Journal of Food and Agriculture
DOI: https://dx.doi.org/10.4038/jfa.v16i1.5279

Potential of Debittered *Pomelo Albedo* Flour (*Citrus maxima*) in Bread: Functional, Nutritional and Phytochemical Characteristics

K.K. Olatoye[1], A.I. lawal[2*], F.B. Ojimi[1]

ABSTRACT

This study explored the use of pomelo albedo as a composite flour in bread production. The pomelo albedo portion of the whole fruit was debittered through the standard method and obtained debittered pomelo albedo flours (DPAF) which were incorporated into wheat flour at four formulations of 0, 10, 20, and 30% for bread production. The impact of DPAF on functional characteristics of composite flours and physical, chemical and sensory characteristics of breads was investigated. The difference between 100% wheat flour and flour enriched with 30% DPAF regarding water absorption (130.00 - 166.33%), bulk density (0.68 - 0.96 g/ ml) and crude fibre (1.50 - 2.42%) was significant giving higher value in DPAF composite flours, while their specific volume (2.93 - 4.14 cm^3/ g) and protein (7.75 - 10.07%) were lower than that of control bread without DPAF. The phytochemical properties of bread varied slightly with incorporation of DPAF. A Sensory evaluation test using a 9-point hedonic scale showed that the appearance, flavor and overall acceptability were within the liking rate for 10% composite bread. The overall results could be useful for guiding the future application of pomelo albedo by-product in the bakery industry.

[1]*Department of Food Science and Technology, Faculty of Agriculture, Kwara State University, Malete, P.M. B.1530, Ilorin, Kwara State, Nigeria.*
[2]*Department of Food Science and Technology, Faculty of Engineering and Technology, First Technical University, Ibadan, Nigeria.*

**tunjawal@gmail.com.*
http://orcid.org/0000-0003-3097-8790

Keywords: Bread properties, Debitterization, Phytochemical, Pomelo albedo flour.

INTRODUCTION

The upkeep of good health as well as the prevention and treatment of diseases depend heavily on food, and to this end the World Health Organization (WHO) had inspired food scientists and other allied sectors to step up their efforts in the creation of novel food items that may provide consumers with nourishing and healthful options (FAO *et al.*, 2022). This has created awareness- in today's consumers who are craving not only ready to eat and convenient food products (bread, snacks, etc.) but also food products with health benefits such as low calorie content, high contents of fibres, proteins and biological activities.

Bread, which is a unique and important bakery product has played a significant role in many nations' diets around the world and throughout recorded history (Jiang *et al*., 2022). Besides ease of consumption, the dough is a great matrix for enhancing various raw materials to improve nutritional and health features (Ogo *et al*., 2021). Nonetheless, bread is generally poor in some nutritional component such as dietary fibre, phenolic and antioxidant components (Odunlade *et al*., 2017), a problem that can be resolved by incorporating flours from fruits peels such as albedo flours, which can raise the amount of fibre in the product and possibly boost the bioactive content in the product.

Among the citrus fruits, pomelo (*Citrus grandi*s) is one of the most important being the largest with a round shape, widely cultivated around the world and an excellent sources of vitamin C, folic acid, pectin, and secondary metabolites such as polyphenol compounds (phenolic, flavonoid, and limonoids) (Liu *et al*., 2016). One notable part of pomelo fruit is its albedo, the mesophyll portion, a-by-product of 20 - 40% of fruit weight remaining during juice extraction which has been characterized with high retention of dietary fibre, minerals and phytochemicals. It is largely unused nor subjected to further processing, so inappropriate pomelo peel disposal is likely to cause environmental pollution due to its high perishability (Oboh and Ademosun, 2012). One possible way to achieve sustainable goal 12 listed in the Agenda 2030 sustainable development goals (reduction of food waste by 50%) could be possible through valorization and utilization of this valuable plant biomass in bread production. Therefore, the creative usage of pomelo albedo flours as composite flours in bread will help to increase bread's nutritious value while reducing waste. The prospect of employing such flours for the manufacturing of bread is unclear, but little research has been done on the impact of wheat-albedo composite flours on the creation of snacks like sausage (Soriao *et al*., 2015). The aim of this study was to investigate the application potential of debittered pomelo albedo flour (DPAF) in making bread and to assess the physical, nutritional and sensory characteristics of the product.

MATERIALS AND METHODS

Materials

Pomelo fruit (fresh) was purchased from local market in Ilorin, Kwara State, Nigeria. The healthy fruits, were randomly selected from the market shelves, packed in corrugated paper boxes and transported to the food processing laboratory in Kwara State University. Wheat flour (Golden penny baker's grade), margarine, granulated sugar, salt and baker's brand of yeast were purchased from the local market. All other chemicals used were of analytical grade and obtained from the food chemistry laboratory of the Kwara State University, Ilorin, Nigeria.

Preparation of Debittered Flour

Fully developed pomelo (*Citrus grandis*) fruits were sorted, cleaned, and peeled (Figure 1). The albedo layers were then manually separated from the flavedo using a knife. The debitterization was carried out by cooking the albedo portion in a boiling saline (3% w/v) solution for 10 min (Soriao *et al*., 2015), draining and then drying at 65 ^{0}C for 2 hrs in a cabinet oven (OV-160 BS, Cheshire, England). The dried samples were milled (Hammer mill II, Romer laboratories, USA) into a fine powder, sieved (60 mm) and stored in a transparent polyethylene bag at 4 ^{0}C (Figure 1).

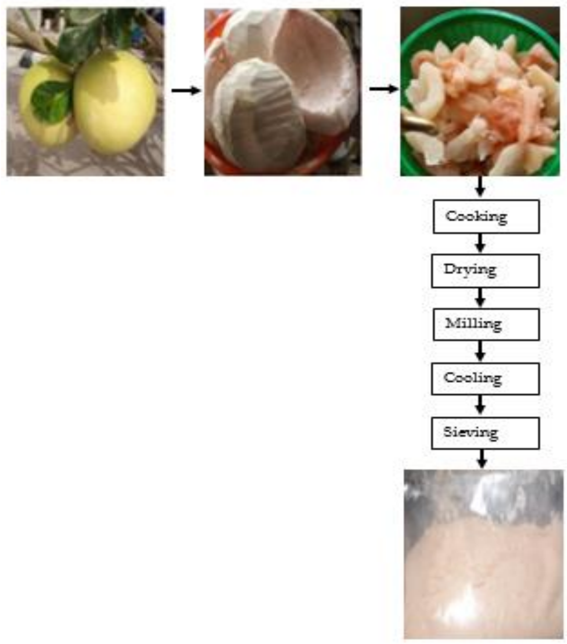

Figure 1. Flow chart for the production of debittered pomelo albedo flour (DPAF).

Composite flours were prepared from mixture of wheat and Pomelo albedo flours (DPAF) at varying ratios of 100:0, 90:10, 80:20, and 70:30, respectively. The composite flours obtained were mixed with other ingredients (yeast: 1.5 g/ 100 g, margarine: 5 g/ 100 g, sugar: 10 g/ 100 g, salt: 1 g/ 100 g, and water: 50 g/ 100 g) to make a dough that was kneaded, cut, moulded and proofed (1 hour at 40 ^{0}C, RH of 40%). The dough was baked for

15 minutes at 220 ^{0}C in a commercial electric oven and cooled at room temperature for further analysis.

Determination of Functional Properties

A flour sample (1 g) suspended in extra distilled water (10 mL) was tested for its water absorption capacity (WAC), and the weight gain was determined by expressing as a percentage of the original weight of the sediment that was left after the supernatant was decanted (Lawal and Akinoso, 2019). The ratio of the volume occupied before and after swelling was used to express the swelling power, which was calculated using the method described by Olapade and Adegboye (2018). After tapping the samples on a fibre board, the bulk density was calculated as the ratio of weight (g) per unit volume (ml) of the samples (Akinoso *et al*., 2021). The Olapade and Adegboye (2018) approach was also used to determine the oil absorption capacity. One gram of sample was combined with 10 mL of soybean oil (Sp. Gravity: 0.9092) and left to stand for 30 minutes at room temperature (28 ± 2°C) followed by centrifugation for 30 min at 300 rpm.

Mineral and Proximate Composition

The raw formulation's and bread's proximate (moisture content, protein, fat, ash, crude fibre and carbohydrates contents) and mineral (K, Na and Fe) compositions were assessed using the AOAC (2009) methodology.

Ferric Reducing Antioxidant Power, Total Phenolic, Total Flavonoid and Antioxidant Capacity

About 10 ml of distilled water was used to make a suspension of 1 g of the flours and bread samples which was stirred (magnetic stirrer) for one hour with 10 ml of 70% acetone. The suspension was centrifuged (10,000 x g for 15 minutes) at 28 ± 2 ^{0}C to obtain the supernatant needed for antioxidant tests. Ferric reducing antioxidant power (FRAP), total phenolic (TPC) and total flavonoid (TFC) contents were based on suggested methods by Şengül *et al*. (2014). While TFC (415 nm), FRAP (593 nm) and TPC (760 nm) absorbance were measured against their respective blanks, the calibration standard curves of ascorbic acid, gallic acid and quercetin were used to estimate FRAP (AAE mg/ g), TPC (GAE mg/ g) and TFC (QE mg/ g) values, respectively. For antioxidant capacity, 1 ml of the supernatant sample was added to 4 ml methanol solution of DPPH and absorbance was recorded from UV-Visible Spectrophotometer (Shimadzu, UV-1800, Japan) at 517 nm wavelength after 1 h. Inhibition of free radical by DPPH was calculated using the percentage differences in reading of blank and the sample (Lawal and Akinoso, 2019).

Physical Properties of Bread

The method described by Odunlade *et al.* (2017) was used to calculate the physical characteristics of the baked bread, including volume, weight, and specific volume. The loaf's volume was measured inside a known-capacity container that was also filled with sorghum grains. The bread loaf's volume was determined as the number of grains displaced. The specific volume of the loaf was calculated from the ratio of the volume to the weight of the bread.

Sensory Evaluation

Forty semi-trained panelists with equal numbers of men and women with the, ages between 22 to 45 chosen from the students and employees of Kwara State University, Ilorin, rated the sensory qualities of bread. Samples of bread were placed on disposable white plates and coded with three random numerals. The panellists gave the bread ratings (hedonic 9 point scale) between 1 (dislike extremely) and 9 (like extremely) for its appearance, taste, texture, flavor, and general acceptability after testing the samples in random order.

Statistical Analysis

ANOVA was performed on the collected data, and Duncan multiple range tests were employed to separate the means at the 5% level of significance (SPSS 16.0). The findings of each test were provided as a mean with standard deviation after being carried out independently three times.

RESULTS AND DISCUSSIONS

Functional Properties

The values of water absorption capacity (WAC), for wheat flour (WF) and debittered pomelo albedo flour (DPAF) blends are presented in Table 1. WAC for the control (FW0) is 130% ± 0.75 and the values obtained is in agreement with the result presented by Chandra *et al*. (2015) which indicated WAC of the

Table 1. Functional analysis of raw flours.

Sample	Water absorption capacity (%)	Swelling capacity (%)	Oil absorption capacity (%)	Bulk density (g/ml)
FW0	130.00 ± 0.75^{d}	7.60 ± 0.17^{a}	135.00 ± 0.64^{a}	0.68 ± 0.01^{c}
FB1	144.00 ± 0.75^{c}	7.38 ± 0.07^{b}	127.67 ± 3.51^{b}	0.83 ± 0.01^{b}
FB2	162.67 ± 1.02^{b}	7.27 ± 0.20^{b}	90.00 ± 6.56^{c}	0.92 ± 0.02^{a}
FB3	166.33 ± 0.88^{a}	6.81 ± 0.23^{c}	81.33 ± 2.08^{d}	0.96 ± 0.03^{a}

Mean values along the same column with different superscripts are significantly different ($p < 0.05$). FW0: 100% wheat flour. FB1, FB2 and FB3 represent flour samples containing wheat flour: debittered pomelo albedo flour (90:10, 80:20, and 70:30).

control wheat flour was 140.00% ± 12.25. The addition of DPAF shows an increasing trend in WAC of flour blends as FB3> FB2> FB1. Kultys and Moczkowska-Wyrwisz (2022) attributed the direct proportionality relationship of carrot pomace inclusion during pasta production to increase the dietary fibre content of flour blends. The polysaccharides present in dietary fibres either on hydrophilic site or in the voids of the molecules have strong affinity for water (Jiang *et al*., 2022). The swelling capacity of flour blends decreased with increasing trend in the incorporation ratio of DPAF: WF; i.e. FB3 - 6.81% < FB2 - 7.27% < FB3 - 7.38%. Also, all flour blends were significantly lower (p <0.05) than the control (7.60%). The trend observed could be due to dilution of starch content with a considerable increase in DPAF. Swelling power has a high reputation among functional properties being an important factor that affects starch-based products (Lawal and Akinoso, 2019). The OAC capacity ranged from 81.33% (FB3: 70% FW and 30% DBAF) to 135.00% (FW0: 100% WF). It is obvious that OAC decreased with an increase in the proportion of DPAF and this could be a reflection of the reduction in the level of protein in the flour blends. Flour blends with high protein contents have been reported to have elevated levels of OAC, since non-polar region of amino acids (which are hydrophobic in nature) can exhibit high interaction with hydrocarbon chains of lipids (Olatoye *et al*., 2018). The bulk density of flours ranged between 0.68 and 0.96 g/ cm^3. FW0 (0.68 g/ cm^3) had the lowest while FB3 (0.96 g/ cm^3) had the highest bulk density. According to Chandra *et al*. (2015), the value recorded for control (FW0) was 0.76 ± 0.19 and it was closer to our study. Generally, the Bulk density increased with an increase in the incorporation of DPAF in the blends and this observation was similar to the findings of Olapade and Adegboye (2018). According to Akinoso *et al.* (2021), flours with high bulk density are suitable ingredients in food products that required high gel strength.

Mineral and Proximate Compositions

Results for mineral composition of flour blends (DPAF-WF) were presented in Table 2. These results indicate that the incorporation of DPAF with WF has a significant effect on mineral K, Na and Fe contents of flour blends. All three minerals were noted to be higher in composite flours than wheat flours. As percentages of DPAF flour supplementation increased, K, Na and Fe contents of flour blends and breads also increased. According to Ogo *et al.* (2012), the Fe values are lower than the results obtained in wheat flours substituted with water melon rinds flours and orange pomace flour, in which the Fe values ranged between 8.81-9.23 mg/ 100 g. Generally, mineral elements are known for their unique roles in metabolic processes which is highly important for healthy living of man, therefore the inclusion of DPAF in wheat flour for bread production could greatly improve the nutritional status of people.

The proximate content is shown in Table 2. In all studies, significant differences ($p \leq 0.05$) were recorded between control (FW0) flour, DPAF-WF blends and breads containing the composite formulations. The moisture contents of bread from different flour blends ranged from 25.23 to 28.23%. FB7 had the lowest while FB6 had the highest values. The values were comparable to the range (21.90 - 27.90%) obtained by Odunlade *et al.* (2017). The variation in moisture content of bread could be attributed to supplementation levels of DPAF and chemical composition of the flour blends. According to Miranda-Ramos *et al*. (2019) larger intake of total dietary fibre is associated with an increase in moisture. This is mostly because that fibre rich flour has more hydroxyl groups than refined flour, which allow for more water contact through hydrogen bonding. Generally crude fibres of the flour incorporated with *Pomelo albedo* were higher than that of the control flour, suggesting that the addition of DPAF is an effective measure for elevating the fibre levels in food products since fruits by-products is classified as fibre rich value-added products. All the formulated breads showed higher fibre contents than their suitable ingredients in food products that required high gel strength. Similar findings were reported by Ogo *et al.* (2021) for a novel biscuit made from composite flour of water melon rinds, orange pomace and wheat flours. Also, Kultys and Moczkowska-Wyrwisz (2022) attributed the direct proportional increase of fibre in pasta to the percentage share of carrot and beetroot apple pomace in the product. Regarding proteins and fats, their content varies significantly ($p \leq 0.05$) with different substitution levels for both flour and breads. Also, the observed values were significantly ($p \leq 0.05$) lower compared to that of control raw flour blends and breads. It is worth to notice that the range of fat values (2.13 - 2.47%) and protein (7.75 - 9.64%) recorded for bread were in agreement with the results of Odunlade *et al.* (2017), which indicated that fat and protein content of the bread enriched with green leafy vegetable were 1.90 ± 0.5% and 11.00 ± 3.9%, respectively. Ash content was significantly higher in bread from composite flours compared with the control sample. Among different flour blends, ash content of FB1 (1.33%), FB2 (1.37%), and FB3 (1.51%) was significantly higher than FW0 (0.76%). The ash content ranged from 0.79 - 1.83% in bread sample of this study and the data were tally with Odunlade *et al.* (2017) who reported 1.10 - 2.40% range of ash content in bread supplemented with different levels of leafy vegetables. Carbohydrates are the major organic compounds in bread. The FB6 bread had the lowest (56.37%), being significantly ($p \leq 0.05$) different from all other DPAF-WF breads. The inclusion of DPAF in the bread production decreased the carbohydrate content compared to the flour blends and this is a good strategy to meet the calorie reduction demand in food industry (Ramírez-Jiménez *et al*., 2018). Due to its composition, which is rich in non-digestible carbohydrates including crude fibre, polysaccharides rich food such as DPAF in this study have strong potential to reduce glycaemic index of the bread.

Phytochemical Composition

Table 3 presents the phytochemical composition (FRAP, TPC, TFC, and antioxidant activity) of DPAF-WF flour blends and breads. FRAP of flour blends and breads ranged between 0.62 and 1.91 AAE mg/ g. Among the bread

Table 2. Proximate and mineral analysis of the flours and breads.

Samples	FW0	FB1	FB2	FB3	FB4	FB5	FB6	FB7
Moisture (%)	10.73 ± 0.2^{d}	9.75 ± 3.06^{d}	8.41 ± 0.17^{e}	7.46 ± 0.2^{e}	26.63 ± 1.04^{b}	25.50 ± 0.76^{b}	28.23 ± 1.26^{a}	25.23 ± 1.41^{c}
Protein (%)	10.07 ± 0.69^{a}	9.70 ± 0.04^{a}	8.58 ± 0.04^{b}	8.32 ± 0.04^{b}	8.09 ± 0.27^{bc}	7.75 ± 0.04^{c}	8.69 ± 0.32^{b}	9.64 ± 0.78^{a}
Ash (%)	0.76 ± 0.12^{f}	1.33 ± 0.05^{d}	1.37 ± 0.05^{cd}	1.51 ± 0.12^{b}	1.47 ± 0.11^{bc}	1.83 ± 0.15^{a}	1.80 ± 0.08^{a}	0.79 ± 0.07^{e}
Fat (%)	1.33 ± 0.05^{e}	1.26 ± 0.01^{f}	1.14 ± 0.01^{g}	1.10 ± 0.01^{g}	2.32 ± 0.20^{b}	2.20 ± 0.00^{c}	2.13 ± 0.00^{d}	2.47 ± 0.10^{a}
Crude fibre (%)	1.52 ± 0.08^{d}	1.68 ± 0.0^{c}	1.80 ± 0.00^{b}	2.34 ± 0.14^{a}	1.74 ± 0.07^{bc}	1.89 ± 0.08^{b}	2.42 ± 0.01^{a}	1.50 ± 0.05^{d}
Carbohydrates (%)	75.59 ± 0.22^{b}	76.28 ± 2.10^{b}	78.52 ± 0.45^{a}	79.27 ± 1.34^{a}	59.75 ± 0.17^{c}	60.84 ± 1.31^{c}	56.73 ± 0.00^{d}	60.37 ± 1.46^{c}
K (mg/ 100 g)	154.05 ± 3.98^{d}	163.82 ± 2.98^{c}	187.69 ± 3.2^{b}	201.01 ± 4.2^{a}	164.62 ± 2.13^{c}	185.32 ± 2.2^{b}	202.34 ± 3.52^{a}	152.41 ± 2.5^{d}
Na (mg/ 100 g)	200.88 ± 2.0^{f}	220.50 ± 4.86^{d}	249.34 ± 2.13^{c}	256.02 ± 5.72^{b}	230.15 ± 1.9	257.05 ± 0.96^{b}	270.66 ± 4.43^{a}	208.86 ± 2.27^{e}
Fe (mg/ 100 g)	1.85 ± 0.1^{e}	1.98 ± 0.41^{e}	2.18 ± 0.41^{d}	2.64 ± 0.19^{b}	1.92 ± 0.31^{e}	2.36 ± 0.30^{c}	2.93 ± 0.14^{a}	1.88 ±0.1^{e}

Mean values along the same row with different superscripts are significantly different ($p < 0.05$). FW0: 100% wheat flour. FB1, FB2 and FB3 represent flour samples containing wheat flour: debittered pomelo albedo flour (90:10, 80:20, and 70:30). FB7: 100% wheat bread. FB4, FB5, FB6 breads samples containing wheat flour: debittered pomelo albedo flour (100:0, 90:10, 80:20, and 70:30).

Table 3. Phytochemical analysis of flours and breads.

Sample	FRAP (AAE mg/ g)	Total phenolic (GAE mg/ g)	Flavonoid (QE mg/ g)	Antioxidant capacity (%)
FW0	1.65 ± 0.01^{c}	0.19 ± 0.02^{b}	0.38 ± 0.02^{c}	8.37 ± 0.31^{c}
FB1	1.76 ± 0.01^{b}	0.19 ± 0.00^{b}	0.47 ± 0.01^{ab}	8.62 ± 0.23^{b}
FB2	1.78 ± 0.02^{b}	0.20 ± 0.01^{ab}	0.47 ± 0.01^{ab}	8.96 ± 0.26^{b}
FB3	1.91 ± 0.00^{a}	0.23 ± 0.02^{a}	0.48 ± 0.03^{a}	9.76 ± 0.31^{a}
FB4	0.67 ± 0.03^{ef}	0.04 ± 0.00^{d}	0.45 ± 0.01^{b}	7.92 ± 0.20^{d}
FB5	0.72 ± 0.04^{e}	0.03 ± 0.00^{d}	0.45 ± 0.00^{b}	8.30 ± 0.11^{c}
FB6	0.98 ± 0.00^{d}	0.08 ± 0.00^{c}	0.46 ± 0.00^{ab}	8.67 ± 0.08^{bc}
FB7	0.62 ± 0.06^{f}	0.03 ± 0.00^{d}	0.31 ± 0.01^{d}	7.06 ± 0.20^{e}

Mean values along the same column with different superscripts are significantly different (p <0.05). FW0: 100% wheat flour. FB1, FB2 and FB3 represent flour samples containing wheat flour: debittered pomelo albedo flour (90:10, 80:20, and 70:30). FB7:100% wheat bread. FB4, FB5, FB6 breads samples containing wheat flour: debittered pomelo albedo flour (90:10, 80:20, and 70:30).

samples, FB7 had the lowest anti oxidative competence as assessed by FRAP while FB6 had the highest. The FRAP content increased slightly, as the quantity of added DPAF was increasing and quantity of WF decreasing. The significantly (p <0.05) higher FRAP value of FB6 than FB7 is an indication of strong polyphenol content than control wheat flour bread. According to Oboh and Ademosun (2012), dietary polyphenol aids to reduce blood pressure, systemic inflammation and insulin resistance in the body. TPC (0.03 - 0.23 GAE mg/ g) flavonoid (0.31 - 0.48 QE mg/ g) and total antioxidant (7.06 - 9.76%) also exhibit a similar trend, with a slight increase between 10 and 20 substitution levels, while only 30% substitution level of DPAF significantly (p ≤0.05) increased the phytochemical composition of the bread. These result are in variance with a previous study carried out on wheat bread supplemented with leafy vegetable powders, which showed that TPC (85.50 - 106.0 mg GAE/ g), DPPH (35.0 - 52.0%) and FRAP (126.7 - 134.0 μAAE/ G) increase with levels of vegetables in bread (Odunlade *et al*., 2017). Indeed, repeated cooking during debittering of pamelo albedo had a significant effect on leaching of phytochemicals and other soluble compounds in water, and this could be accounted for the reduced phytochemical potency of DPAF. Studies done previously on various vegetables demonstrated that the total polyphenol content and antioxidant activity of samples could be higher or lower (Şengül *et al.*, 2014) compared to fresh vegetables after cooking while Oboh and Ademosun, (2012) attributed such changes to the release, destruction, or production of redox-active metabolites during food processing.

Physical Properties of Bread

Figure 2 shows the physical properties of breads. On the whole, the bread weight was improved while volume was decreased with an increasing amount of DPAF substitution compared to the FW7 bread. When the amounts of DPAF addition are 10, 20 and 30 (%), the bread weights were 151.48, 157.36 and 162.74 g, respectively, while bread volumes were 510.03, 496.51 and 475.63 cm^3, respectively. For specific volume, the FW7 and FW6 had the highest (4.14 cm^3/g) and lowest (2.93 cm^3/g) values, respectively. The trend of values was similar for the volume of the bread. Miranda-Ramos *et al.* (2019) reported that a high volume-to-weight ratio is preferred from an economic perspective of bread production. Thus, specific volume is a crucial feature of bread. Previous studies indicated that gluten dilution that emanated from the addition of gluten-free ingredients had a negative influence on composite bread volume (Jiang *et al.*, 2022).

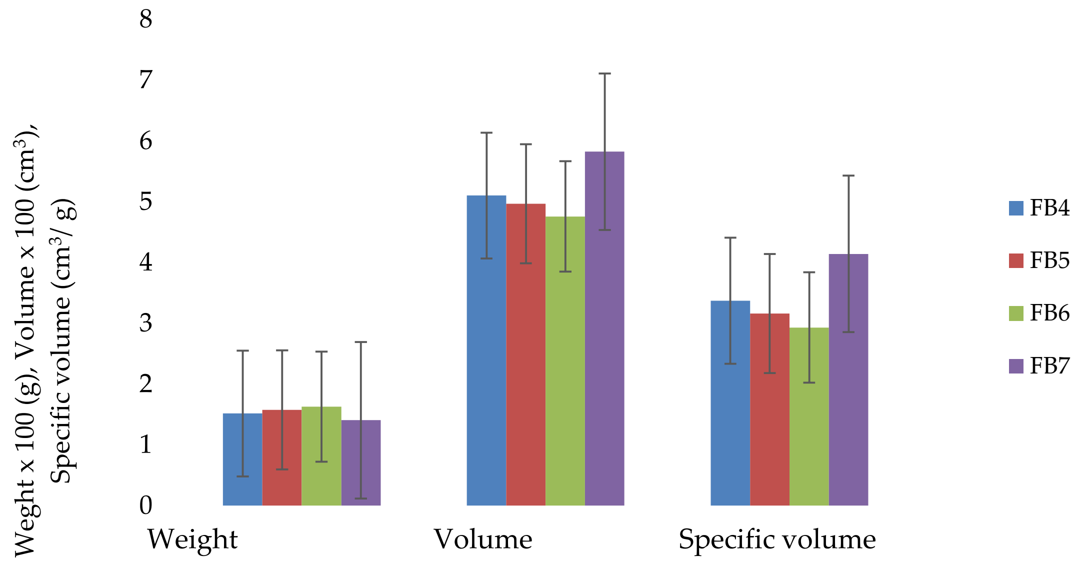

Figure 2. Physical properties of bread.

Sensory Characteristics

In Table 4, the mean values that consumers assigned to each bread formulation are shown with each attribute measurement. The results showed that the flavour was not significantly different (p ≥0.05) among bread formulations while other parameters were significant. Among the wheat-based bread substituted with DPAF, only FB4 had a rating in the category of 6 (like slightly), while the remaining (FB5 and FB6) were mainly rated in the category of 5, demonstrating that the consumers had an indifferent (neither liked nor disliked) opinion about the products. These may be partly attributed to the unusual use of DPAF wheat in bread formulation, which has led to a level of neophobia that is a typical association with the development of new products (Ramírez-Jiménez *et al*., 2018). In general, bread with a higher DPAF content tends to be less palatable, less attractive (from an appearance stand point), and have a lower texture grade.

CONCLUSION

The current study offers useful details regarding the use of debittered albedo flours in bread formulation. Bulk density and water absorption of composite flours were increased. The formulated bread from the composite flours revealed that DPAF had a huge impact on the crude fibre content of the bread compared to the WF7 (100% wheat bread). With regard to bread specific volume, increasing the contents of albedo flours had a larger unfavorable effect. It should be noted that debitterization procedure affected the phytochemical contents of flours

Table 4. Sensory analysis of the breads.

Sample	Taste	Appearance	Texture	Flavor	Overall acceptability
FW7	6.94 ± 1.19^{a}	6.96 ± 1.2^{a}	7.26 ± 1.24^{a}	6.26 ± 0.92^{a}	7.50 ± 0.83^{a}
FB4	5.90 ± 1.20^{b}	6.18 ± 1.00^{ab}	5.78 ± 1.49^{b}	6.42 ± 1.57^{a}	6.06 ± 0.59^{ab}
FB5	5.18 ± 1.12^{b}	5.72 ± 1.33^{b}	5.76 ± 1.53^{b}	6.40 ± 0.97^{a}	5.3 ± 0.87^{bc}
FB6	3.96 ± 0.00^{c}	4.98 ± 1.28^{c}	5.36 ± 1.23^{b}	5.96 ± 1.68^{a}	5.18 ± 0.77^{c}

Mean values along the same column with different superscripts are significantly different (p <0.05). FW7: 100% wheat flour bread. FB4, FB5 and FB6 represent bread samples containing wheat flour: debittered pomelo albedo flour (90:10, 80:20, and 70:30).

flours and bread, and addition of DPAF (up to 20%) did not effectively increase the antioxidant activities of bread. For sensory evaluation, the FW4 bread showed the highest taste, appearance, texture, flavor and overall acceptability among the composites bread while its overall acceptability was slightly lower than FW7 bread.

REFERENCES

Akinoso, R., Lawal, A. I., Olatoye, K. K. and Olayioye, D. O. (2021). Physicochemical, textural and organoleptic characteristics of West African stiff dough ‘Amala’’ made from soaked and unsoaked cocoyam flour. *Journal of Microbiology, Biotechnology and Food Sciences,* 11(2): 1-5. DOI: https://doi.org/10.15414/jmbfs.3728

AOAC. (2009). Official Methods of Analysis. *Association of Official Analytical Chemists,* 14.

Chandra, S., Singh, S. and Kumari, D. (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.

FAO, IFAD, and UNICEF. (2022). The state of food security and nutrition in the world 2022. *The State of Food Security and Nutrition in the World.* 1(1): 2-260. DOI: https://doi.org/10.4060/cc0639en

Jiang, X., Wang, X. and Zhou, S. (2022). Effect of flaxseed marc flour on high-yield wheat bread production: Comparison in baking, staling, antioxidant and digestion properties. *LWT - Food Science and Technology*, 169: 1-9.

Kultys, E. and Moczkowska-Wyrwisz, M. (2022). Effect of using carrot pomace and beetroot-apple pomace on physicochemical and sensory properties of pasta. *LWT - Food Science and Technology*, 168: 1-10.

Lawal, A. I. and Akinoso, R. (2019). Physical properties, proximate composition and antioxidant activities of aerial yam (*Dioscorea bulbifera*) bulbils grown in Nigeria. *Acta Periodica Technologica*, 50: 143-151. DOI: https://doi.org/10.2298/apt1950143l

Liu, X., Guo, M., Cai, L. N., Liu, L. and Li, Y. Y. (2016). Study on the honey pomelo tea beverage with fruit peel and fruit grain. *Food Research and Development*, 23: 86-89. DOI: https://doi.org/https://doi.org/10.3969/j.issn.1005-6521.2016.23.021

Miranda-Ramos, K. C., Sanz-Ponce, N. and Haros, C. M. (2019). Evaluation of technological and nutritional quality of bread enriched with amaranth flour. *LWT,* 114:1–8. DOI: https://doi.org/10.1016/j.lwt.2019.108418

Oboh, G. and Ademosun, A. O. (2012).

Shaddock peels (*Citrus maxima*) phenolic extracts inhibit α-amylase, α-glucosidase and angiotensin I-converting enzyme activities: A nutraceutical approach to diabetes management. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 5(3): 148-152. DOI: https://doi.org/10.1016/j.dsx.2012.02.008

Odunlade, T. V., Famuwagun, A. A., Taiwo, K. A., Gbadamosi, S. O., Oyedele, D. J. and Adebooye, O. . (2017). Chemical composition and quality characteristics of wheat bread supplemented with leafy vegetable powders. *Journal of Food Quality*, 40: 1-7.

Ogo, A. O., Ajekwe, D. J., Enenche, D. E. and Obochi, G. O. (2021). Quality evaluation of novel biscuits made from wheat supplemented with watermelon rinds and orange pomace flour blends. *Food and Nutrition Sciences*, 12(3): 332-341.

Olapade, A. A. and Adegboye, Z. O. (2018). Chemical, functional, pasting and sensory properties of fried chips produced from cassava flour enriched with cowpea flour. *Croat. J. Food Sci. Technol.*, 10(2): 220-225.

Olatoye, K. K., Babalola, K. A. and Lawal, A. I. (2018). Effect of african breadfruit (*Treculia africana*) seed supplementation on some chemical and sensory attributes of fried water yam (*Dioscorea alata*) ball. *Acta Periodica Technologica*, *49*: 125-135. DOI: https://doi.org/10.2298/APT1849125O

Ramírez-Jiménez, A. K., Gaytán-Martínez, M., Morales-Sánchez, E. and Loarca-Piña, G. (2018). Functional properties and sensory value of snack bars added with common bean flour as a source of bioactive compounds. *LWT - Food Science and Technology*, 89: 674-680.

Şengül, M., Yildiz, H. and Kavaz, A. (2014). The effect of cooking on total polyphenolic content and antioxidant activity of selected vegetables. *International Journal of Food Properties*, 17(3): 481-490.

Soriao, A. B. P., Dale, A. G., Cruz, C. G. M. D., Indiongco, P. C. K., Manucom, J. L. M., Masangcay, J. N. M., Mañago, J. A. R. and Narvaez, M. B. (2015). Dehydration of pomelo (*Citrus grandis*) albedo and its utilization as a source of dietary fibre in Philippine pork sausage. *Agriculture and Natural Resources*, 49(4): 606-614.