

QUALITY EVALUATION OF FLOUR AND BISCUIT PRODUCED FROM SWEET POTATO AND ORANGE POMACE

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Abstract

This study exploited the food and functional potentials of orange pomace, a solid waste of orange juice production, in producing composite flours and acceptable biscuit. Orange pomace and sweet potato were processed into flour; at 0%, 5%, 10%, 15%, 20%, 25% and 30% levels, orange pomace flour was utilized to substitute sweet potato flour. Using conventional techniques, pasting and functional analysis were performed on the composite flours, likewise the proximate composition, antioxidant activity, physical characteristics and sensory acceptability of biscuits made from the composite flours were assessed. Wheat biscuit served as control. The pasting and functional qualities of the composite flours varied; addition of orange pomace considerably decreased peak viscosity (86.08 - 146.92 RVU) and breakdown viscosity (12.58 - 39.67 RVU) with varying impact on setback viscosity (43.00 - 62.75 RVU) and final viscosity (117.33 - 172.08 RVU). Biscuits produced from the composite flours were found to be significantly denser in ash (3.25 - 4.85%) and crude fibre (4.62 - 11.15%). The inclusion of orange pomace significantly increased DPPH, FRAP and total phenolic content with values ranging from 73.23 to 83.44%, 4.85 to 9.92 mg vit. C/g and 17.93 to 24.75 mg GAE/g respectively. Biscuit produced from 85% sweet potato and 15% orange pomace composite flour showed significant higher acceptability and it compared favourably with the control. This study demonstrated that sweet potato-orange pomace composite flours could be used to make biscuits that people would find acceptable and that would support the waste-to-wealth drive as well as human fiber intake and its associated health benefits.

Keywords: Sweet potato; Orange pomace; Biscuit; Pasting properties; Antioxidant activity; Sensory acceptability

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Introduction

In many developing nations in the tropics and subtropics, sweet potatoes (*Ipomoea batatas* L. (Lam.)) rank fourth in importance among staple crops, behind rice, corn, and cassava (Fetuga *et al.*, 2014; Giri and Sakhale, 2019). Between 1993 and 2013, Nigeria produced more than 2.12 million metric tons of sweet potatoes, making it the top producer in Africa (FAOSTAT 2011; Olatunde *et al.*, 2016). Due to its short maturity period, adaptability to a variety of climate conditions, and ability to grow on less fertile soil, sweet potatoes have a great deal of potential for usage as food in developing countries with limited resources. Sweet potatoes come in a variety of colors, ranging from white to yellow-orange and deep purple, for both the skin and flesh. Nutritionally, Sweet potato is rich in carbohydrate consisting mainly of starch and sugar (occurring as sucrose, glucose, and fructose), and small amounts of pectins, hemicellulose, and cellulose (Ohizua 2017). It contains a significant quantity of dietary fiber, ascorbic acid, beta-carotene (particularly the orange-fleshed type), lysine (the primary limiting amino acid in cereals), and a few significant phytochemicals (Olaleye *et al.*, 2020). In spite of its nutritional quality and production record, the crop is still underutilized due to its high perishability nature leading to a huge post harvest loss. To decrease post-harvest loss and boost utilization capacity, sweet potatoes must be processed into flour for use in food and non-food applications.

Orange (*Citrus sinensis*) is one of the most well known and distributed fruits; orange pomace is a major waste during production of orange juice. It is estimated that during the commercial manufacturing of fruit juice, 50% of the entire weight of citrus fruit is industrial waste (pulp, seeds, and peels) (Fernández-Fernández *et al.*, 2021). Orange pomace, a major waste in fruit juice production, contains an edible portion of the fruit that includes segments, broken pulp sacs and a center core. Orange pomace is a rich source of fiber (58.90 - 59.06%) and has been suggested to be an ideal ingredient for development of fibre rich food products (Syeda *et al.*, 2022). Dietary fibre has been reported to ameliorate certain chronic intestinal disorders; it attenuates the glycemic response to foods and promotes positive physiological changes in human gastrointestinal functions such as reduction in nutrient uptake and blood plasma cholesterol levels (Thondre, 2013; Andrade *et al.*, 2014). The favorable impact of fiber on postprandial glycemia has been documented in both individuals with metabolic

syndrome and diabetes as well as in healthy populations. The current study examined the sweet potato-orange pomace biscuits' proximate composition, antioxidant activity, and sensory acceptability in addition to the functional and pasting qualities of the sweet potato-orange pomace composite flour.

Materials and methods

Sources of Materials

Sweet potato and orange used in this work were sourced from *Ago-Aduloju* market, very close to Federal Polytechnic Ado-Ekiti Campus

Production of Sweet Potato Flour and Orange Pomace Flour

Sweet potato roots were cleaned under running water to get rid of any debris, peeled and thinly cut with a kitchen knife to facilitate drying. This was followed by drying the slices in hot air oven (DHG 9030A; Hinotek Group Ltd., China) at 70°C for 48 hours; dried slices of sweet potatoes were ground into flour in a hammer mill (FT2 hammer mill, Armfield, England), sieved (0.5 mm) and packaged in polyethylene bag for further use. Oranges were carefully cleaned, peeled, and cut in half before the juice was extracted using a Master Chef Juice Extractor (United Arab Emirates). Orange pomace (consisting of segments, broken pulp sacs and a center core) obtained was spread out on a tray and oven dried in hot air oven (DHG 9030A; Hinotek Group Ltd., China) at 60°C for 14 hours. Using a blender (VTCL Solitaire Mixer Blender, India), dried orange pomace was ground into flour, sieved (0.5 mm) and packaged in polyethylene bag for further use.

Formulation of Composite Flour

Orange pomace flour was used to substitute sweet potato flour at 0% (SP), 5% (SPP1), 10% (SPP2), 15% (SPP3), 20% (SPP4), 25% (SPP5) and 30% (SPP6) levels; the samples were thoroughly mixed together manually to ensure homogeneity.

Pasting and Functional Properties of Sweet Potato-Orange Pomace Composite Flour

Rapid Visco Analyser (RVA) (RVA 4500; Perten Instruments, Sweden) connected with computer (thermocline for widows (TCW) software) for viscometric data acquisition was used to evaluate the pasting characteristics of the samples. The sample was allowed to acclimate to

50°C for one minute. It was then heated to 95°C in 3 minutes and 45 seconds, held there for two minutes and 30 seconds, cooled to 50°C in 3 minutes and 45 seconds, and maintained at that temperature for two minutes. Values for the following pasting parameters were obtained: peak, trough, breakdown, final, and setback viscosities as well as pasting temperature and peak time. According to the process outlined by Sathe *et al.* (1982) water and oil absorption capacities of the samples were evaluated, swelling power at 60°C was determined using the approach of Kaur *et al.* (2011). Dispersibility and wetability were evaluated using the procedures described by Adegunwa *et al.* (2017). Foaming capacity was assessed using the procedure of Onwuka (2005). Bulk densities both packed and loose, were evaluated using the procedure described by Mpotokwane *et al.* (2008).

Production of Sweet Potato-Orange Pomace Biscuits

Using the recipe in Table 1, sweet potato-orange pomace composite flours with other ingredients were weighed accurately. The pre-weighed flour, sugar, salt and baking powder were mixed thoroughly followed by the addition of vegetable fat (Topper, Heerenveen, Holland); mixture of water and milk were then added with proper mixing to make adequate dough. The dough was rolled on a board using rolling pin to a thickness of about 0.2 - 0.3 cm. The rolled dough was cut into shapes, arranged on a greased tray and baked at 180°C for 25 minutes in a preheated oven. After allowing the biscuits to cool, they were packaged in polyethylene bags.

Table 1. Recipe for production of biscuits

Ingredients	Percentage (%)
Flour	100
Sugar	22
Vegetable Fat	38
Milk	5
Salt	1
Baking powder	1.3

Proximate Composition and Antioxidant Activity of Sweet Potato-Orange Pomace Biscuits

Methods described by AOAC (2005) for moisture (925.10), protein (kjeldahl method, 2001.11), ash (923.03), fat (soxhlet extraction method, 963.15) and fibre (978.10) were used to determine proximate composition while carbohydrate was determined by difference. The aqueous extract was prepared according to Obob

et al. (2010)'s method: the biscuit samples were ground into powder in a blender, and the powder (10 g each) was extracted (by soaking) for 24 hrs at 37°C using 100mL of distilled water. The mixture was filtered and the filtrate was centrifuged to obtain supernatant extract which was stored at 4°C. DPPH (1,1-diphenyl-2-picryl-hydrazyl) radical scavenging ability was carried out using the method outlined by Moodley *et al.* (2015). FRAP (ferric reducing antioxidant power) was evaluated using the procedure described by Nyau *et al.* (2015). Total phenolic content was determined using the method outlined by Mahloko *et al.* (2019).

Physical Characteristics and Sensory Evaluation of Sweet Potato-Orange Pomace Biscuit

A weighing scale was used to measure the biscuit samples' weight (g), a calibrated ruler was used to measure their diameter (cm), and the height of five stacked biscuits was measured and divided by five to get the thickness (cm) of each biscuit. The thickness of each biscuit was divided by its diameter to determine the spread ratio. Twenty panelists who are acquainted with the sensory characteristics of biscuits were given coded samples of the biscuits to assess during the sensory evaluation. The samples were assessed for taste, aroma, color, crispiness, and general acceptability using a nine-point hedonic scale, where 1 denotes dislike extremely and 9 indicates like extremely. Biscuit produced from wheat flour was used as control.

Statistical Analysis

The statistical significance ($p \leq 0.05$) of the difference in the experimental data was assessed by utilizing the Analysis of Variance (ANOVA) approach with the SPSS 21.0 software package (Statistical Package for Social Scientist, Michigan, USA).

Results and Discussion

Pasting Properties

Table 2 displays the composite flours' pasting characteristics. The outcome shows that almost all of the pasting indices were significantly affected by the level of orange pomace. When the amount of orange pomace was increased, the peak viscosity decreased. At 100% sweet potato, the peak viscosity was 146.92 RVU, and at the highest amount of orange pomace used, it was 86.08 RVU. Peak viscosity, which is the maximum viscosity during the heating time, indicates the strength of the paste that forms during processing of flour for use in food applications. The sweet potato-orange pomace

composite flour's low peak viscosity suggests a weak paste strength, which could be undesirable in some culinary products like dumpling dough. A comparable decrease in the final viscosity was noted; however, there was an initial rise in the final viscosity, particularly at the 10% and 15% levels of orange pomace inclusion. The diluting effect of non-starchy orange pomace on the starchy component in the composite flours may be the cause of the decrease in peak and final viscosities. Flour's potential applications for food products are determined by its peak and final viscosities. The range of peak and final viscosities in this study were lower than 66.29 - 348.92 RVU and 35.25 - 353.67 RVU respectively reported for cooking banana, pigeon pea and sweet potato flour blends (Ohizua *et al.*, 2017)

For composite flours with a higher level of orange pomace, there was a minor fall in viscosity during the isothermal portion of the pasting test known as the trough; as a result, those samples had a minimal breakdown viscosity. This observation may be explained by the fibrous part of the orange pomace acting as a shield for the starch granules, rather than the starch granules' inherent ability to endure disintegration during heating and shearing. After cooling to 50°C, a process known as setback occurs when starch molecules retrograde or reorganize. Setback viscosity values varied; the sample containing 10% orange pomace had the greatest value, while the sample containing 25% orange pomace had the lowest. Setback has a positive correlation with retrogradation tendency and invariably indicate dough digestibility (Alamu *et al.*, 2017). It is anticipated that samples with low setback values will have high digestibility indices and strong resistance to retrogradation. The pasting temperature, which also affects the energy cost of food preparation, is a measurement of the lowest temperature needed to cook a specific food sample. Up to a 15% level of inclusion, the pasting

temperature of the flour blends increased as the amount of orange pomace increased; beyond that, it remained constant. The high pasting temperature of samples with high amount of orange pomace laid credence to the high water absorption capacity of the samples; Julanti *et al.* (2015) reported that a high pasting temperature usually indicates that flour has high water absorption capacity. The peak time increased significantly when orange pomace flour was used to substitute sweet potato flour.

Functional Properties

Functional properties are physicochemical characteristics that show the intricate relationship between the molecular conformation, content, and structures of various food macromolecules. These qualities aid in the prediction of food material behavior and suitability for various food applications. Table 3 shows the functional characteristics of the composite flours. The ranges for swelling power and water absorption capacity were 2.50 to 4.30 g/g and 2.00 to 3.90 mL/g, respectively. These two functional indices increased along with increase in the amount of orange pomace in the composite flours. This increase may be attributed to the high fibre content in the orange pomace. Food materials' functional qualities are typically influenced by the type and concentration of chemical components they contain, including carbohydrate, fiber, protein, and fat (Fetuga *et al.*, 2014). Ability of flour sample to absorb water and swell is a major consideration in the choice of flour for bakery and non bakery products because it improves texture and yield of food products (Bamigbola *et al.*, 2016). Previous report has suggested that orange pomace with high water holding capacity could be used to improve texture, reduce syneresis and serve as thickening agent (Syeda *et al.*, 2022). The swelling values of the composite flour were lower than 13.80 g/g reported for cassava flour (Kusumayanti *et al.*, 2015).

Table 2. Pasting properties of sweet potato-orange pomace composite flours

Samples	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Pasting Temperature (°C)	Peak Time (Mins.)
SP	146.92±1.33 ^a	107.00±1.10 ^b	39.67±0.93 ^a	159.67±1.56 ^c	52.67±0.32 ^c	79.95±0.25 ^c	5.00±0.02 ^d
SPP1	105.75±1.12 ^d	85.92±0.61 ^c	19.83±0.48 ^c	139.25±1.07 ^d	53.33±0.66 ^c	81.50±0.15 ^b	5.07±0.01 ^c
SPP2	133.08±1.41 ^c	105.58±0.96 ^b	27.50±0.59 ^b	168.33±1.24 ^b	62.75±1.00 ^a	81.45±0.10 ^b	5.07±0.00 ^c
SPP3	140.08±1.03 ^b	112.83±1.21 ^a	27.25±0.42 ^b	172.08±0.83 ^a	59.25±0.74 ^b	82.30±0.20 ^a	5.07±0.01 ^c
SPP4	98.17±1.16 ^e	83.17±0.56 ^d	15.00±0.71 ^d	127.17±0.96 ^e	44.00±0.69 ^d	82.30±0.10 ^a	5.20±0.01 ^a
SPP5	95.42±0.68 ^f	82.58±0.76 ^d	12.83±0.39 ^e	125.58±0.88 ^e	43.00±0.61 ^d	82.30±0.15 ^a	5.20±0.02 ^a
SPP6	86.08±1.23 ^g	73.50±0.92 ^e	12.58±0.46 ^e	117.33±1.00 ^f	43.83±0.76 ^d	82.30±0.10 ^a	5.13±0.00 ^b

Values in the same column followed by different superscript are significantly different ($P \leq 0.05$)

SP = 100% sweet potato; SPP1 = 95% sweet potato & 5% orange pomace; SPP2 = 90% sweet potato & 10% orange pomace; SPP3 = 85% sweet potato & 15% orange pomace; SPP4 = 80% sweet potato & 20% orange pomace; SPP5 = 75% sweet potato & 25% orange pomace; SPP6 = 70% sweet potato & 30% orange pomace

Table 3. Functional properties of sweet potato-orange pomace composite flours

Samples	SP (g/g)	WAC (ml/g)	OAC (ml/g)	D (%)	W (Secs)	FC (%)	PBD (g/ml)	LBD (g/ml)
SP	2.90±0.03 ^c	2.00±0.01 ^e	2.00±0.02 ^a	66.50±0.50 ^b	47.00±0.14 ^a	6.10±0.30 ^a	0.70±0.01 ^b	0.50±0.00 ^b
SPP1	2.50±0.00 ^d	2.80±0.03 ^d	1.60±0.00 ^b	68.50±0.50 ^a	47.11±0.20 ^a	2.80±0.10 ^d	0.70±0.20 ^b	0.50±0.01 ^b
SPP2	3.70±0.04 ^b	3.10±0.02 ^c	2.00±0.01 ^a	68.00±0.50 ^a	42.15±0.25 ^c	2.40±0.00 ^e	0.70±0.01 ^b	0.50±0.01 ^b
SPP3	3.70±0.04 ^b	3.50±0.02 ^b	2.10±0.00 ^a	66.00±0.00 ^b	45.50±0.46 ^b	3.90±0.10 ^c	0.70±0.00 ^b	0.50±0.00 ^b
SPP4	3.80±0.03 ^b	3.70±0.01 ^{ab}	1.60±0.03 ^b	64.00±0.50 ^c	40.74±0.13 ^d	3.90±0.20 ^c	0.90±0.01 ^a	0.60±0.01 ^a
SPP5	4.30±0.02 ^a	3.80±0.03 ^a	1.40±0.01 ^c	62.00±0.50 ^d	43.25±0.34 ^c	5.00±0.20 ^b	0.90±0.02 ^a	0.60±0.01 ^a
SPP6	4.10±0.03 ^a	3.90±0.03 ^a	1.40±0.02 ^c	61.00±1.00 ^d	37.54±0.61 ^e	5.00±0.20 ^b	0.90±0.02 ^a	0.60±0.00 ^a

Values in the same column followed by different superscript are significantly different ($P \leq 0.05$)

SP = Swelling Power; WAC = Water Absorption Capacity; OAC = Oil Absorption Capacity D = Dispersibility

W = Wettability; FC = Foaming capacity; PBD = Packed Bulk Density; LBD = Loose Bulk Density

SP = 100% sweet potato; SPP1 = 95% sweet potato & 5% orange pomace; SPP2 = 90% sweet potato & 10% orange pomace; SPP3 = 85% sweet potato & 15% orange pomace; SPP4 = 80% sweet potato & 20% orange pomace; SPP5 = 75% sweet potato & 25% orange pomace; SPP6 = 70% sweet potato & 30% orange pomace.

Table 4. Proximate composition of biscuits produced from sweet potato-orange pomace composite flours

Samples	Moisture	Ash	Fat	Fibre	Protein	Carbohydrate
SP	9.65±0.13 ^d	3.27±0.08 ^d	4.15±0.15 ^a	4.62±0.20 ^f	4.09±0.25 ^a	74.22±0.25 ^a
SPP1	9.59±0.18 ^d	3.25±0.10 ^d	4.18±0.24 ^a	4.78±0.10 ^f	4.00±0.23 ^a	74.20±0.21 ^a
SPP2	9.89±0.10 ^d	3.44±0.11 ^d	4.28±0.21 ^a	5.81±0.14 ^e	3.22±0.09 ^b	73.36±0.20 ^b
SPP3	10.93±0.12 ^c	4.09±0.10 ^c	4.21±0.20 ^a	7.08±0.21 ^d	3.41±0.10 ^b	70.28±0.18 ^c
SPP4	11.34±0.23 ^c	4.73±0.19 ^a	3.92±0.00 ^b	8.15±0.26 ^c	2.49±0.08 ^c	69.37±0.11 ^d
SPP5	11.91±0.20 ^b	4.43±0.20 ^b	3.45±0.10 ^c	9.24±0.30 ^b	2.77±0.14 ^c	68.20±0.10 ^e
SPP6	12.80±0.17 ^a	4.85±0.27 ^a	3.17±0.10 ^d	11.15±0.32 ^a	2.14±0.00 ^d	65.89±0.34 ^f

Values in the same column followed by different superscript are significantly different ($P \leq 0.05$)

SP = 100% sweet potato; SPP1 = 95% sweet potato & 5% orange pomace; SPP2 = 90% sweet potato & 10% orange pomace; SPP3 = 85% sweet potato & 15% orange pomace; SPP4 = 80% sweet potato & 20% orange pomace; SPP5 = 75% sweet potato & 25% orange pomace; SPP6 = 70% sweet potato & 30% orange pomace

The oil absorption capacity fluctuated; a larger amount of pomace inclusion tended to diminish oil absorption capacity, which implies that the flour blends would not be appropriate for products that need emulsion stabilization. As the amount of orange pomace increased, the dispersibility and wettability values decreased, ranging from 61.00 to 68.50% and 37.54 to 47.11 seconds, respectively. Samples containing a greater amount of orange pomace inclusion may have limited reconstitution ability based on their low dispersibility values. Low reconstitution capacity is indicated by low dispersibility value. But the same samples' low wettability values indicate that it can quickly soak in water for good mixing (Arinola *et al.*, 2023), which may not necessarily translate to strong reconstitution ability. The foaming capacity value first decreased sharply at the lowest level of sweet potato substitution with orange pomace, but it thereafter increased as the amount of orange pomace increased. This observation could be the result of chemical interactions between the two flours' constituents, which could have impacted the blends' pH, protein content, and solubility. Protein type and quantity, solubility, and pH all have an impact on foaming capacity, which is a crucial functional attribute in several food preparations. With values ranging from 0.70 to 0.90 g/ml for

packed bulk density and 0.50 to 0.60 g/ml for loose bulk density, replacing sweet potatoes with orange pomace generally boosted both packed and loose bulk density. Generally bulk density indicates the heaviness of powder food material and the packaging materials required for the transportation of such food material. This study's reported packed bulk density was similar to that of plantain-tiger nut flour blends, which ranged from 0.81 to 0.92 g/mL (Adegunwa *et al.*, 2017).

Proximate Composition

The proximate composition of biscuits produced from the composite flours is presented in Table 4.

The biscuit samples' moisture and ash levels ranged from 9.59 to 12.80% and 3.25 to 4.85%, respectively; a rise in the amount of orange pomace in the biscuits seemed to have raised these two proximate components. Moisture content might be a good indicator of a product's shelf stability. Ash is an indicator of all the mineral elements present in a sample and is crucial for the body's metabolism of other nutrients (Arinola *et al.*, 2020). There was a modest rise in fat content at first, but at the highest amount of orange pomace employed in this study, the value decreased to 3.17%. The major proximate principle in orange pomace is fiber, with values of

31.83% and 14.11% for insoluble and soluble fiber respectively (Nagarajaiah and Prakash, 2016). Therefore, it is not surprising that the biscuits' fiber contents increased significantly as the amount of orange pomace in the samples increased. Syeda *et al.* (2022) reported values ranging from 58.90 - 59.06% as crude fibre content of orange pomace. It is well recognized that fiber has vital physiological functions in the body. The protein content decreased as the amount of orange pomace increased, which might be explained by dilution effect. The protein and carbohydrate amounts ranged from 2.14 - 4.09% and 65.89 - 74.22%, respectively.

Antioxidants Activity and Physical Properties

The total phenolic constituent of 100% sweet potato flour was 17.93 mg GAE/g, this value increased to 24.75 mg GAE/g in the biscuit that contained the highest level of orange pomace (Table 5). This result suggests the presence of phenolic compounds in the samples. Most bioactive compounds, which are known to contain phenol group, have been reported to be involved in biochemical activities which is beneficial to human health. The comparatively high total phenolic content of the biscuits made with orange pomace, despite the lack of a bioaccessibility investigation in this study, indicates that the phenolic compounds may be able to endure processing conditions and may even have positive effects on human health. One element that affects a bioactive compound's bioavailability is its resistance to the circumstances of the human digestive system and food processing (Fernández-Fernández *et al.* 2021). According to a report (Gutiérrez-Grijalva *et al.*, 2019), some phenolic compounds may have their chemical

structures changed while those of other compounds may not due to pH changes during food digestion.

DPPH and FRAP were used to assess the biscuits' antioxidant activity. DPPH evaluates a dietary sample's capacity to halt free radicals and stop their subsequent unfavorable metabolic reactions in the body. The range of DPPH values was 73.23 to 83.44%, and it seemed that the values rose as the amount of orange pomace in the composite flour increased. The total phenolic content of the samples may have contributed to their elevated DPPH values; from the result it is apparent that a positive correlation exists between DPPH values and total phenolic contents. This observation aligns with prior research, indicating that phenolic chemicals via their capacity to scavenge free radicals, chelate metallic catalysts, and activate antioxidant enzymes, are responsible for the antioxidant activity of dietary components (Obboh *et al.* 2015). This shows that biscuits made from sweet potato and orange pomace may have health benefits in addition to their nutritional value. The range of 4.85 to 9.92 mg vit. C/g for FRAP values followed a similar pattern to that of DPPH values. The FRAP values varied significantly from one another. FRAP is an antioxidant index that measures a sample's capacity to convert Iron III to Iron II through the transfer of electrons and hydrogen atoms. Inclusion of orange pomace had a fluctuating effect on the weight and diameter of biscuits produced with values ranging from 8.43 to 13.03 g and 4.77 to 5.13 cm respectively (Table 5). A cursory look at the result of the thickness and spread ratio shows that while inclusion of orange pomace caused a reduction in the former, it increased the latter.

Table 5. Antioxidants activity and physical characteristics of biscuits produced from sweet potato-orange pomace composite flours

Samples	DPPH (%)	FRAP (mg vit. C/g)	Total Phenolic Content (mg GAE/g)	Weight (g)	Diameter (cm)	Thickness (cm)	Spread ratio
SP	73.23±0.18 ^e	4.85±0.11 ^e	17.93±0.09 ^f	10.57±0.03 ^d	4.77±0.01 ^c	0.82±0.01 ^{ab}	5.82±0.00 ^d
SPP1	73.44±0.20 ^e	5.43±0.08 ^{de}	18.35±0.10 ^{ef}	12.26±0.01 ^b	4.97±0.01 ^{ab}	0.80±0.00 ^{ab}	6.21±0.02 ^c
SPP2	73.78±0.10 ^e	5.89±0.10 ^d	18.81±0.11 ^{de}	11.20±0.03 ^c	4.87±0.00 ^{bc}	0.84±0.02 ^a	5.79±0.01 ^d
SPP3	74.88±0.12 ^d	7.37±0.21 ^c	19.32±0.10 ^d	10.73±0.00 ^{cd}	5.07±0.02 ^a	0.84±0.00 ^a	6.04±0.01 ^c
SPP4	76.37±0.09 ^c	8.23±0.17 ^b	20.40±0.16 ^c	13.03±0.02 ^a	4.83±0.00 ^{bc}	0.78±0.02 ^b	6.19±0.03 ^c
SPP5	80.30±0.16 ^b	9.71±0.12 ^a	22.43±0.14 ^b	8.43±0.01 ^f	4.97±0.01 ^{ab}	0.60±0.02 ^d	8.28±0.02 ^a
SPP6	83.44±0.21 ^a	9.92±0.15 ^a	24.75±0.23 ^a	10.00±0.02 ^e	5.13±0.02 ^a	0.70±0.01 ^c	7.33±0.4 ^b

Values in the same column followed by different superscript are significantly different ($P \leq 0.05$)

SP = 100% sweet potato; SPP1 = 95% sweet potato & 5% orange pomace; SPP2 = 90% sweet potato & 10% orange pomace; SPP3 = 85% sweet potato & 15% orange pomace; SPP4 = 80% sweet potato & 20% orange pomace; SPP5 = 75% sweet potato & 25% orange pomace; SPP6 = 70% sweet potato & 30% orange pomace

Table 6. Sensory acceptability of biscuits produced from sweet potato-orange pomace composite flours

Samples	Taste	Aroma	Colour	Crispiness	Overall Acceptability
SP	7.82 ^{ab}	6.95 ^b	7.29 ^b	7.09 ^{ab}	7.13 ^{bc}
SPP1	7.64 ^b	6.70 ^b	7.36 ^b	6.93 ^b	6.67 ^c
SPP2	7.70 ^b	6.14 ^c	6.92 ^{bc}	7.14 ^b	6.80 ^c
SPP3	7.81 ^{ab}	6.57 ^{bc}	6.63 ^{cd}	7.17 ^{ab}	7.48 ^{ab}
SPP4	6.07 ^c	5.55 ^d	6.21 ^d	6.10 ^c	6.79 ^c
SPP5	6.14 ^c	5.43 ^d	5.50 ^e	5.71 ^d	5.93 ^d
SPP6	5.11 ^d	5.14 ^d	4.90 ^f	4.93 ^e	5.14 ^e
Control	8.30 ^a	7.80 ^a	8.26 ^a	7.67 ^a	7.91 ^a

Values in the same column followed by different superscript are significantly different ($P \leq 0.05$)

SP = 100% sweet potato; SPP1 = 95% sweet potato & 5% orange pomace; SPP2 = 90% sweet potato & 10% orange pomace; SPP3 = 85% sweet potato & 15% orange pomace; SPP4 = 80% sweet potato & 20% orange pomace; SPP5 = 75% sweet potato & 25% orange pomace; SPP6 = 70% sweet potato & 30% orange pomace

Sensory Acceptability

According to the statistical analysis, there were notable differences between the biscuit samples in each of the sensory qualities examined (Table 6). In terms of aroma and colour, biscuits produced from the composite flours received lower significant scores than the control; however inclusion of orange pomace up to 15% and 10% did not result in any significant difference in the aroma and colour respectively when compared with biscuit produced from 100% sweet potato. The taste of the biscuits made with 100% sweet potato flour, the biscuits made with 15% orange pomace, and the control biscuit made with wheat flour did not significantly differ from one another. However, when orange pomace inclusion exceeded 15%, biscuits samples received significantly lower taste scores; this may be attributed to the bitter aftertaste of orange pomace as a result of its bitter inherent compounds. This same pattern of result was observed for crispiness.

Biscuits made with 15% orange pomace and those made with 100% sweet potato flour did not significantly differ in terms of overall acceptability; however, the two biscuit samples were significantly different from other biscuit samples made with sweet potato-orange pomace composite flours. The only biscuit that compared favourably with the control was the one made with a flour blend that had 15% orange pomace, since there was no discernible difference between the two samples. This implies that a composite flour consisting of 15% orange pomace and 85% sweet potato might yield satisfactory biscuits. It is significant to remember that differences in the baking conditions and sample formulation will ultimately affect how widely accepted the biscuits are as a whole.

Conclusion

The functional and pasting qualities of the sweet potato-orange pomace composite flours were appreciable and may make them suitable for use in a wide range of applications that typically require the use of other flours. Incorporating orange pomace into sweet potato for the production of biscuit did not only improved certain proximate nutrients, but also enhanced free radicals scavenging ability of the biscuit, thereby having potential to reduce the occurrence of degenerative diseases initiated by free radicals. An assessment of sensory acceptability showed that biscuits made with composite flour consisting of 15% orange pomace and 85% sweet potato might be considered acceptable.

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