Functional Properties, Hydrolysis and Estimated Glycemic Indices of Processed Orange and Creamed Coloured Skinned Sweet Potatoes

Olufunmilayo S. Omoba[1], Oluwafunmilayo C. Ogunnowo[1], Aderonke I. Olagunju[1], Rebecca O. Oloniyo[2], and Olugbenga O. Awolu[1]

[1] Department of Food Science and Technology, Federal University of Technology, Akure, Nigeria.
[2] Department of Food Science and Technology, Kogi State University, Anyigba, Nigeria

ARTICLE HISTORY
Received Date: 6th June, 2025
Accepted Date: 8th August, 2025

http: www.njphr.nspri.gov.ng
ISSN: 2630-7022

CORRESPONDING AUTHOR
Oluwafunmilayo C. Ogunnowo
Department of Food Science and Technology,
Federal University of Technology,
Akure, Nigeria
ogunnowooc@futa.edu.ng

CONFLICT OF INTEREST: None
ETHICAL APPROVAL: Not Applicable

This is a publication of the Nigerian Stored Products Research Institute (NSPRI)

OPEN ACCESS

Abstract

In the present work, orange-coloured sweet potatoes (OCSP) and cream-coloured skinned sweet potatoes (CCSP) were processed using the following methods: steaming (with or without peeling), roasting, boiling (with or without peeling), and frying. The functional and pasting properties, colour (L a* b*ΔE*), hydrolysis, and estimated glycemic indices (eGI), as well as the glycemic loads (GL) of the processed sweet potatoes, were studied. Results revealed that processing methods increased the swelling capacities, water absorption capacities, and bulk densities of sweet potato flours, with steaming (with or without peel) having the highest values. Processing methods reduced lightness (L*). They increased the yellowness (b*) of the sweet potato flours, while well-visible colour differences (ΔE*) were observed in the processed samples compared to the control (RAW – OC and RAW – CC). Processing reduced the HI, eGI, and GL of the sweet potatoes; the lowest values of these parameters were observed in the roasted samples. In this study, roasting was observed to provide significant nutritional benefits,making it a suitable dietary regimen for individuals who require low- to medium-glycemic index (GI) foods.*

Keywords:
Cream coloured, Estimated glycemic indices, Pasting properties, Processed, Sweet potatoes

Introduction

Sweet potato (*Ipomoea batatas (L)*) is a dicotyledonous, starchy, tuberous vegetable characterised by its sweet taste. It is a vital commodity, particularly in underdeveloped nations, ranking fifth among food crops in terms of fresh weight. (Truong, et al., 2018). According to Shekhar et al. (2015), sweet potato varieties include white-skinned, cream-skinned, and yellow-to-orange-skinned sweet potatoes. Sweet potato varieties are unique sources of vitamins, dietary fibre, and minerals, and are deficient in fat and cholesterol (Eke-Ejiofor & Onyeso, 2019). They could therefore offer nutritional benefits to rural and urban dwellers.

Orange-colored skinned sweet potato (OCSP) is a biofortified cultivar of sweet potato grown due to its high provitamin A carotenoid content (International Potato Centre, 2017). It was introduced into Nigeria in 2015 through a three-year project in Osun and Kwara States, pioneered by the International Potato Centre (CIP), which ended in 2017. According to Abdulla et al. (2014), OCSP is also a unique source of vitamin C, B6, copper, dietary fibre, manganese, potassium, and iron.

Approximately 2.73 million tonnes of sweet potatoes are consumed in Nigeria, utilising diverse processing techniques that include boiling, frying, roasting, and steaming

How to cite:
Omoba, O. S., Ogunnowo, O. C., Olagunju, A. I., Oloniyo, R. O., & Olugbenga, O. A. (2025). Functional Properties, Hydrolysis and Estimated Glycemic Indices of Processed Orange and Creamed Coloured Skinned Sweet Potatoes. *Nigerian Journal of Post-Harvest Research*, 3(6), 50-62

(Olagunju et al., 2020). These methods or processing techniques often result in a significant reduction in specific micronutrients in the food, especially provitamin A and vitamin C (Olagunju et al., 2020). However, the advantages of cooking may include increased digestibility, improved nutrient availability, enhanced palatability, and extended shelf life of the food (Satheesh & Workneh, 2019). The consumption of β-carotene-rich sweet potato varieties could be encouraged in developing countries where Vitamin A deficiency (VAD) poses significant health challenges. Regular consumption of β-carotene-rich foods may help boost the immune system and reduce the risk of cardiovascular diseases (Ahmed et al., 2010). The use of OCSP flour in the production of confectionery products, such as cakes, bread, and biscuits, through extrusion cooking, has been reported by several authors (Adegbanke et al., 2018; Satheesh & Workneh, 2019; Omoba et al., 2020; Oloniyo et al., 2021). Likewise, OCSP has also been used in the production of healthy drinks and juices (Kolawole et al., 2018; Sathheesh & Workneh, 2019). Processing techniques, especially boiling and steaming, are pretreatments or preprocessing methods used in the production of breakfast or extruded products (Olubunmi et al., 2017). They significantly affect the chemical constituents of sweet potatoes (Ikanone & Oyekan, 2014; Olagunju, 2020), which in turn influence the functionality of sweet potato flour (Hung & Morita, 2003).

Previous researchers had reported on the valuable properties of flour and starch from native sweet potato (Ndangui et al., 2014; Tortoe et al., 2017; Guo et al., 2019; Tong et al., 2020), while there is a dearth of evidence on the valuable properties of flour from thermally processed sweet potato.

The carbohydrates in food are classified based on how they impact the blood glucose levels, which is known as the Glycemic Index (GI) after consumption. Carbohydrate foods with a low GI value (<55) are digested, absorbed, and metabolised gradually (slowly), resulting in a low and slow or gradual increase in the blood sugar (Wolever et al. 1991)

This study, therefore, aims to investigate the impact of these processing techniques (boiling, steaming, roasting, and frying) on the functional properties, hydrolysis, and glycemic indices of orange-coloured and cream-coloured skinned sweet potato flours.

Materials and methods

Materials

Orange-skinned sweet potatoes (Mother's Delight variety) used were acquired from the demonstration farm of the International Potato Centre (CIP), Iloko–Ijesa, Osun State, Nigeria (Latitude 7.6524 and Longitude 4.8236). The cream coloured skinned sweet potatoes (Hannah variety) were purchased from "*Erekesan* market", Akure, Ondo State, Nigeria. Analytical grade chemicals and reagents were used for the analysis.

Sample preparation

Four thousand nine hundred grams (4.9kg) of each sweet potato variety were washed and divided into seven equal parts and subjected to different processing methods as described by Gouado et al. (2011). Seven hundred grams (700g) each of orange cream-skinned sweet potato tubers and creamed coloured sweet potato (OCSP and CCSP) were peeled, sliced, and oven-dried (Techmel and Techmel USA, DHG-9101.ISA) at 55 °C for 24 h, and then pulverised to fine flour.

***Steaming*:** One thousand four hundred grams (1400 g) of tubers were divided into two equal parts of seven hundred grams (700 g) each. One part (700 g) was skinned, wrapped in banana leaves, cooked in water at 95 ± 5 °C in an aluminium pot with a mesh separating the water from the wrapped potatoes, and covered for 30 minutes to obtain steamed with peel (SWP). The second part, weighing 700 grams (700 g), was unpeeled and subjected to the same procedure as the peeled part to obtain steamed without peel (SWOP).

***Roasting*:** Seven hundred grams (700 g) of each variety were roasted with peel in an oven (Nexus, GCCR-NX-800IS) at 200 °C for 30 min. The samples were turned regularly during roasting to avoid burning.

***Boiling*:** One thousand, four hundred grams (1,400 g) of tuber was divided into two equal parts, peeled and unpeeled, and boiled separately at 100 °C for 20 minutes.

***Frying*:** Seven hundred grams (700 g) of potatoes were peeled, sliced, and fried at 150 °C for 5 minutes in a Binatone Deep Fryer (MC-DF 1023, China) using King's vegetable oil.

All processed sweet potato samples (RAW-OC, RAW-CC, SWP-OC, SWP-CC, SWOP-OC, SWOP-CC, ROAST-OC, ROAST-CC, BWP-OC, BWP-CC, BWOP-OC, BWOP-CC, FRIED-OC, FRIED-CC) were oven-dried (Techmel and Techmel USA, DHG-9101.ISA) at 55±5 °C for two hours, milled using a hammer mill (model 4, Arthur H. Thomas Co., Philadelphia, PA), sieved through a 1mm screen mesh, packaged in a hermetically sealed container, and stored at 4 °C until use.

Physical attributes of sweet potato samples

The physical attributes of sweet potato samples were examined using the procedure described by Teye & Abano (2012). The orange-skinned sweet potato (Mother's Delight variety) and cream coloured skinned sweet potato (Hannah variety) were evaluated virtually for peel and colour. The diameter was measured by a Vernier calliper (Vernier AF1125 Digital Calliper (0.01mm precision) and a tape rule. Three (3) pieces from each lot of the two sweet potato varieties were randomly selected and evaluated, and afterwards documented. The masses of each of the above-mentioned skinned tubers were measured using an electronic weighing balance (Mettle Instrument PJ6, Switzerland) and also documented.

The same varieties, whose lengths and weights were previously measured (as above), were uniquely divided into three sections: head, middle, and tail. The diameters of the marked sections were then assessed (i.e., DH, DM, and DT). They were measured along these distinct portions, from the head to the tail, using two perpendicular lines with a Vernier calliper, and the average values for the assessments at each portion of the tuber were calculated. Thus, three tuber diameters were obtained for each tuber. The same tubers measured were cut into three slices along the designated lines, after which peels, that is, the periderm and cortex, were removed from the tuber flesh. The calliper was used to measure the thickness of the peels removed from each tuber, specifically the peel thickness at the head (PH), middle (PM), and tail (PT).

The peel proportion by weight *(PPW)* of sweet potato samples

Sweet potato tubers were weighed, and the mass recorded (*M1*). The potatoes, peeled carefully as explained above, had their peels removed from the individual tubers, which were then weighed (*M2*). Peel proportion by weight (PPW) of each tuber was then determined using Eq. 1.

□*1*□*2* (1)

Solid density of sweet potato tuber

The skinned whole sweet potato tuber was weighed on an analytical balance (Mg). The weighed sweet potato was released into a measuring cylinder (250ml) containing a known volume of water, and the difference in volume (Vcm^3) was recorded as the volume occupied by the tuber. Three replicates were done for each sweet potato variety, and the data were analysed. The density of tubers was subsequently calculated using Equation 2.

D=MV (2)

Determination of the swelling capacity (SC) of processed sweet potato flour

The swelling capacity (SC) of processed sweet potato flour samples was determined using the procedure described by Abbey & Ibeh (1988). About ten (10) grams of the flour sample were weighed into a measuring cylinder, and 5 mL of distilled water was added to the flour in the cylinder. The sample volume was noted. The content remained uninterrupted for 1 hour, and the volume was observed and re-recorded.

□□□□*ℎ*□ □□□□□□□□ □□ □□□□□□ □□□□□
□□□□□□□□□□□□□□ □□□□□□□□ □□ □□□□□□ □□□□□□
□□□□□□□□*(3)*

Determination of the dispersibility of processed sweet potato flour

The dispersibility of processed sweet potato flour samples was determined using the method described by Kulkarni et al. (1991). One hundred millilitres (100 mL) of distilled water was added to ten grams (10 g) of flour in a 100 mL measuring cylinder. It was then vigorously stirred and allowed to settle for 3 hours. The volume of the stable elements was then noted and deducted from 100. The variance was recorded as percentage dispersibility.

Determination of water and oil absorption capacities (WAC) of processed sweet potato flour

The technique of Adebowale et al. (2005) was employed to determine the water absorption capacity (WAC) and oil absorption capacities (OAC) of the processed flour samples. Ten millilitres (10 mL) of distilled water or refined soybean oil with a specific gravity of 0.9092 was mixed with 1 g of the processed sweet potato flour in separate beakers. The suspensions were agitated for three minutes with the aid of a stirring device, and then centrifuged at 500 rpm for 30 minutes. The supernatants obtained were carefully decanted and measured in a graduated cylinder (10 mL). The water and oil absorbed by the flour were calculated as the difference between the initial volume of water or oil added to the flour sample and the volume of the supernatant.

Determination of the bulk density of processed sweet potato flour

The gravimetric procedure described by Okaka & Potter (1979) was used to determine the bulk density of flour samples. Fifteen grams (15 g) of processed flour was poured into a standardised measuring cylinder, and the bottom of the cylinder was tapped frequently on the laboratory bench to remove air space between the flour until a persistent volume was attained. Bulk density was obtained by dividing the weight of the flour by the volume.

□□□□□□ □□ □□□
□□□□□□□□□□□□□ □□ □□□
□□□□□□□□□ (4)

Determination of pasting properties of processed sweet potato flour

A Rapid Visco Analyser (RVA4500) was used to assess the pasting characteristics of processed flour (Newport Scientific, 1998). About 2.5 g of the processed flour samples were weighed into empty canisters, and twenty-five (25 mL) of distilled water was added to the canister containing the samples. The solutions were carefully mixed, and the canisters were fitted tightly into the RVA as suggested. Slurries were subjected to heating (50 to 95 °C), with a heating and cooling rate of 11.25 °C per minute. Pasting parameters were obtained from the pasting profile using the Thermocline for Windows software, connected to a computer (Awolu, 2017).

Determination of colour properties of processed sweet potato flour

The colour of processed flours was determined using a colourimeter, PCE-CSM 3. Three characteristics [L*(lightness), a*(redness) and b*(yellowness)] were obtained for the processed flours. The colour difference (ΔE*) between two flour samples was designated as

(5)

ΔL* Δb * and Δa* are the differences between the two samples in L*, b*, and a*, respectively. The ΔE* (colour variation) differs depending on the absorbed colour and the responsiveness of the human eye, as described by Mesias et al. (2016).

Hydrolysis index and Estimated Glycemic index (eGI) processed sweet potato flour samples.

In vitro starch hydrolysis was determined using the method described by Goni et al. (1997). The rate of starch digestion was expressed as the percentage of starch hydrolysed per unit time. The hydrolysis index (HI) was expressed as a percentage for each of the flour samples, calculated as the ratio between the Area Under the Curve (AUC) at 0–180 min for white bread (reference) and the AUC of each sample. The estimated glycemic indices of the processed flour samples were obtained using the equation of Goni et al. (1997), with minor modifications.

(6)

With eGI as Estimated Glycemic Index (%), and HI as Hydrolysis Index (%).

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 17.0 were used to analyse the data. Means separation was carried out using Duncan's New Multiple Range Test (DNMRT), and significant differences were determined at $P \leq 0.05$.

Results and Discussion

Physical attributes of sweet potato tubers

The physical features of sweet potato are vital in the development of handling, harvesting and storing equipment (Teye and Abano, 2012). The physical attributes of the two varieties of sweet potatoes, orange coloured skinned sweet potato (OCSP) and cream coloured skinned sweet potato (CCSP) are presented in Table 1. Colour differs between the two varieties; OCSP exhibits an orange colouration, while CCSP is cream-coloured. The colour difference could be attributed to the high presence of carotenoids in the OCSP compared to the CCSP. The mean tuber length of OCSP and CCSP was 8.75 and 9.65 cm, respectively. The mean tuber length values obtained in this study are less than the mean length (13.42cm) of sweet potatoes documented by Parwada et al. (2011). The difference in the report might be attributed to disparities in tuber age as well as differences in sweet potato cultivar.

The diameter at the head (D_H), diameter at the middle (D_M), and diameter at the tail (D_T) of the OCSP were 3.2, 6.1 and 3.2 cm, respectively, and 3.7, 5.2, and 3.3 cm, respectively, for CCSP. The mean diameter obtained for the two varieties in this study (4.16 cm for OCSP and 4.06 cm for CCSP) was also lower than the 5.38 cm reported by Parwada et al. (2011). The height of the ridges might have influenced the length and diameter of sweet potatoes. According to Parwada et al. (2011), the root diameter of sweet potato reduced with increasing ridge height, while the root length increased with an increase in ridge height.

Table 1: Physical properties of orange coloured and cream coloured skinned sweet potato

Sample	Colour	Length cm	Ppw(g)	D_H	D_M	D_T	$P_{H(cm)}$	$P_{M(cm)}$	$P_{T(cm)}$	D
OCSP (RAW)	Orange	8.75	12.5	3.2	6.1	3.2	0.1	0.1	0.1	1.16
CCSP(RAW)	Cream	9.65	15.0	3.7	5.2	3.3	0.1	0.1	0.1	1.06

Values are means of OCSP= orange coloured skinned sweet potato, CCSP= cream coloured skinned sweet potato L= length, PPW= proportion by weight,D_H=diameter of the head ,D_M=diameter of the middle, D_T=diameter of the tail, P_H=peel thickness at the head, P_M=peel thickness at the middle, P_T= peel thickness at the tail, Density

The densities of OCSP and CCSP were 1.16 g/cm³ and 1.06 g/cm³, respectively. The tuber's density is vital when designing container materials and handling processes for tubers (Akaimo & Raji, 2006). The average thickness of peels of OCSP as well as CCSP at the head (P_H), middle (P_M) and tail (P_T) were 0.1, 0.1, and 0.1 cm, respectively. The peel proportion by weight (PPW) is 12.46 g in OCSP and 15 g in CCSP. The thickness of the peel and the peel proportion by weight (PPW) are required in the development of a machine for peeling tubers.

Influence of processing on functional properties of sweet potato flour

Swelling capacities of orange coloured (OCSP) and cream coloured skinned sweet potatoes (CCSP) significantly ($p \leq 0.05$) increased with processing (Table 2). In OCSP, steaming with peel (SWP – OC) exhibited the highest swelling capacity of 47% increase, while FRIED-OC exhibited the lowest (8%). Similarly, in CCSP, SWP- CC exhibited a 77% increase in swelling capacity. It implies, therefore, that SWP favours the swelling capacity of sweet potatoes, with CCSP tending to swell better than OCSP. A variety of sweet potato types and different processing methods are factors that influence the swelling capacity of flour (Suresh et al., 2015; Uthayakumaran et al., 2025). Awuchi & Echeta (2019) stated that flour having a high amount of starch (amylopectin content) is capable of exhibiting increased swelling capacity, implying that CCSP exhibited higher amylopectin content than OCSP. Additionally, steaming with peel (SWP), as observed in CCSP, may likely reduce the amylose fraction of the processed flour, resulting in the increased development of the amylopectin phosphate complex and, consequently, increasing the swelling capacity. The decreased swelling capacity observed in FRIED-OC may be attributed to the presence of oil, which is capable of reducing water absorption, increasing the gelatinisation temperature, and invariably decreasing swelling capacity (Garcia & Franco, 2015). The capability of the starch content in flour to absorb water and then swell is known as the swelling capacity; it is an essential parameter in bakery goods (Iwe et al., 2016).

A dispersibility of 59.89% was reported for RAW-OC and 55.70% for RAW–CC. The dispersibility of the processed flours varies significantly in OCSP; steaming without peel (SWOP – OC) showed the highest increase in dispersibility, at 4%, compared to RAW – OC. Similarly, in CCSP, ROAST-CC exhibited a 9% increase in dispersibility. Dispersibility measures the degree to which flour can be reconstituted in the presence of water (Adebowale et al. 2008). ROAST- CC will disperse better than other samples in OCSP and CCSP. The high percentage of dispersibility exhibited by RAW – OC and ROAST - CC will make reconstitution into a fine, consistent dough easy (Ohizua et al., 2017). The WAC of orange-coloured sweet potato flour ranged from 331 to 472 g/g, with ROAST-OC having the lowest value. In CCSP, WAC ranged from 244 to 428 g/g, with RAW-OC having the lowest WAC in the two varieties of sweet potatoes (OCSP and CCSP). SWOP exhibited the highest WAC. The Increase observed in water absorption capacities may be related to the hydrophilic constituents, such as starch, fibre, and proteins (polar amino acid residues), in the flour (Suresh & Samsher, 2013; Awuchi et al., 2019). During steaming, pre-gelatinisation occurs, with consequent modification of the starch structural moiety, resulting in high WAC. When the starch is modified, the disordering of intermolecular hydrogen bonding is prompted, causing the release of hydroxyl groups (hydrophilic sites) that can absorb water molecules, leading to swelling. Akubor & Fayhase (2018) reported that a higher water absorption capacity makes it suitable for the invention of ready-to-eat food products, as it stimulates cohesiveness, such as in dough formulation. Flours high in WAC might be ideal in the processing of baked goods and sausage (Iwe et al., 2016).

Likewise, the rise in oil absorption was observed in the processed flour samples of both varieties compared to the raw. FRIED-OC had the highest oil absorption with 8% increase in processed OCSP, while FRIED-CC had the highest oil absorption of 3% increase in processed CCSP. The high OAC observed, especially in FRIED-OC, can be attributed to the presence of non-polar sequences capable of forming hydrophobic interactions with hydrocarbons in foods and flour (Jitngarmkusol et al., 2008; Suresh et al., 2015). The high OAC in the flour enables it to improve the palatability, shelf life, taste, and mouthfeel of food required in food preparation, especially in bakery products (Akubor, 2017).

Bulk density of OCSP varied between 0.69 g/cm^2 and 0.98 g/cm^2 while CCSP ranged from 0.78 g/cm^2 to 0.99 g/cm^2. Bulk density varies with processing and increases with OCSP and CCSP. The variation observed in the bulk densities of the two varieties may be ascribed to the flour starch content. Low bulk densities in processed flours of both varieties are of tremendous benefit in harmonising food formulation (Suresh & Samsher, 2013). Bulk density is important because it is used to design and determine suitable packaging for the product (Iwe et al., 2016).

Table 2: Effect of Processing on Functional Properties of OCSP and CCSP

Sample	Swelling capacity %	Dispersibility %	Water absorption capacity (g/g)	Oil absorption capacity (g/g)	Bulk density g/cm3
Orange coloured skinned sweet potato (OCSP)					
RAW-OC	41.80^g±0.10	59.89^c±0.06	349^d±1.00	136^{ab}±0.01	0.75^e±0.01
SWP-OC	61.50^a±0.10	59.63^d±0.06	349^d±1.00	98^b±1.00	0.91^b ±0.02
SWF-OC	56.30^d± .10	62.37^a± 0.06	472^a± 1.27	122^b±22.2	0.98^a±0.01
ROAST-OC	59.63^b±0.25	61.29^b± 0.06	331^e±1.00	129^{ab}±10.6	0.88^c.± 0.01
BWP-OC	51.17^e±0.15	58.25^f±0.06	389^b±0.58	117^b±1.00.	0.79^d±0.01
BWOP-OC	58.27^c± .15	61.37^b± 0.06	386^b± 5.51	129^{ab}±10.6	0.91^b± 0.01
FRIED-OC	45.33^f± 0.15	58.50^e± 0.10	370^c± 1.00	147^a±9.85	0.69^f±0.01
Cream coloured skinned sweet potato (CCSP)					
RAW-CC	30.67^g±0.15	55.70^f±0.10	244^f±1.00	147^{ab}±9.85	0.78^c±0.01
SWP-CC	54.37^b±0.15	60.47^a±0.06	330^d±0.58	123^c±11.3	0.91^b±0.01
SWOP-CC	46.30^f±0.10	59.33^c±0.12	428^a±1.00	117^c±1.00	0.91^b±0.01
ROAST-CC	49.37^d±0.15	60.57^a±0.12	350^c±1.00	136^b.0±1.0	0.99^a±0.01
BWP-CC	50.70^c±0.20	56.80^e±0.10	370^b±1.55	117^c±1.00	0.99^a±0.01
BWOP-CC	46.80^e±0.10	59.87^b±0.06	311^e±1.00	110^C±11.3	0.83^d±0.01
FRIED-CC	57.20^d±0.10	58.33^d±0.06	311^e±1.00	151^a±3.22	0.88^c±0.01

Values are means. ± Standard deviation. The same subscripts are not significantly different along the column (p≤0.05) —RAW-OC=Orange coloured sweet potato (RAW).SWP-OC=Orange coloured sweet potato steamed with peel. ROAST-OC=Orange coloured sweet potato roasted. SWOP-OC = Orange coloured sweet potato steamed without peel. BWOP-OC=Orange coloured sweet potato boiled without peel. FRIED-OC = Orange coloured sweet potato fried.BWP-OC=Orange coloured sweet potato boiled with peel. RAW-CC =Cream sweet potato, ROAST-CC = Cream coloured sweet potato roasted.FRIED-CC= cream coloured sweet potato fried. SWP-CC=Cream sweet potato steamed with peel.BWP-CC=Cream coloured sweet potato boiled with peel. SWOP-CC= Cream coloured sweet potato without peel.BWOP-CC=Cream coloured sweet potato boiled without peel

Influence of processing on pasting profiles of raw and processed OCSP and CCSP

Table 3 shows the pasting profiles of raw and processed OCSP and CCSP. The Pasting temperature of 53.70 °C was reported for RAW - OF and 79.10 °C for RAW- CF. Pasting temperature indicates the lowest temperature at which the starch particles in the flour swell (Awolu et al., 2018).

It depicts the cooking temperature (Ekunseitan et al., 2016; Kolawole et al., 2018). No pasting temperatures were observed for the processed OCSP and CCSP, indicating that no energy is required during the pasting of the processed flours, and also suggesting that the flours possess weak shear resistance and molecular recombination capacity. The peak viscosity of OCSP ranged from 13 – 629 RVU, and from 40.99-272 RVU for CCSP. The peak viscosity observed in this study for RAW-OF was greater than 247 RVU, which is higher than the value of 247 RVU obtained for OCSP by Kolawole et al. (2018); this difference may be attributed to variations in geographical location.

Table 3: Effect of Processing on Pasting Properties of OFSP and CFSP

Sample	Pasting temp RVU	Peak viscosity RVU	Trough RVU	Breakdown RVU	Final viscosity RVU	Setback viscosity RVU	Peak time (min)
Orange-skinned sweet potato							
RAW-OC	53.70± 1.00	629.0^{a}±1.00	629.0 ^{ab}±1.00	40.00 ^{b}±1.00	1064 ^{k}±1.00	455.00^{k}±1.00	5.27^{abc}±1.0
SWP-OC	_	41.00 ^{b} ±1.00	38.00 ^{d}±1.00	2.00 ^{d}±1.00	56.00 ^{a}±1.00	17.00 ^{c}±1.00	5.87^{abc}±1.00
SWOP-OC	_	69.00 ^{b} ±1.00	616.0 ^{d}±1.00	2.63 ^{d}±1.58	80.00 ^{f}±1.00	15.00 ^{a}±1.00	4.80 ^{bc}±1.00
ROAST-OC	_	13.00 ^{b} ±1.00	71.00 ^{d}±1.00	11.67 ^{c}±17.62	106.00^{h}±1.00	35.00 ^{h}±1.00	6.73 ^{bc}±1.00
BWP-OC	_	60.00 ^{b} ±1.00	55.00 ^{d} ±1.00	5.00 ^{cd}±1.00	77.00 ^{d}±1.00	22.00 ^{e}±1.00	5.53 ^{bc}±1.00
BWOP-OC	_	54.00 ^{b} ±1.00	53.00 ^{d}±1.00	0.97 ^{d}±0.06	78.00 ^{e}±1.00	25.00 ^{f}±1.00	6.07^{abc}±1.00
FRIED=OC	_	73.00 ^{b} ±1.00	72.00 ^{d}±1.00	0.97 ^{d}±0.06	93.00 ^{f}±1.00	21.07 ^{d}±0.99	6.27 ^{bc}±1.00
Cream coloured skinned sweet potato							
RAW-CC	79.10± 1.00	40.99 ^{b} ±5.97	702.0 ^{a}±1.00	397.0 ^{a}±1.00	1103 ^{l}±1.00	401.00^{a}±1.00	4.07 ^{c}±1.00
SWP-CC	_	43.00 ^{b} ±1.00	42.00 ^{d}±1.00	0.97 ^{d}±0.06	58.00 ^{b} ±1.00	16.00 ^{g} ±1.00	6.51 ^{bc}±0.56
SWOP-CC	_	62.00 ^{b} ±1.00	60.00 ^{d}±1.00	2.00±1.00	105.00±1.00	46.00 ^{e}±1.00	6.71 ^{b}±0.84
ROAST-CC	_	96.00 ^{b} ±1.00	89.00 ^{d}±1.00	7.00 ^{cd}±1.00	154.00 ^{i}±1.00	65.00 ^{d}±1.00	5.29^{abc}±2.04
BWP-CC	_	49.00 ^{b} ±1.00	48.00 ^{d}±1.00	0.97 ^{d}±0.06	73.00 ^{c}±1.00	25.00 ^{f}±1.00	6.40^{b}±1.21
BWOP-CC	_	272.0 ^{b} ±1.00	262.0 ^{cd}±1.00	10.00±1.00	433.00±1.00	191.00^{b}±1.00	7.43^{a}±0.70
FRIED-CC	_	200.0 ^{b} ±1.00	450.0 ^{bc}±1.00	5.00 ^{cd}±1.00	279.00 ^{i}±1.00	84.00 ^{c}±1.00	6.44 ^{bc}±1.45

Values are means. ± Standard deviation. The same subscripts are not significantly different along the column ($p \leq 0.05$). RAW-OC=Orange coloured sweet potato (RAW).SWP-OC=Orange coloured sweet potato steamed with peel, ROAST-OC=Orange coloured sweet potato roasted. SWOP-OC Orange coloured sweet potato steamed without peel. BWOP-OC=Orange coloured sweet potato boiled without peel. FRIED-OC = Orange coloured sweet potato fried. BWP-OC=Orange coloured sweet potato boiled with peel.RAW-CC =Cream sweet potato, ROAST-CC = Cream coloured sweet potato roasted. FRIED-CC= cream coloured sweet potato fried. SWP-CC=Cream sweet potato steamed with peel. BWP-CC=Cream coloured sweet potato boiled with peel. SWOP-CC= Cream coloured sweet potato without peel. SBWOP-CC=Cream coloured sweet potato boiled without peel.

The highest viscosity reached during cooking signifies the paste's strength due to gelatinisation (Awolu et al., 2018). Since peak viscosity is linked to the gradation of starch damage in flours, it suggests that starch damage is higher in the processed samples than in the RAW – OC. High peak viscosity indicates the suitability of the sample, especially RAW-OC, for food products that require high elasticity and strength.

The trough viscosity decreased in all the processed potato flours for both OCSP and CCSP. SWP-OC and SWP-CC had the highest decrease, at 93.8% and 93.8%, respectively. Trough viscosity refers to the lowest viscosity in the continuous temperature phase of the RVA pasting curve and also indicates the paste's ability to withstand collapse upon chilling (Adebowale et al., 2012).

Similarly, the processing methods employed significantly decreased the breakdown viscosity in both processed OCSP and CCSP. The trend of inflated starch granules breaking when held at high temperatures and subjected to uninterrupted shearing is indicative of breakdown viscosity. It is also an indicator of paste stability (Akanbi et al., 2009). The breakdown of starch in a molecule may be influenced by several factors, including the type of material, temperature, and the extent of mixing and shear applied to the mixture (Newport Scientific, 1998).

The low breakdown viscosity recorded by the diverse processing methods may be a result of the inability of the processed sample to paste due to initial starch breakdown. Processing resulted in a 90-95% decrease in the final viscosity of both varieties (OCSP& CCSP). Samples SWP-OF and SWP-CF exhibit the highest decrease in final viscosity, reaching 95%. Thermal dilapidation of the starch particles through heat treatment resulted in a low final viscosity of the flours from cooked samples. Final viscosity is a parameter generally used to determine the quality of a starch-based flour and its ability to form a gel after processing (Adebowale et al., 2012).

Processing techniques employed decreased the setback viscosity of the flours, with samples SWP-OC and SWP-CC exhibiting the lowest setback values, indicating that these may have a high level of retrogradation. The peak time of flours significantly ($p < 0.05$) increased in both samples (OCSP and CCSP) with processing. The increase observed in the peak time of the processed OCSP and CCSP might be due to the partial gelatinisation of the samples as a result of the different processing techniques. According to Akanbi et al. (2009), the peak time is the time (in mins) when the peak viscosity occurs.

Effect of processing on the colour profile of raw and processed OCSP and CCSP

The effect of processing on the colour profile of raw and processed OCSP and CCSP is presented in Table 4. Colour is a vital attribute, linked to the nutritional properties of the food, and dictates the final purchasing price and general acceptability of the products (Xiao et al., 2014; Omoba et al., 2020). Both varieties significantly ($p \leq 0.05$) decreased in L* values with processing; SWOP-OC had the highest decrease of 25% in OCSP, and BWP-CC had the highest decrease of 5% in CCSP. Similarly, OCSP significantly ($p \leq 0.05$) increased in the b* values, with FRIED-OC exhibiting the highest percentage increase (13%). This finding contradicts the observations of a previous author, who reported a decrease in b* values due to frying, which was attributed to the browning reaction that occurs during frying (Sobukola et al., 2018). The increase in b* values, which indicate yellowness, detected in this study, might be ascribed to the temperature (< 170 °C) used in frying resulting in desirable products. Marked significant differences were visualised in processed OCSP samples with ΔE values ranging from 9.13 – 25.11, while well-visible colour differences were observed in CCSP processed samples (ΔE=1.2-5.2), compared to the control (RAW –OC and RAW – CC).

Influence of processing on the hydrolysis index (HI) and estimated glycemic index (eGI) of OCSP and CCSP

The influence of processing on the hydrolysis index (HI) and estimated glycemic index (eGI) of the samples was presented in Table 5. The HI value of 49 was reported for OCSP, and 43 for CCSP. The processing methods employed decreased the HI of OCSP; SWP-OF had the highest decrease (22%), followed by ROAST-OC and BWP-OC, which decreased by 20%, while BWP-CC decreased by 15%. According to Nani et al (2016) and Corrado et al. (2023), the HI characterises the food's starch digestibility as it relates to the starch digestibility of white bread (a reference). The high HI leads to a higher rate of digestibility. The study shows the processes (SWP, ROAST, and BWP) reduced starch hydrolysis, and these may be related to the chemical structure of starches (amylose-amylopectin ratio).

An estimated glycemic index of 67 (medium GI) was reported for both OCSP and CCSP flours (Table 5). The estimated glycemic index decreased with processing methods, except for SWP-CC and BWP-CC, which showed an increase in the estimated glycemic index (eGI). The increase observed may be attributed to the ability of steaming and boiling (with or without peel) to expose the potato starch matrix and invariably promote gelatinisation, which consequently predisposes the potatoes to enzymatic digestion and increases the hydrolysis rate, which is directly proportional to the glycemic index. Similarly, an increase in the eGI of BWP-CC and SWP-CC may be linked to the starch's capacity to absorb water and undergo swelling (i.e., gelatinisation), which irreparably disrupts the crystalline structure of the starch, making it readily hydrolysed by amylase. This observation is similar to that of Gracia-Eleazu et al. (2014) and Hu et al. (2022), who reported higher digestibility in boiled sweet potatoes compared to other culinary practices. For OCSP, the ROAST-OC and BWP - OC had the lowest eGI of 60, respectively, while for CCSP, the SWOP–CC and FRIED – CC exhibited the lowest eGI of 60, respectively. Food is classified into three categories based on its glycemic index, which include high-glycemic-index food (70), medium-glycemic-index food (56-69), and low-glycemic-index food (<55), as reported by Foster–Powell et al. (2002).

Table 4: Effect of Processing on Colour of OCSP and CCSP

Sample	L*	a*	b*	C	Hue	▲E
Orange coloured skinned sweet potato (OCSP)						
RAW-OC	85.75^{a}±1.85	5.73^{f}±0.55	24.19^{d}±1.35	24.86^{d}±1.35	76.70^{a}±0.57	
SWP-OC	73.69^{c}±1.38	14.18^{b}±0.60	26.85^{cd}±1.71	30.36^{bc}±1.79	62.15^{e}±0.84	15.9
SWOP-OC	64.01^{d}±1.41	16.03^{a}±1.33	27.08^{c}±3.48	32.08^{abc}±3.67	59.93^{f}±1.02	25.11
ROAST-OC	77.97^{b}±0.67	12.40^{cd}±0.21	28.30^{bc}±0.72	30.90^{bc}±0.60	66.34^{d}±0.84	11.85
BWP-OC	79.11^{b}±1.75	10.79^{e}±0.44	26.45^{cd}±1.23	28.57^{c}±0.53	67.80^{c}±0.44	9.13
BWOP-OC	78.02^{b}±1.79	13.23^{bc}±0.78	31.30^{ab}±1.53	33.98^{ab}±1.70	67.10^{cd}±0.43	14.66
FRIED-OC	73.21^{c}±1.20	11.43^{de}±0.63	33.12^{a}±1.73	35.04^{a}±1.29	70.95^{b}±0.44	17.12
Cream-coloured skinned sweet potato (CCSP)						
RAW-CC	83.09^{ab}±1.46	5.198^{c}±0.23	15.74^{c}±0.57	16.57^{bc}±0.53	71.71^{c}±1.07	
SWP-CC	82.55^{abc}±1.42	4.049^{d}±0.20	15.76^{c}±1.93	16.27^{bc}±1.91	75.60^{a}±1.23	1.2
SWOP-CC	81.76^{abc}±2.39	3.705^{d}±0.20	14.35^{c}±1.93	14.82^{c}±1.91	75.42^{a}±1.23	2.4
ROAST-CC	82.13^{a}±1.89	5.992^{b}±0.46	19.28^{ab}±1.73	20.19^{a}±0.83	72.75^{bc}±0.64	4.0
BWP-CC	79.12^{c}±2.45	6.28^{b}±0.26	20.92^{a}±0.80	21.84^{a}±0.83	73.29^{b}±0.38	4.11
BWO-CC	79.73^{bc}±1.42	7.096^{a}±0.14	19.28^{ab}±0.53	20.55^{a}±0.51	69.79^{d}±0.58	5.2
FRIED-CC	80.93^{bc}±2.90	4.182^{d}±0.12	17.68^{b}±0.68	18.17^{b}±0.69	76.69^{a}±0.20	3.0

Values are means. ± Standard deviation. The same subscripts are not significantly different along the column ($p \leq 0.05$) —RAW-OC=Orange coloured sweet potato (RAW).SWP-OC=Orange coloured sweet potato steamed with peel. ROAST-OC=Orange coloured sweet potato roasted. *SWOP-OC =* Orange coloured sweet potato steamed without peel. *BWOP-OC*=Orange coloured sweet potato boiled without peel. *FRIED-OC* = Orange coloured sweet potato fried. BWP-OC=Orange coloured sweet potato boiled with peel. *RAW-CC* =Cream sweet potato*, ROAST-CC* Cream coloured sweet potato roasted. *FRIED-CC*= cream coloured sweet potato fried. *SWP-CC*=Cream sweet potato steamed with peel.*BWP-CC*=Cream coloured sweet potato boiled with peel. *SWOP-CC*= Cream coloured sweet potato without peel*; BWOP-CF*=Cream coloured sweet potato boiled without peel

Table 5: Effect of Processing on Hydrolysis index and Estimated Glycemic index

Sample	Hydrolysis index(HI)	Estimated Glycemic Index
Orange coloured skinned sweet potato (OCSP)		
RAW-OC	49.00^{a} ± 0.3	66.61^{a}± 1.5
SWP-OC	38.18^{f} ± 0.5	60.67^{e}± 1.3
SWOP-OC	46.58^{b} ± 0.2	65.00^{b}± 2.3
BWP-OC	39.02^{e} ± 0.6	60.00^{f}± 1.6
BWOP-OC	44.20^{d} ± 0.3	63.64^{d}± 1.3
FRIED-OC	44.63^{c} ± 0.2	64.21^{c}± 2.0
ROAST-OC	39.02^{e} ± 0.1	60.00^{f}± 1.4
Cream coloured skinned sweet potato (CCSP)		
RAW-CC	43.07^{e} ± 0.1	66.61^{d}± 1.2
SWP-CC	49.00^{d} ± 0.3	67.85^{b}± 2.1
SWOP-CC	51.26^{b} ± 0.4	59.91^{f}± 1.4
BWP-CC	36.80 ^{g}± 0.3	68.73^{a} ± 1.3
BWOP-CC	52.88^{a} ± 0.2	67.45^{c}± 2.1
FRIED-CC	50.52^{c} ± 0.4	60.45^{e}± 2.0
ROAST-CC	37.77f ± 0.6	66.61^{d}± 1.4

Values are means. ± Standard deviation. The same subscripts are not significantly different along the column ($p \leq 0.05$). *RAW-OC=Orange coloured sweet potato (RAW).SWP-OC=Orange coloured sweet potato steamed with peel. ROAST-OC=Orange coloured sweet potato roasted. SWOP-OC: Orange-coloured sweet potato steamed without peel. BWOP-OC=Orange coloured sweet potato boiled without peel. FRIED-OC = Orange coloured sweet potato fried. BWP-OC=Orange coloured sweet potato boiled with peel. RAW-CC =Cream sweet potato, ROAST-CC = Cream coloured sweet potato roasted. FRIED-CC= cream coloured sweet potato fried.SWP-CC=Cream sweet potato steamed with peel. BWP-CC=Cream coloured sweet potato boiled with peel. SWOP-CC= Cream coloured sweet potato without peel; BWOP-CF=Cream coloured sweet potato boiled without peel*

OCSP and CCSP are classified as middle GI foods (GI 56-69), resulting in an intermediate increase in blood glucose. The decrease in the GI of ROAST –OC may be attributed to weak gelatinisation of the starch as a consequence of dry heat. However, the GI of all processed OCSP was reduced with processing compared to the RAW-OC, although they all exhibited a medium glycemic index (56-69). Thus, the comparison of the GI of processed sweet potatoes shows variances of medical importance and can form a basis for dietary guidance to diabetic subjects, especially as Raw GI > Fried GI > Boiled / SWOP - OC GI > Roasted GI in OCSP.

Conclusions

This study highlights the physical properties of sweet potato varieties (Orange and cream coloured skinned), effects of common household processing methods, steaming (with and without peel), roasting, boiling (with and without peel) and frying on the functional, pasting properties, colour, hydrolysis index and estimated glycemic index of OCSP and CCSP were evaluated. Results revealed that the physical properties of both varieties differed; additionally, processing methods increased the swelling capacity, water absorption, and bulk density of both sweet potato varieties. SWOP exhibited the highest WAC in OCSP and CCSP, while SWOP exhibited the highest bulk density in OCSP, ROAST-CC, and BWP–CC exhibited the highest bulk densities. The effect of the processing methods varies; results revealed that processing methods (steaming, boiling) may depend on the targeted product. The estimated glycemic index reduced with processing, which is more pronounced in ROAST-OC and BWOP-CC. These processing methods will provide immense nutritional benefits to consumers who require food with a low to medium GI.

Data availability

The data will be made available upon request.

Funding

This work was supported by the TETFUND Institution-Based Research (IBR) Grant of the Federal University of Technology, Akure, Nigeria. [TETFUND/ 155C].

References

Abdulla, G., El-Shourbagy, G. A., & Sitohy, M. Z. (2014). Effect of pre-drying, blanching, and citric acid treatment on the quality of fried sweet potato chips. *American Journal of Food Technology, 9*(1), 39–48. https://doi.org/10.3923/ajft.2014.39.48

Adebowale, K. O., Olu-Owolabi, B. I., Olawumi, E. K., & Lawal, O. S. (2005). Functional properties of native, physically, and chemically modified breadfruit (*Artocarpus artillis*) starch. *Industrial Crops and Products, 21*, 343–351. https://doi.org/10.1016/j.indcrop.2004.05.002

Adebowale, A. A., Adegoke, M. T., Sanni, S. A., Adegunwa, M. O., & Fetuga, G. O. (2012). Functional properties and biscuit-making potentials of sorghum–wheat flour composite. *American Journal of Food Technology, 7*, 372–379. https://doi.org/10.3923/ajft.2012.372.379

Adebowale, A. A., Sanni, L. O., & Ladapo, F. O. (2008). Chemical, functional, and sensory properties of instant yam–breadfruit. *Nigerian Food Journal, 26*(1), 2–12.

Adegbanke, B. M., Kolawole, F. L., Suleiman, H. D., Sanni-Olayiwola, H. O., & Kareem, H. B. (2018). Production and sensory evaluation of *kunun-saki* sweetened with orange-fleshed sweet potato (*Ipomoea batatas*) syrup. *Croatian Journal of Food Science and Technology, 10*(2), 239–244. https://doi.org/10.17508/cjfst.10.2.15

Ahmed, M., Sorifa, A. M., & Eun, J. B. (2010). Effect of pretreatments and drying temperatures on sweet potato flour. *International Journal of Food Science & Technology, 45*(4), 726–732. https://doi.org/10.1111/j.1365-2621.2010.02191.x

Akanbi, C. T., Nazamid, S., & Adebowale, A. A. (2009). Functional and pasting properties of tropical breadfruit (*Artocarpus altilis*) starch from Ile-Ife, Osun State, Nigeria. *Food Research Journal, 16*, 151–157.

Akubor, P., & Fayashe, T. (2018). Chemical composition, functional properties, and performance of soybean and wheat flour blends in instant fried noodles. *South Asian Journal of Food Technology and Environment, 4*, 690–699.

Akubor, P. I. (2017). Characterisation of fruit wines from baobab (*Adansonia digitata*), pineapple (*Ananas sativus*), and carrot (*Daucus carota*) tropical fruits. *Asian Journal of Biotechnology and Bioresource Technology, 1*(3), 1–10. https://doi.org/10.9734/AJB2T/2017/35643

Awolu, O. O. (2017). Optimization of the functional characteristics, pasting and rheological properties of pearl millet-based composite flour. Heliyon, 3(2).

Awolu, O. O., Sudha, L. M., & Manohar, B. (2018). Influence of defatted mango kernel seed flour addition on the rheological characteristics and cookie-making quality of wheat flour. *Food*

Science & Nutrition, 6(8), 2363–2373. https://doi.org/10.1002/fsn3.780

Awuchi, C. G., & Echeta, K. C. (2019). Current developments in sugar alcohols: Chemistry, nutrition, and health concerns of sorbitol, xylitol, glycerol, arabitol, inositol, maltitol, and lactitol. *International Journal of Advanced Academic Research, 5*(11), 1–33.

Corrado, M., Zafeiriou, P., Ahn-Jarvis, J. H., Savva, G. M., Edwards, C. H., & Hazard, B. A. (2023). Impact of storage on starch digestibility and texture of high-amylose wheat bread. *Food Hydrocolloids, 135*, 108139. https://doi.org/10.1016/j.foodhyd.2022.108139

Ekunseitan, O. F., Obadina, A. O., Sobukola, O. P., Omemu, A. M., Adegunwa, M. O., Kajihausa, O. E., Adebowale, A. A., Sanni, S. A., Sanni, L. O., & Keith, T. (2016). Nutritional composition, functional and pasting properties of wheat, mushroom, and high-quality cassava composite flour. *Journal of Food Processing and Preservation, 40*(6), 13150. https://doi.org/10.1111/jfpp.13150

Eke-Ejiofor, J., & Onyeso, B. U. (2019). Effect of processing methods on the physicochemical, mineral, and carotene content of orange-fleshed sweet potato (*OFSP*). *Journal of Food Research, 8*(3), 50–58. https://doi.org/10.5539/jfr.v8n3p50

Foster-Powell, K., Holt, S. H. A., & Miller, J. C. B. (2002). International table of glycemic index and glycemic load values. *American Journal of Clinical Nutrition, 76*(1), 5–56. https://doi.org/10.1093/ajcn/76.1.5

Gracia - Eleazu, C. O., Okafor, P. N., & Ifeoma, I. (2014). Biochemical basis of the use of cocoyam (Colocassia esculenta L.) in the dietary management of diabetes and its complications in streptozotocin induced diabetes in rats. *Asian Pacific Journal of Tropics Disease*, 4, S705-S711. https: //doi.org /10.1016/S2222-1808(14)60711-8.

Goni, I., Garcia-Alonso, A., & Saura-Calixto, F. (1997). A starch hydrolysis procedure to estimate glycemic index. *Nutrition Research, 17*, 427–437. https://doi.org/10.1016/S0271-5317(97)00010-9

Gouado, I., Demasse, M. A., Etame, L. G., Meyimgo, O. R. S., Ejoh, A. R., & Fokou, E. (2011). Impact of three cooking methods (steaming, roasting on charcoal, and frying) on the β-carotene and vitamin C contents of plantain and sweet potato. *American Journal of Food Technology, 6*, 994–1001. https://doi.org/10.3923/ajft.2011.994.1001

Guo, K., Liu, T., Xu, A., Zhang, L., Bian, X., & Wei, C. (2019). Structural and functional properties of starches from root tubers of white, yellow, and purple sweet potatoes. *Food Hydrocolloids, 89*, 829–836. https://doi.org/10.1016/j.foodhyd.2018.11.048

Hu, Y., Sun, H., & Mu, T. (2022). Effects of sweet potato leaf powder on sensory, texture, nutrition, and digestive characteristics of steamed bread. *Journal of Food Processing and Preservation, 46*(7), e16697. https://doi.org/10.1111/jfpp.16697

Ikanone, C. E. O., & Oyekan, P. O. (2014). Effect of boiling on total carbohydrate, vitamin C, and mineral content of Irish sweet (*Ipomoea batatas*) potatoes tuber. *Nigerian Food Journal, 32*(2), 33–39. https://doi.org/10.1016/S0189-7241(15)30115-6

International Potato Center. (2017). *Sweet potato in Africa*. https://cipotato.org/research/sweetpotato-in-africa/

Iwe, M. O., Onyeukwu, U., & Agiriga, A. N. (2016). Proximate, functional, and pasting properties of FARO 44 rice, African yam bean, and brown cowpea seeds composite flour. *Cogent Food & Agriculture, 2*(1), 1142409. https://doi.org/10.1080/23311932.2016.1142409

Jitngarmkusol, S., Hongsuwankul, J., & Tananuwong, K. (2008). Chemical composition, functional properties, and microstructure of defatted macadamia flours. *Food Chemistry, 110*(1), 23–30. https://doi.org/10.1016/j.foodchem.2008.01.050

Kolawole, F. L., Balogun, M. A., Usman, F. D., & Akeem, S. A. (2016). Effect of drying methods on the chemical and functional properties of potato (*Solanum tuberosum*) and sweet potato (*Ipomoea batatas*) varieties. *Nigerian Journal of Agriculture, Food and Environment, 12*(4), 151–156.

Kolawole, F. L., Balogun, M. A., & Oyeyinka, S. (2018). Production and sensory evaluation of *kunun-zaki* sweetened with orange-fleshed sweet potato (*Ipomoea batatas*) syrup.

Croatian Journal of Food Science and Technology, 10(2), 239–244. https://doi.org/10.17508/cjfst.2018.10.2.15

Kolawole, F. L., Akinwande, B. A., & Ade-Omowaye, B. I. (2018). Chemical composition, colour, functional, and pasting properties of orange-fleshed sweet potato, *Pleurotus tuber-regium* sclerotium, and their flour blends. *Annals of Food Science and Technology, 19*(3), 423–432.

Kulkarni, K. D., Kulkarni, D. N., & Ingle, U. M. (1991). Sorghum malt-based weaning formulations: Preparation, functional properties, and nutritive value. *Food and Nutrition Bulletin, 13*(4), 322–327. https://doi.org/10.1177/156482659101300407

Mesias, M., Holgado, F., Marquez-Ruiz, G., & Morales, F. J. (2016). Risk/benefit considerations of new formulations of wheat-based biscuits supplemented with different amounts of chia flour. *LWT - Food Science and Technology, 73,* 528–535. https://doi.org/10.1016/j.lwt.2016.06.056

Nani, R. S., Eni, H., & Yustinus, M. (2016). *In vitro* starch digestibility and estimated glycemic index of Indonesian cowpea starch (*Vigna unguiculata*). *Pakistan Journal of Nutrition, 16*(1), 1–8. https://doi.org/10.3923/pjn.2017.1.8

Ndangui, C. B., Petit, J., Gaiani, C., Nzikou, J. M., & Scher, J. (2014). Impact of thermal and chemical pretreatments on physicochemical, rheological, and functional properties of sweet potato (*Ipomoea batatas* Lam) flour. *Food and Bioprocess Technology, 7*(12), 3618–3628. https://doi.org/10.1007/s11947-014-1361-3

Newport Scientific. (1998). *Applications manual for the Rapid Visco Analyser using Thermocline for Windows*. Warriewood, Australia: Newport Scientific Pty Limited.

Okaka, J. C., & Potter, N. (1979). Physicochemical and functional properties of cowpea powders processed to reduce beany flavour. *Journal of Food Science, 44*(4), 1235–1240. https://doi.org/10.1111/j.1365-2621.1979.tb03488.x

Olagunju, A. I., Omoba, O. S., Awolu, O. O., Rotowa, O. K., Oloniyo, R. O., & Ogunnowo, O. C. (2020). Physicochemical, antioxidant properties, and carotenoid retention loss of culinary processed orange-fleshed sweet potato. *Journal of Culinary Science & Technology, 19*(6), 535–554. https://doi.org/10.1080/15428052.2020.1799278

Oloniyo, R. O., Omoba, O. S., Awolu, O. O., & Olagunju, A. I. (2021). Orange‐fleshed sweet potato composite bread: A good carrier of β-carotene and antioxidant properties. *Journal of Food Biochemistry, 45*(3), e13423. https://doi.org/10.1111/jfbc.13423

Olubunmi, A. A., Abraham, I. O., Mojirade, L. A., Afolake, B., & Kehinde, O. (2017). Development, evaluation, and sensory quality of orange-fleshed sweet potato (*Ipomoea batatas* Lam) extruded pasta products. *Croatian Journal of Food Technology, Biotechnology and Nutrition, 12*(1), 83–89.

Omoba, O. S., Olagunju, A. I., Iwaeni, O. O., & Obafaye, R. O. (2020). Effect of tiger nut fiber on the quality characteristics and consumer acceptability of cakes made from orange-fleshed sweet potato flour. *Journal of Culinary Science & Technology, 19*(3), 228–246. https://doi.org/10.1080/15428052.2020.1747036

Parwada, C., Gadzirayi, C. T., & Sithole, A. B. (2011). Effects of ridge height and planting orientation on *Ipomoea batatas* (sweet potato) production. *Journal of Agricultural Biotechnology and Sustainable Development, 3*(4), 72–76.

Satheesh, N., & Workneh, S. (2019). Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. *Food Science & Nutrition, 7*(6), 1920–1945. https://doi.org/10.1002/fsn3.1063

Shekhar, S., Mishra, D., Buragohain, A., Chakraborty, S., & Chakraborty, N. (2015). Comparative analysis of phytochemicals and nutrient availability in two contrasting cultivars of sweet potato (*Ipomoea batatas* L.). *Food Chemistry, 173*, 957–965. https://doi.org/10.1016/j.foodchem.2014.09.172

Suresh, C., & Samsher, S. (2013). Assessment of functional properties of different flours. *African Journal of Agricultural Research, 8*(38), 4849–4852. https://doi.org/10.5897/AJAR2013.6905

Suresh, C., Samsher, S., & Durvesh, K. (2015). Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *Journal of Food*

Science and Technology, *52*(6), 3681–3688. https://doi.org/10.1007/s13197-014-1427-2

Sobukola, P. O., Adebowale, A. R. A., Wahab, A. B., Obadina, A. O., Kajihausa, E. O., Adegunwa, O. M., ... & Tomlins, K. (2018). The antinutritional and vitamin composition of high‐quality yam flour as affected by yam specie, pretreatment, and drying method. Food Science & Nutrition, 6(8), 1985-1990.

Teye, E., & Abano, E. E. (2012). Physical properties of two varieties of sweet potato grown in the coastal savannah zone. *International Journal of Science and Nature*, *3*(1), 105–109.

Tong, C., Ru, W., Wu, L., Wu, W., & Bao, J. (2020). Fine structure and relationships with functional properties of pigmented sweet potato starches. *Food Chemistry*, *311*(2), 126011. https://doi.org/10.1016/j.foodchem.2019.126011

Tortoe, C., Akonor, P. T., Koch, K., Menzel, C., & Adofo, K. (2017). Physicochemical and functional properties of flour from twelve varieties of Ghanaian sweet potatoes. *International Food Research Journal*, *24*(6), 2549–2556.

Truong, V. D., Avula, R. Y., Pecota, K. V., & Yencho, G. C. (2018). Sweetpotato production, processing, and nutritional quality. In *Handbook of Vegetables and Vegetable Processing* (2nd ed., pp. 811–838). Wiley-Blackwell.

Uthayakumaran, T., Pushparaja, V., Nadarajah, K., & Vasantharuba, S. (2025). Investigation of drying kinetics, nutrient profile, physicochemical, and functional properties of purple yam (*Dioscorea alata*) under different drying conditions. *Journal of Food Measurement and Characterization*, *19*(1), 210–226. https://doi.org/10.1007/s11694-024-01745-3

Wolever, T. M. S., Jenkins, D. J. A., Jenkins, A., & Josse, R. G. (1991). The glycemic index: Methodology and clinical implications. *American Journal of Clinical Nutrition*, *54*(5), 846–854. https://doi.org/10.1093/ajcn/54.5.846

Xiao, H. W., Law, C. L., Sun, D. W., & Gao, Z. J. (2014). Color change kinetics of American ginseng (*Panax quinquefolium*) slices during air impingement drying. *Drying Technology*, *32*(4), 418–427. https://doi.org/10.1080/07373937.2013.834928