sieved (0.45mm) into flour prior to analysis using a hammer mill and siever respectively. The analysis was carried out in central processing laboratory in Federal university Wukari. All the chemicals used were high grade chemicals

Determination of proximate composition

Moisture content

Moisture content of samples was determined by hot air oven drying at 105°C to constant weight (AOAC, 2010). An empty crucible would be weighed and 2g of the sample would be transferred into the crucible in triplicate. The sample would be taken into the hot air oven and dried for 24 hours at 105°C. The crucible and its contents would now cool in the desiccator and their weights would be taken. The loss in weight would be calculated as moisture content as follows:

% Moisture = {(weight of sample – weight of dried sample)/weight of sample} × 100

Ash content

Ash content was determined by the AOAC, (2010) method. About 5 g of each sample would be weigh into a crucible. The samples would be incinerated in a Muffle furnace at 550°C until a light grey ash is observed and a constant weight would be obtained. The sample would now cool in the desiccator and weighed. The ash content would be calculated as follows:

%Ash = {(weight of sample – weight of ashes)/weight of sample} × 100

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Protein content

Protein content was determined by the AOAC, (2010) method. About 2 g of the sample would be put into the digestion flask. Ten grams of copper sulphate and sodium sulphate (catalyst) in the ratio 5:1, respectively and 25ml concentrated (sulfuric) H_2SO_4 acid would be added to the digestion flask. The flask would be placed into the digestion block in the fume cupboard and heated until frothing ceased giving clear and light blue green coloration. The mixture would be then allowed to cooled and diluted with distilled water until it reached 250ml of volumetric flask. Distillation apparatus would be connected, and 10 ml of the mixture would be poured into the receiver of the distillation apparatus and also 10 ml of 40% sodium hydroxide would be added. The released ammonia by boric acid would be then treated with 0.02 m of hydrochloric acid until the green colour change to purple. The nitrogen (%) in the sample would be calculated using the formula:

$$Nitrogen\ (\%) = \frac{(Titre - Blank)\ x\ 14.008\ x\ Normality}{Weight\ of\ sample}\ x\ 100$$

% Crude protein = % Nitrogen x 6.25

Crude fibre content

Crude fibre was determined by the AOAC, (2010) method. About 5 g of each sample would be weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent would be added. It would then be brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask would be removed from the heater, cooled a little then filtered through a 15.0 cm number 4 Whatman paper. The residue would be wash with hot water stirred once with a spatula and transferred to a porcelain dish. The samples would be dry overnight at 105°C. After drying, it was transferred to a desiccator and weighed as W_1. It would then heat in a muffle furnace at 500°C for 6 hours, allowed to cool, and reweighed as W_2. The Crude fibre content would be calculated as:

$$\%\ Crude\ fibre = \frac{W_1 - W_2}{W_0}\ x\ 100$$

Where:

W_1 = Weight of crucible + Fibre + Ash

W_2 = Weight of crucible + Ash

W_0 = Dry weight of food sample

Fat content

Fat content (solvent extraction) is determined by the AOAC, (2010) method. About 2g of the sample would be weighed and the weight of the flat bottom flask would be taken with the extractor mounted on it. The thimble would be held half way into the extractor and the weighed sample. Extraction would be carried out using (boiling point 40-60°C). The thimble would be plug with cotton wool. At completion of extraction, which would last for about 8 hours, the solvent would be removed by evaporation on a water bath and the remaining part in the flask would be dry at 80°C for 30 minutes in the air oven to dry the fat and then cool in a desiccator. The flask would now be reweighed and percentage fat would be calculated as follows:

$$Fat(\%) = \frac{Weight\ loss}{Weight\ of\ sample}\ x\ 100$$

Carbohydrate content

Carbohydrate content were determined by difference method as described by AOAC, (2010) which is obtained as %Carbohydrate = 100% - (% Moisture - % Protein - % Crude fiber - % Ash - % Crude fat)

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Determination of Mineral composition

Three (3) macro (Ca, Na, K) and one (1) trace minerals (Fe) were determined using Atomic Absorption Spectrophotometer (Buck scientific Model 210VGP). Standard solutions (dissolute pure metal in Hcl usually 500ml) with optimum range for each element were prepared and all the operational instruction for setting up the instrument for the analysis of specific element was strictly followed as described by AOAC (2010)

Determination of Functional properties

Bulk Density

This Bulk density was described by Narayana and Narasinga (1984) 3g of sample was weight into 10mm graduated cylinder, top against your hand 10 times the volume and the flour after taping was recorded

$$\text{Bulk density} = \frac{weight\ of\ sample(g)}{sample\ volume} \times 100$$

Solubility and Swelling Power

Solubility and swelling power were determined based on a modification of the method of Leach *et al.*, (1959). One gram of the flour sample was transferred into a pre-weighed graduated centrifuge tube (50 ml). Distilled water was added to give a total volume of 40 ml. The suspension was stirred just sufficiently and uniformly avoiding excessive speed. The sample in the centrifuge tube was heated at 85˚C in a thermostatically regulated temperature water bath for 30 minutes with constant stirring. The tube was removed, wiped dry on the outside and cooled to room temperature. It was then centrifuged for 15 minutes at 2200 rpm. The solubility was determined by evaporating the supernatant and weighing the residue. The sediment was also weighed. The percentage (%) solubility and swelling power were then calculated. Percentage solubility and swelling power were calculated as follows:

% Solubility = (weight of residue /Weight of sample) × 100

Swelling power = weight of sediment × 100 /Weight of sample (dry basis) × (100 - % solubility)

Water Absorption Capacity (WAC)

Water absorption capacity (WAC) was determined at 25˚C according to the method of Sathe and Salunkhe (1981). An aqueous suspension was made by dissolving 2 g of the flour sample in 40 ml of water. The suspension was agitated for 1 hour on Griffin flask shaker after which it was centrifuged for 10 minutes at 2200 rpm. The free water was decanted from the wet sample and drained for 10 minutes by inverting the tubes over filter paper placed in a flask and wet sample weighed. Percent WAC was calculated as follows:

% WAC = weight of water bound × 100 % /Weight of sample (dry basis)

Oil Absorption Capacity (OAC)

The oil absorption capacity was determined using the method described by (Onwuka 2001) was used. One gram of the flour was mixed with 10 ml refined corn oil in a centrifuge tube and allowed to stand at room temperature (30 ± 2°C) for 1 hr. It was centrifuged at 1600 x g for 20 min. The volume of free oil was recorded and decanted. Fat absorption capacity was expressed as ml of oil bound by 100 g dried flour**.** The volume of the free oil could be read directly from the graduated centrifuge tube or could be calculated using the equation below.

The value is also expressed as gram of oil absorbed per gram of sample.

% OAC = {(amount of oil added −free oil) /(weight of sample × density of corn oil)} × 100.

Statistical Analysis

Results of the various analyses is subjected to analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS, version 25.0) and means generated will be separated using Duncan multiple range test (p <0.05).

RESULTS AND DISCUSSIONS

Proximate composition

Table 4.1. Proximate composition of cream flesh sweet potato (CFSP) flour

Sample	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude Fibre (%)	Carbohydrate (%)
Shade	$5.65^{a}\pm0.00$	$3.66^{b}\pm0.00$	$11.67^{c}\pm0.00$	$2.87^{c}\pm0.00$	$3.23^{d}\pm0.00$	$69.48^{a}\pm0.01$
Oven	$8.07^{c}\pm0.00$	$4.32^{d}\pm0.00$	$9.86^{b}\pm0.00$	$2.33^{a}\pm0.16$	$2.69^{b}\pm0.00$	$72.92^{b}\pm0.01$
Micro	$12.53^{d}\pm0.00$	$3.43^{a}\pm0.00$	$8.99^{a}\pm0.00$	$2.60^{b}\pm0.00$	$2.98^{c}\pm0.00$	$73.67^{c}\pm0.01$
Sun	$6.84^{b}\pm0.01$	$3.87^{c}\pm0.00$	$11.15^{c}\pm0.01$	$2.47^{ab}\pm0.00$	$2.48^{a}\pm0.01$	$72.64^{b}\pm0.00$

Data represent means of three determinations ± standard deviation Values with different alphabets in the same column are significantly different (P < .05)

The results in Table 4.1 indicated that the different drying methods had significant effect (P < .05) on the proximate composition of cream flesh sweet potatoes (CFSP) flour.

The moisture content of food products plays a crucial role in determining their shelf stability, and this has significant implications for the preservation and quality of dried sweet potato products. In this study, the sample dried using a microwave exhibited the highest moisture content (12.53%). This may be attributed to surface browning during the microwave drying process, which could trap moisture within the sample. On the other hand, the sample dried in the shade had the lowest moisture content (5.65%), likely due to better air ventilation, which facilitates the removal of moisture. Similar findings were reported by Fana et al. (2015), who observed a moisture range of 4 to 8% in orange-fleshed sweet potato (OFSP) flour, and by Tortoe et al. (2017), who documented a range of 7.6 to 10% for twelve varieties of Ghanaian sweet potatoes. The low moisture content observed in this study is advantageous for storage, as it helps to prevent microbial growth and prolong the shelf life of sweet potato flour.

Regarding fat content, microwave-dried samples had the lowest fat content (3.43%). A significant difference was observed in fat content among the drying methods, with the oven-dried samples having the highest fat content (4.32%). This variation could be attributed to the oxidation of lipids or the melting of fat due to the high heat applied during oven drying, which may have reduced the fat content (Tsado et al., 2015). The fat content recorded in this study is higher compared to the range of 0.72% to 1.3% found in white and orange-fleshed sweet potatoes (Sanoussi et al., 2013) and the 0.9% to 2.5% range reported by Fana et al. (2015). This suggests that different drying methods and potentially the specific varieties of sweet potato used may result in variations in fat content.

Protein content also varied significantly among drying methods. Microwave and oven-dried samples had the lowest protein contents (8.99% and 9.86%, respectively), which were significantly lower (P < 0.05) than the protein content of shade-dried (11.67%) and sun-dried (11.15%) samples. The alteration of protein molecules during microwave drying may account for this reduction in protein content. The protein content observed in this study is notably higher than that reported by Obomeghei et al. (2020), which ranged from 2.3% to 2.9%, and the range of 2.8% to 3.3% reported by Sanoussi et al. (2013). These differences could be attributed to variations in sweet potato cultivars and varieties, as well as the drying methods employed.

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The carbohydrate content of the sweet potato samples also showed notable variation, with oven-dried samples having the highest carbohydrate content (73.67%), while shade-dried samples had the lowest (69.48%). This difference may be due to the heat resilience of amylopectin, a starch component that contributes to the waxy texture of sweet potato starch. The carbohydrate content recorded in this study is lower than the 82.3% to 86.5% range observed for yellow and pink-fleshed sweet potatoes (Obomeghei et al., 2020; Fana et al., 2015), as well as the 80% to 84% range documented by Sanoussi et al. (2013). These variations in carbohydrate content could be influenced by the drying method, cultivar, and the inherent starch composition of the sweet potatoes used in the study.

Ash content, which reflects the inorganic mineral composition of food, also varied significantly across the drying methods. The shade-dried samples had the highest ash content (2.87%), while the oven-dried samples had the lowest (2.33%). These differences could result from the variations in drying conditions, including temperature and exposure time. The ash content found in this study was higher than the 1.37% and 1.73% for white and orange-fleshed sweet potatoes reported by Sanoussi et al. (2013), as well as the range of 1.8% to 2.8% documented by Obomeghei et al. (2020). The higher ash content in this study could be attributed to the water losses during processing, which often concentrate minerals in the final product, as seen in the case of roasted and fried plantains (Thomas et al., 2017).

Finally, the crude fiber content of the sweet potato samples ranged from 2.48% to 3.23%, with the highest value observed in the shade-dried samples (3.23%) and the lowest in the sun-dried samples (2.48%). The significant difference ($P \leq 0.05$) in fiber content between the drying methods may be attributed to differences in temperature and drying duration. The crude fiber content observed in this study falls within the range reported by Obomeghei et al. (2020), which ranged from 2.2% to 3.4% for four varieties of sweet potato in Nigeria.

The results of this study highlight the significant impact of different drying methods on the proximate composition of sweet potatoes, particularly in terms of moisture content, fat, protein, carbohydrates, ash, and crude fiber. The choice of drying method plays a crucial role in determining the nutritional quality of the final product, with some methods better preserving specific nutrients than others. These findings are important for food processors and consumers aiming to optimize the nutritional value of sweet potato products, and they underscore the need for continued research to refine drying techniques for enhanced product quality and shelf life.

Mineral composition

Table 4.2. Mineral Composition of cream flesh sweet potato (CFSP) flour

Sample	**Iron (mg/100g)**	**Calcium (mg/100g)**	**Sodium (mg/100g)**	**Potassium (mg/100g)**
Shade	$2.88^{c}\pm0.00$	$164.34^{d}\pm0.00$	$209.53^{d}\pm0.28$	$285.43^{d}\pm0.01$
Oven	$2.42^{a}\pm0.01$	$137.53^{a}\pm0.00$	$187.44^{a}\pm0.01$	$236.16^{a}\pm0.00$
Micro	$2.64^{b}\pm0.01$	$154.28^{c}\pm0.01$	$200.57^{c}\pm0.00$	$258.37^{c}\pm0.01$
Sun	$2.45^{a}\pm0.01$	$151.58^{b}\pm0.01$	$191.12^{b}\pm0.00$	$240.11^{b}\pm0.01$

Data represent means of three determinations ± standard deviation

Values with different alphabets in the same column are significantly different ($P < .05$)

The Mineral compositions of cream flesh sweet potato (CFSP) flour dried with different drying methods are presented in Table 4.2.

Iron content exhibited a noticeable decrease across the different drying methods, with the shade-dried sample having the highest iron concentration at 2.88 mg/100g, while the oven-dried sample had the lowest at 2.42 mg/100g. A significant difference ($P \leq 0.05$) was observed between the various drying techniques. Previous studies have reported lower iron values in sweet potatoes dried using sun-drying methods. For instance, Lyimo et al. (2010) found iron levels ranging from 0.52 mg/100g to 0.65 mg/100g in six different varieties of Tanzanian sweet potatoes dried using sun drying. Similarly, Ndanyi et al. (2021) reported iron contents ranging from 0.4 mg/100g to 0.68 mg/100g in orange-fleshed sweet potatoes, which were significantly lower ($P < 0.001$) than the iron content in white and yellow-fleshed varieties, which ranged from 0.17 mg/100g to 0.24 mg/100g. The variation in iron content observed in different studies can be attributed to several factors, including cultivar differences, agro-climatic conditions, and environmental influences (Yousif et al., 1982).

For calcium, the highest concentration was found in the shade-dried sample at 164.34 mg/100g, while the oven-dried sample exhibited the lowest calcium content at 137.53 mg/100g. A significant difference ($P < 0.05$) was found between the drying methods, with shade-dried samples showing the highest calcium levels compared to those dried by other methods. This variation in calcium concentration could be attributed to differences in the varieties of sweet potato used as well as the agro-geological conditions in which they were grown (Endrias et al., 2016). The calcium content in this study is notably higher than the values reported by Endrias et al. (2016), who found 47.00 mg/100g and 45.54 mg/100g for peeled and unpeeled orange-fleshed sweet potatoes, respectively. Additionally, the calcium content in this study exceeds the 34 mg/100g to 39 mg/100g range reported by Laurie et al. (2012).

Sodium content followed a similar trend, with the highest concentration found in the shade-dried sample at 209.53 mg/100g, and the lowest value observed in the oven-dried sample at 187.44 mg/100g. The sodium content in the shade-dried sample was significantly different ($P < 0.05$) from the other drying methods. Furthermore, it was higher than the sodium content reported by Sanoussi et al. (2016), where sodium levels ranged from 29.00 mg/100g to 34.00 mg/100g. This study also found higher sodium content than the 23.00 mg/100g to 59.00 mg/100g range reported by Udom et al. (2009). Variations in sodium content, similar to those in iron, can arise from differences in cultivar, agro-climatic conditions, and environmental factors (Yousif et al., 1982).

Potassium levels were highest in the shade-dried sample at 285.43 mg/100g and lowest in the oven-dried sample at 236.16 mg/100g. As with other minerals, the variation in potassium content could be attributed to cultivar differences and agro-geological conditions (Endrias et al., 2016). The potassium values in this study were lower than those reported by Sanoussi et al. (2016), who found a range between 308.67 mg/100g and 328.67 mg/100g, as well as lower than the values reported by Ellong et al. (2014), which ranged from 338.00 mg/100g to 407.04 mg/100g. However, the potassium levels in this study were higher than the 191.00 mg/100g to 334.00 mg/100g range reported by Laurie et al. (2012).

Significant variations were observed in the mineral content of sweet potato samples dried using different methods, with the shade-drying method generally preserving higher levels of iron, calcium, sodium, and potassium. The differences in mineral content across drying techniques highlight the influence of drying methods on nutrient retention, which is essential for improving the nutritional quality of processed sweet potato products. Moreover, the discrepancies in mineral concentrations reported across various studies can be attributed to factors such as cultivar type, agro-climatic conditions, and environmental influences, as noted by previous research (Yousif et al., 1982).

Functional properties

Table 4.3. Functional properties of cream flesh sweet potato (CFSP) flour

Sample	**Bulk density(g/ml)**	**Water absorption capacity (g/ml)**	**Oil absorption capacity (g/ml)**	**Swelling capacity (ml)**
Shade	$2.59^{d}\pm0.00$	$18.67^{a}\pm1.16$	$10.33^{a}\pm0.58$	$5.94^{c}\pm0.00$
Oven	$2.16^{b}\pm0.00$	$22.00^{b}\pm1.00$	$13.00^{b}\pm1.00$	$5.98^{d}\pm0.00$
Micro	$2.41^{c}\pm0.01$	$32.67^{c}\pm0.58$	$10.33^{a}\pm0.58$	$5.34^{a}\pm0.00$
Sun	$1.69^{a}\pm0.00$	$21.33^{b}\pm1.53$	$9.00^{a}\pm1.00$	$5.56^{b}\pm0.00$

Data represent means of three determinations ± standard deviation

Values with different alphabets in the same column are significantly different (P < .05)

The Functional properties of cream flesh sweet potatoes (CFSP) flour dried with different drying methods are presented in Table 4.3

The bulk density of the sun-dried flour sample was found to be 1.69 g/ml, which is lower compared to the bulk densities of flour samples dried using other methods such as shade drying (2.59 g/ml), oven drying (2.16 g/ml), and microwave drying (2.41 g/ml). These findings suggest that the drying method significantly affects the bulk density of the flour. The bulk density observed in this study is higher than that reported for sweet potato varieties; specifically, Onuh et al. (2004) documented values of 0.96 g/ml for the red variety and 0.9 g/ml for the yellow variety of sweet potato. Additionally, Grabowski et al. (2006) reported a range of 0.6 g/ml to 0.8 g/ml for spray-dried sweet potato powders. The observed variations in bulk density may be attributed to differences in particle size and the compactness of the flour, as indicated by Igbabul et al. (2014) and Olubunmi et al. (2017).

Regarding oil absorption capacity, significant differences (P < 0.05) were found among the sweet potato flour samples dried using various methods. The oil absorption capacities of the shade-dried, oven-dried, and sun-dried samples were 10.33 g/ml, 13.00 g/ml, and 9.00 g/ml, respectively. Among these, the sun-dried sample exhibited the lowest oil absorption capacity at 9.00 g/ml, while the oven-dried sample had the highest value at 13.00 g/ml. The oil absorption capacities of the shade-dried and microwave-dried samples were similar. These results are lower compared to the values reported by Obomeghei et al. (2020), which ranged from 31 to 51 g/ml for orange-fleshed sweet potatoes. Additionally, Onuh et al. (2004) documented an oil absorption capacity of 21 g/100 ml for the red variety and 18 g/100 ml for the white variety of sweet potato. The high oil absorption capacity of the oven-dried sample could be attributed to the presence of greater amounts of hydrophobic constituents in the flour, as well as a larger particle size, both of which are influenced by the drying method (Kaur & Singh, 2006).

For water absorption capacity, significant differences (P < 0.05) were observed across the drying methods. Microwave-dried flour exhibited the highest water absorption capacity at 32.67 g/100 ml, while shade-dried flour showed the lowest value at 18.67 g/100 ml. These values are lower than those reported by Onuh et al. (2004), who found values of 60 g/100 ml for the red variety and 95 g/100 ml for the white variety. Similarly, Obomeghei et al. (2020) reported water absorption capacities of 58 g/100 ml and 83 g/100 ml for yellow and pink-fleshed sweet potato, respectively. The higher water absorption capacity observed in the microwave-dried sample could be linked to the loosely associated amylose and amylopectin present during the pre-gelatinization process of the slurry after drying (Das et al., 2010).

In terms of swelling power, the flour sample dried in the oven exhibited the highest swelling power at 5.98 g/ml, while the microwave-dried sample had the lowest at 5.34 g/ml. There was a significant difference (P < 0.05) in the swelling power of the samples. The range of swelling power observed in this study is higher than the range of 2.4% to 4.6% reported by Ali et al. (2012) for three varieties of sweet potato and also exceeds the 1.2% and 1.7% reported by Obomeghei et al. (2020) for white and pink-fleshed sweet potato flour. The high swelling power observed in the oven-dried sample may be attributed to the effect of the temperature of the rehydrating water (Afolabi et al., 2021).

CONCLUSION

The results from this study indicate that the shade drying method outperforms natural sun and other drying methods in several key aspects. Specifically, shade drying resulted in a higher bulk density and retained more of the chemical composition, including fiber, fat, protein, and ash content. Additionally, the moisture content was lower in shade-dried sweet potatoes, making them less prone to spoilage and deterioration during storage. Furthermore, the shade drying method preserved higher levels of essential minerals such as calcium (Ca), potassium (K), sodium (Na), and iron (Fe), highlighting its superior ability to maintain the nutritional quality of sweet potatoes compared to sun and the other drying methods. Overall, shade drying proves to be a better alternative to sun, oven and microwave for preserving both the physical and nutritional properties of sweet potatoes.

REFERENCES

1. Afolabi, K.A., Taiwo, K.A., Morakinyo,T.A., & Badiora, O.A, (2021) Studies on Physico-chemical, mineral and sensory properties of sweet potato flour. European journal of Applied Sciences, 9(3), 94-109.
2. Agoreyo, B. O., Akpiroroh, O., Orukpe, O. A., Akissoe, O. A. (2011). Physical, chemical and sensory evaluation of dried yam (Dioscorea rotundata) tubers, flour and amala, a flour-derived product. Journal of Tropical Science. 41:151-155.
3. Akissoé N, Hounhouigan J, Mestres C, Nago M (2003) How blanching and drying affect the colour and functional characteristics of yam (Dioscorea cayenensis-rotundata) flour. Food Chemistry 82:257–264
4. Ali, N. Falade, K.O., Akingbala, J.O. (2012). Effect of Cultivar on Quality Attributes of Sweet Potato Fries and Crisps. Food and Nutrition Sciences 3:224 -232
5. Antonio, G.C., Alves, D.G., Azoubel, O.M., Murr, F.E.X., Park, K.J., (2008) Influence of osmotic dehydration and high temperature short time processes on dried sweet potato (Ipomoea batatas Lam.). Journal Food Engineering 84:375–382
6. AOAC (2010) Official Methods of Analysis of Association of Official Analytical Chemists. 18th Edition, Washington, DC.
7. Baysal, T., Icier, F., Ersus, S., Yildiz, H. (2003). Effects of microwave and infrared drying on the quality of carrot and garlic. European Food Research Technology. 218:68-73.
8. Carsky, M. (2008). Design of a dryer for citrus peels. Journal of Food Engineering 87**:** pp 40-44.
9. Das, A.B., Singh, G., Singh, S., & Riar, C.S. (2010) Effect of acetylation and dual modification on physico-chemical rheological and morphological characteristics of sweet potato starch. Carbohydrate polymers, 80 725-732.
10. Demir, V., Gunhan, T., Yagcioglu, A. K. (2007). Mathematical modeling of convection drying of green table olives. Biosystems Engineering 98: 47-53.
11. Dincer, I., Sahin, A. Z. (2004). A new model for thermodynamic analysis of a drying process. International Journal of Heat and Mass Transfer 47: 645-652.
12. Ellong E. N., Billard C., Adenet S. (2014). Comparison of Physicochemical, Organoleptic and Nutritional Abilities of Eight Sweet Potato (Ipomoea batatas) Varieties. Food and Nutrition Sciences, 5: 196-211
13. Endrias, D., Negussie, R., Gulelat, D (2016). comparison of three sweet potato (ipomoea Batatas (L.) lam) varieties on nutritional and anti-nutritional factors. Global journal of science frontier Research:D Agriculture and veterinary, 16(4), 1-11 https://doi.org/10.1016/j.trstmh.2006.05.010
14. Ertekin, C., Yaldiz, O. (2004). Drying of eggplant and selection of a suitable thin layer drying model. Journal of Food Engineering 63: 349-359.
15. Fana, H., Shimelis, A., Abrehet, F., (2015). Effects of Pre-treatments and drying Methods on Chemical Composition, Microbial and Sensory Quality of Orange-Fleshed Sweet Potato Flour and Porridge. Am. Journal of Food Science and Technology 3 (3) 82 – 88.
16. FAO (2010) FaoStat: Agriculture Data. http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor (September 02, 2010)
17. Grabowski, S., Marcotte, M. Ramaswamy, H.S. (2003) Drying of fruits, vegetables, and spices. In: Chakraverty A, editors. Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. New York, USA: CRC press; p. 653–695.
18. Igbabul, B.D., Bello, B.D., & Ekeh, C.N. (2014). Proximate composition and functional properties of wheat, sweet potato and hamburger bean flour blends. Global Advocate Research JOURNAL of food Science Technology, 3(4), 118-124
19. Laurie, S. M., van Jaarsveld, P. J., Faber, M., Philpott, M. F., Labuschagne, M. T. (2012). Trans-β-carotene, selected mineral content and potential nutritional contribution of 12 sweet potato varieties. Journal of Food Composition and Analysis, 27(2), 151–159. https://doi.org/10.1016/j.jfca.2012.05.005
20. Leach, H.W., Mc Cowen, L.D., Schoch, T.J. (1959) Structure of the starch granule. I. Swelling and Solubility pattern of various starches, Cereal chemistry, 36: 534-544
21. Lyimo, M. E., Gimbi, D., Kihinga, T. (2010). Effect of processing methods on nutrient contents of six sweet potato varieties grown in lake zone of Tanzania. Tanzania Journal of Agricultural Sciences, 10(1), 55–61.

22. Kaur, M., & Singh, N. (2006). Relationships between selected properties of seeds, flours, and starches from different chickpea cultivars. International Journal of Food Proposition, 9, 597-608
23. Mujumdar, A. S., Law, C. L. (2010). Drying Technology: Trends and Applications in Postharvest Processing Food Bioprocess. Technology 3:843–852
24. Narayana K., Narasinga Rao, M.S. (1984) Effect of partial proteolysis on the functional properties of winged pea (Psophocarpustetragonolobus) flour. Journal of Food Science, 49: 944 – 947. http://dx.doi.org/10.1111/j.1365-2621. 1984.tb13247.x
25. Ndanyi V. C. M., Abong' G. O., Okoth M. W., Kaaya A. N., Mulindwa J., Wanjekeche E., Shibairo S. I., Owade J.O. (2021) Physicochemical properties and flour pasting profiles of popular sweet potato varieties from Kenya and Uganda. East African Journal of Science, Technology and Innovation, Vol. 2 Special issue
26. Obomeghei, A. A., Olapade, A.A., Akinoso, R., (2020) Evaluation of the chemical composition, Functional And Pasting Properties of Four Varieties of Nigerian Sweet Potato [Ipomoea Batatas l. (Lam.)] Flour. African Journal of Food, Agriculture, Nutrition and Development 20 (3) 15764-15778 DOI: 10.18697/ajfand.91.18405
27. Oliveira, S. Brandão, T., Silva, C., (2015). "Influence of Drying Processes and Pretreatments on Nutritional and Bioactive Characteristics of Dried Vegetables: A Review," Food Enginnering Review,
28. Olubunmi, A.A., Abraham, I.O., Mojirade, L.A., Afolake, B., & Kehinde, O.E., (2017). Development, evaluation and sensory quality of orange-fleshed sweet potato (ipomoea batatas lam) extruded pasta products. Croatia Journal of Food Technology, Biotechnology and Nutrition, 12(1-2), 83- 89.
29. Onwuka, G. I., (2001) Food Analysis and Instrumentation, Course Handout, Department of Food Science and Technolgy, Micheal Okpara University of Agriculture Umudike 18-174,
30. Sanoussi, A. F., Adjatin, A., Dansi, A., Adebowale, A., Sanni, L. O., Sanni, A. (2016). Mineral composition of ten elites sweet potato (Ipomoea Batatas [L] Lam) landraces of Benin. International Journal of Current Microbiology and Applied Sciences, 5(1), 103–115.https://doi.org/10.20546/ijcmas.2016.501. 009
31. Sathe, S.K., Salunkhe D.K., (1981) Functional Properties of the great northern bean. Proteins, emulsions, foaming, viscosity and gelation properties. Journal Food Science;46: 71.
32. Sharma, A., Chen, C.R., Lan, N. V., (2009) Solar-energy drying systems: A review, Renewable and Sustainable Energy Reviews, 13, pp. 1185-1210.
33. Shi, Q., Xue, C., Zhao, Y., Li, Z. Wang, X. (2008). Drying characteristics of horse (Trachurus japonicus) dried in a heat pump dehumidifier. Journal of Food Engineering 84:12-20
34. Simal, S., Femenía, A., Llull, P., Rosselló, C. (2000). Dehydration of aloe vera: simulation of Simpson, W. T. 1991.
35. Tiwari, A. (2016) "A Review on Solar Drying of Agricultural Produce," Journal of Food Process. Technology, 7 (9), 1–12.
36. Tortoe, C., Akonor, P.T., Koch, K., Menxel, C., Adofo, K., (2017). Physicochemical and functional properties of flour from twelve varieties of Ghanian sweet potatoes. International Food Research Journal 24 (6) 2549 – 2556
37. Ukom, A. N., Ojimelukwe, P. C., Okpara, D. A. (2009). Nutrient composition of selected sweet potato [Ipomea batatas (L) Lam] varieties as influenced by different levels of nitrogen fertilizer application. Pakistan Journal of Nutrition, 8(11), 1791–1795. https://doi.org/10.3923/1791-1795
38. Xiao, H.W., Lin, H., Yao, X.D., Du, Z.L., Lou, Z., Gao, Z.C., (2009) Effects of different pretreatments on drying kinetics and quality of sweet potato bars undergoing air impingement drying. International Journal Food Engineering 5 (5): 5