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Effect of Partial Substitution of Wheat Flour with Sweet Potato Flour on the Chemical Properties, Bioactive Compounds and Digestibility of Bread Produced in Faranah

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Abstract

The reliance on imported wheat flour and the need to improve the nutritional quality of bakery products justify the exploration of local raw materials as alternative ingredients. This study evaluated the effect of partial substitution of wheat flour with sweet potato flour on the chemical characteristics, bioactive compounds, and digestibility of bread produced in Faranah. Bread formulations were prepared by replacing 10 to 50% of wheat flour with sweet potato flour obtained from four varieties. Chemical parameters (moisture, dry matter, ash, protein, starch, and fiber contents), bioactive compounds (carotene and total polyphenols), and digestibility were determined. Results showed a significant increase in ash content (3.66 ± 1.26%) and dietary fiber (12.87 ± 0.06%) in enriched breads. Carotene content increased from 0.58 ± 0.04 g/kg in the control to 2.72 ± 0.16 g/kg, while total polyphenol content reached 952.58 ± 10.62 mg GAE/100 g compared to 307.03 ± 2.70 mg GAE/100 g in the control. Digestibility decreased with increasing substitution levels, from 93.26 ± 4.16% in the control. Principal component analysis revealed a positive correlation between carotene and polyphenols and a negative association with digestibility. Substitution levels of 30–40% offer the best compromise between nutritional enrichment and acceptable digestibility.

Keywords: Substitution; Sweet Potato Flour; Wheat Flour; Bread; Bioactive Compounds; Digestibility

1. Introduction

In West Africa, the consumption of bakery products, especially bread, is steadily increasing, even in non-wheat-producing countries like Guinea. This growing dependence on wheat imports makes national economies more vulnerable to the volatility of international markets. Ruvette [1] points out that using sweet potato for flour and bread production can reduce dependence on wheat imports, save foreign currency, expand the grain industry through local ingredients, and improve food security. This situation underlines the need to promote blended flours made from local raw materials.

Studies have shown that partially replacing wheat flour with carob flour (up to 15%) improves dietary fiber and unsaturated fatty acid content. Adding dietary fiber from wheat bran significantly increases the fiber content of bread [2]. Olapade and Oluwole [3] improved the nutritional value of bread by substituting up to 15% of wheat flour with cowpea flour. Johnston et al. [4] significantly increased the protein content of bread by incorporating up to 20% fava

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bean flour. Meng et al. [5] found that adding potato and sweet potato flour reduced dough formation time and bread hardness. Idolo [6] showed that substituting up to 25% sweet potato flour for wheat flour improves nutritional quality and reduces production cost.

Sweet potato (Ipomoea batatas) is globally ranked among the major root crops and exhibits high nutrient density, especially in carotenoids, phenolic compounds, and dietary fibers. Recent research has focused on composite flour applications in bread to enhance dietary fiber and β-carotene contents, contributing to improved micronutrient intake and antioxidant potential [5, 12].

Vitamin A deficiency is a prevalent problem in developing countries and can cause blindness, illness, and premature death in infants, pregnant women, and breastfeeding women [7]. Partially replacing wheat flour with sweet potato-enriched composite flour in bread baking can help address this deficiency while improving the functional properties of the final product.

Despite these advances, a comprehensive evaluation of the combined effects on chemical quality, bioactive compound content, and starch digestibility of breads with sweet potato flour substitution remains limited in the West African context. This study therefore evaluated the effect of partial substitution of wheat flour with sweet potato flour on the chemical characteristics, bioactive compounds, and digestibility of bread produced in Faranah.

2. Materials and Methods

2.1. Raw Materials

Four different varieties of mature sweet potato tubers were harvested and used to prepare sweet potato flour. Wheat flour was purchased from the local market in Faranah town.

2.2. Bread Formulation and Baking

Six bread formulations were prepared: T: 100% wheat flour (control); P1: 90% wheat flour + 10% sweet potato flour; P2: 80% + 20%; P3: 70% + 30%; P4: 60% + 40%; P5: 50% + 50%. All formulations were prepared using the same proportions of other raw materials. After cooling, samples were dried at 60°C and ground into bread flour, then packaged for subsequent analyses.

2.3. Chemical Composition Analysis

Moisture, ash, dry matter, protein, and starch contents were determined according to AOAC methods (2000). Moisture content was determined by drying at 105°C to constant weight (AOAC 925.09). Ash content was determined by incineration at 550°C for 12 hours (AOAC 940.26). Crude protein was determined by the Kjeldahl method with a nitrogen-to-protein conversion factor of 6.25 (AOAC 976.05), and results were expressed as g/100 g dry weight. Total starch was determined by AOAC method 2002.02. Crude fiber content was calculated from insoluble and soluble lignin fractions according to Sluiter et al. [8] and Ayeni et al. [9].

2.4. Determination of β-Carotene Content

The β-carotene content was determined following Kourouma et al. [10] with slight modifications. Absorbances of the carotenoid-rich crude supernatants were measured at 453, 505, and 663 nm. The β-carotene content was calculated as:

$$\beta\text{-carotene } (\%) = 0.216\, A_{663} + 0.304\, A_{505} + 0.452\, A_{453}$$

2.5. Determination of Total Polyphenol Content

Total phenolic content (TPC) was measured using the Folin–Ciocalteu method. Results were expressed in milligrams of gallic acid equivalent per 100 g dry matter (mg GAE/100 g).

2.6. *In Vitro* Digestibility

In vitro starch digestibility was analyzed to quantify rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS) fractions following enzymatic digestion protocols.

2.7. Statistical Analysis

All statistical analyses were performed using SPSS version 20 (IBM, USA). Results are expressed as mean ± standard deviation. A p-value < 0.05 was considered statistically significant. All measurements were conducted in triplicate. Duncan's multiple range test was used for mean comparison.

3. Results and Discussion

3.1. Chemical Composition of the Breads

The different substitution rates of sweet potato flour for wheat flour had significant effects ($p < 0.05$) on all chemical parameters measured (Table 1). Treatment P15 (50% V3) presented the highest moisture content (12.81 ± 1.35%), whereas other formulations showed a general trend of decreased moisture and increased dry matter with increasing substitution levels.

Ash content increased significantly with substitution rate, from 0.87 ± 0.01% in the control to 3.66 ± 1.26% in P5 (50% V1) and 3.15 ± 0.00% in P15 (50% V3), consistent with the higher mineral content of sweet potato flour [5, 11]. Protein content (expressed as g/100 g dry weight) varied between 9.06 ± 0.23% (P12: 20% V3) and 15.62 ± 0.36% (P8: 30% V2). Some formulations at low substitution rates showed protein dilution due to the relatively lower protein content of sweet potato compared to wheat. Starch content increased markedly, reaching maximum values for P11 (31.04 ± 0.45%), P5 (30.20 ± 0.28%), and P8 (28.04 ± 0.24%). Fiber content ranged from 3.63 ± 0.02% (P7: 20% V2) to 12.87 ± 0.06% (P6: 10% V2), showing an overall increase compared to the control (4.03 ± 0.07%). This is consistent with reports by Meng et al. [5] and Mitiku et al. [12], who observed similar fiber increases when incorporating root and tuber flours into bread.

Table 1 Chemical composition of breads formulated with partial substitution of wheat flour by sweet potato flour from four varieties

Treatment	Moisture (%)	Dry Matter (%)	Ash (%)	Protein (mg/g)	Starch (%)	Fiber (%)
T (control)	7.77 ± 0.33 bc	92.22 ± 0.33 ab	0.87 ± 0.01 i	12.97 ± 0.34 d	3.93 ± 0.04 j	4.03 ± 0.07 jk
P1: 10% V1	6.86 ± 0.11 bc	93.13 ± 0.11 ab	0.90 ± 0.15 i	9.56 ± 0.42 ij	16.09 ± 0.18 f	11.31 ± 0.69 bc
P2: 20% V1	7.71 ± 0.10 bc	92.28 ± 0.10 ab	2.37 ± 0.01 def	11.30 ± 0.46 gh	12.90 ± 0.68 j	11.49 ± 0.72 bc
P3: 30% V1	5.73 ± 0.16 c	94.26 ± 0.16 a	2.77 ± 0.07 bcdef	10.02 ± 0.00 i	14.55 ± 0.68 gh	11.51 ± 0.65 bc
P4: 40% V1	5.98 ± 0.01 c	94.01 ± 0.01 a	2.90 ± 0.00 bcd	12.97 ± 0.06 e	17.24 ± 0.21 e	5.26 ± 0.05 i
P5: 50% V1	8.04 ± 0.20 bc	91.95 ± 0.20 ab	3.66 ± 1.26 a	13.82 ± 0.23 c	30.20 ± 0.28 b	9.93 ± 0.07 e
P6: 10% V2	5.47 ± 0.15 c	94.52 ± 0.15 a	2.25 ± 0.02 f	10.85 ± 0.10 h	13.67 ± 0.25 i	12.87 ± 0.06 a
P7: 20% V2	6.38 ± 1.49 bc	93.61 ± 1.49 ab	2.66 ± 0.00 bcdef	14.83 ± 0.49 b	21.37 ± 0.33 d	3.63 ± 0.02 k
P8: 30% V2	5.59 ± 0.19 c	94.40 ± 0.19 a	1.38 ± 0.24 ghi	15.62 ± 0.36 a	28.04 ± 0.24 c	8.90 ± 0.96 f
P9: 40% V2	5.00 ± 0.09 c	94.99 ± 0.09 a	1.34 ± 0.17 ghi	11.69 ± 0.34 efg	17.89 ± 1.03 e	7.56 ± 0.05 g
P10: 50% V2	5.39 ± 0.17 c	94.60 ± 0.17 a	3.02 ± 0.02 bc	12.15 ± 0.37 d	14.55 ± 0.44 gh	11.94 ± 0.05 b
P11: 10% V3	5.29 ± 0.09 c	94.70 ± 0.01 a	2.34 ± 0.00 ef	11.13 ± 0.19 h	31.04 ± 0.45 a	7.58 ± 0.07 g
P12: 20% V3	6.18 ± 0.17 bc	93.81 ± 0.00 ab	1.66 ± 0.07 g	9.06 ± 0.23 j	13.87 ± 0.32 hi	6.79 ± 0.08 h
P13: 30% V3	5.36 ± 0.01 c	94.63 ± 0.11 a	2.82 ± 0.02 bcde	10.86 ± 0.40 h	21.98 ± 0.53 d	10.89 ± 0.07 cd
P14: 40% V3	5.93 ± 0.00 c	94.06 ± 0.13 a	1.53 ± 0.02 gh	13.72 ± 0.17 c	14.21 ± 0.13 hi	11.86 ± 0.75 b
P15: 50% V3	12.81 ± 1.35 a	87.18 ± 7.35 c	3.15 ± 0.00 b	13.82 ± 0.23 c	10.92 ± 0.35 h	12.02 ± 0.02 b
P16: 10% V4	9.40 ± 1.25 b	90.59 ± 1.25 b	1.08 ± 0.03 hi	14.09 ± 0.22 c	21.37 ± 0.33 d	5.89 ± 0.69 i
P17: 20% V4	7.87 ± 0.00 bc	92.12 ± 0.00 ab	2.57 ± 0.19 cdef	12.23 ± 0.08 e	6.62 ± 0.17 i	11.35 ± 0.05 bc
P18: 30% V4	7.60 ± 0.10 bc	92.39 ± 0.10 ab	1.67 ± 0.08 g	11.76 ± 0.27 efg	10.68 ± 0.16 h	10.51 ± 0.05 de
P19: 40% V4	7.69 ± 0.03 bc	92.30 ± 0.03 ab	1.70 ± 0.25 g	11.86 ± 0.20 ef	15.19 ± 0.38 g	4.39 ± 0.07 j
P20: 50% V4	8.03 ± 0.13 bc	91.96 ± 0.13 ab	1.72 ± 0.07 g	11.39 ± 0.45 fgh	16.47 ± 0.19 f	7.79 ± 0.65 g

Different letters in a column indicate statistical significance ($p < 0.05$, Duncan's test). T: control (100% wheat flour); P1–P5: V1 substitution; P6–P10: V2; P11–P15: V3; P16–P20: V4.

3.2. Bioactive Compounds and Digestibility

All enriched formulations showed a significant increase ($p < 0.05$) in carotenoid content compared to the control (0.58 ± 0.04 g/kg). The highest values were recorded for P4: 40% V1 (2.72 ± 0.16 g/kg), P3: 30% V1 (2.46 ± 0.18 g/kg), P5: 50% V1 (2.39 ± 0.68 g/kg), and P20: 50% V4 (2.35 ± 0.26 g/kg). This confirms that sweet potato flour is an effective source of provitamin A carotenoids, and its incorporation into bread enables significant enrichment of the final product [12, 13]. Total polyphenol content increased markedly in enriched formulations, rising from 307.03 ± 2.70 mg GAE/100 g in the control to values exceeding 900 mg GAE/100 g for P5: 50% V1 (952.58 ± 10.62 mg GAE/100 g). The formulations with the highest polyphenol levels were P5 (952.58 ± 10.62), P10: 50% V2 (839.64 ± 47.92), P1: 10% V1 (826.53 ± 22.51), and P9: 40% V2 (797.39 ± 11.65 mg GAE/100 g). This increase reflects the intrinsic richness of sweet potato in phenolic compounds, primarily localized in cell walls [11].

Digestibility decreased markedly with increasing substitution rates, particularly in formulations rich in polyphenols and fiber. The control exhibited very high digestibility (93.26 ± 4.16%), while some formulations showed very low values, notably P6: 10% V2 (4.20 ± 0.13%), P14: 40% V3 (5.95 ± 0.51%), and P2: 20% V1 (4.80 ± 1.58%). However, certain formulations maintained intermediate-to-high digestibility: P8: 30% V2 (84.55 ± 3.30%), P7: 20% V2 (74.00 ± 0.58%), and P10: 50% V2 (52.83 ± 5.33%). These results suggest that the effect of substitution on digestibility depends not only on incorporation rate but also on the sweet potato variety, consistent with Meng et al. [5]. The high fiber and polyphenol contents of certain formulations likely inhibit starch-enzyme interactions, thereby reducing starch hydrolysis and digestibility [11, 13].

Table 2 Carotene, total polyphenol, and digestibility values of composite breads

Traitement	Carotene (%)	Total polyphenol (mg GAE/100 g)	Digestibility (%)
T	0,58 ± 0,04 g	307,03 ± 2,7	93,26 ± 4,16 a
P1 : 10% V1	1,23 ± 0,21 ef	826,53 ± 22,51 bc	22,22 ± 1,00 gfi
P2 : 20% V1	2,1 ± 0,53 abc	521,24 ± 11,15 jkl	4,8 ± 1,58 m
P3 : 30% V1	2,46 ± 0,18 ab	774,8 ± 37,62 d	51,08 ± 0,50 d
P4 : 40% V1	2,72 ± 0,16 a	671,34 ± 15,6 f	39,66 ± 0,55 e
P5 : 50% V1	2,39 ± 0,68 ab	952,58 ± 10,62 a	24,68 ± 2,8 gf
P6 : 10% V2	1,98 ± 0,07 bc	727,44 ± 11,00 e	4,20 ± 0,13 m
P7 : 20% V2	1,54 ± 0,37 cdef	701,22 ± 13,16 ef	74 ± 0,58 c
P8 : 30% V2	1,01 ± 0,13 fg	558,4 ± 6,5 gh	84,55 ± 3,30 b
P9 : 40% V2	1,54 ± 0,08 cdef	797,39 ± 11,65 cd	31,58 ± 0,87 f
P10 : 50% V2	1,49 ± 0,00 cdef	839,64 ± 47,92 b	52,83 ± 5,33 d
P11 : 10% V3	1,18 ± 0,20 efg	544,56 ± 11,21 hij	26,02 ± 9,08 g
P12 : 20% V3	1,25 ± 0,10 def	498,66 ± 15,3 kl	49,32 ± 3,54 d
P13 : 30% V3	1,47 ± 0,18 cdef	550,39 ± 19,3 hi	38,58 ± 1,67 e
P14 : 40% V3	1,43 ± 0,87 cdef	503,76 ± 18,03 ikl	5,95 ± 0,51 m
P15 : 50% V3	1,89 ± 0,17 bcd	503,03 ± 24,08 jkl	12,39 ± 0,42 kl
P16: 10% V4	1,66 ± 0,66 cdef	558,4 ± 15,56 gh	16,32 ± 1,31 jk
P17 : 20% V4	1,83 ± 0,13 bcde	477,53± 24,77 l	9,45 ± 1,17 km
P18: 30% V4	1,07 ± 0,27 fg	546,02 ± 33,51 hij	20,07 ± 5,12 fij
P19: 40% V4	1,95 ± 0,00 bc	566,42 ± 10,9 gh	16,94 ± 0,80 ijk
P20 : 50% V4	2,35 ± 0,26 ab	595,56 ± 52,3 g	25,62 ± 1,85 g

T: control (100% wheat flour); GAE: gallic acid equivalent. Different letters indicate significant differences ($p < 0.05$, Duncan's test).

3.3. Principal Component Analysis and Hierarchical Cluster Analysis

Principal component analysis (PCA) highlighted significant relationships among the nutritional parameters of the enriched breads (Figure 1). A positive correlation between carotene and total polyphenols indicated a synergistic functional enrichment with increasing substitution rate. Conversely, the negative relationship between polyphenols and digestibility suggests interactions between these compounds and starch that may limit enzymatic activity, consistent with the antinutritional properties of polyphenols reported in the literature [11].

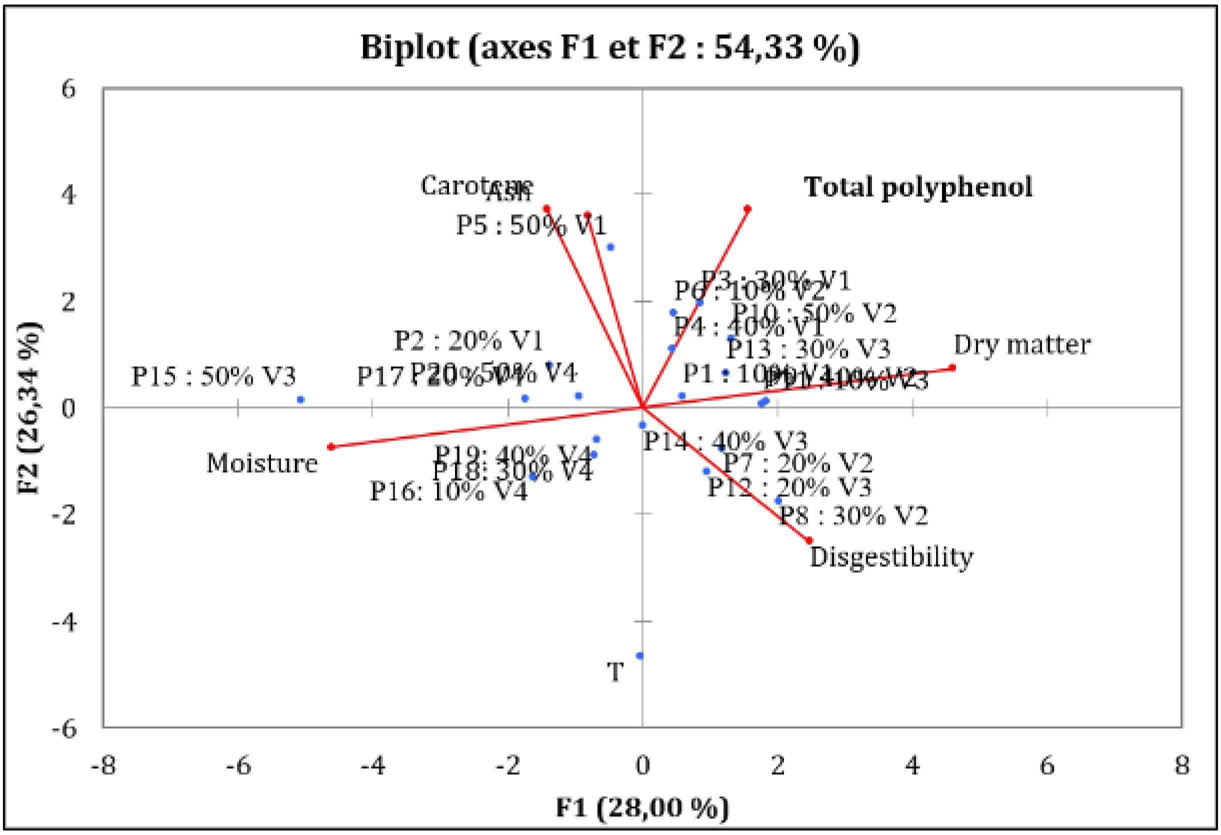

Figure 1 Principal component analysis of irrigation frequencies combined with biometric parameters of okra.

Figure 1 Principal component analysis of breads combined with biochemical parameters

Hierarchical cluster analysis (HCA) grouped the bread formulations according to their nutritional and functional similarities, yielding three main clusters (Figure 2). The first cluster, close to the control, comprised breads with low substitution rates that conserved technological characteristics similar to wheat bread, including high digestibility and more stable structure. The second cluster corresponded to moderate substitution formulations, characterized by a better balance between enrichment in bioactive compounds (carotenoids and polyphenols) and the maintenance of satisfactory technological properties. The third cluster grouped high-substitution breads, which displayed higher antioxidant compound contents but lower digestibility and more pronounced structural modifications.

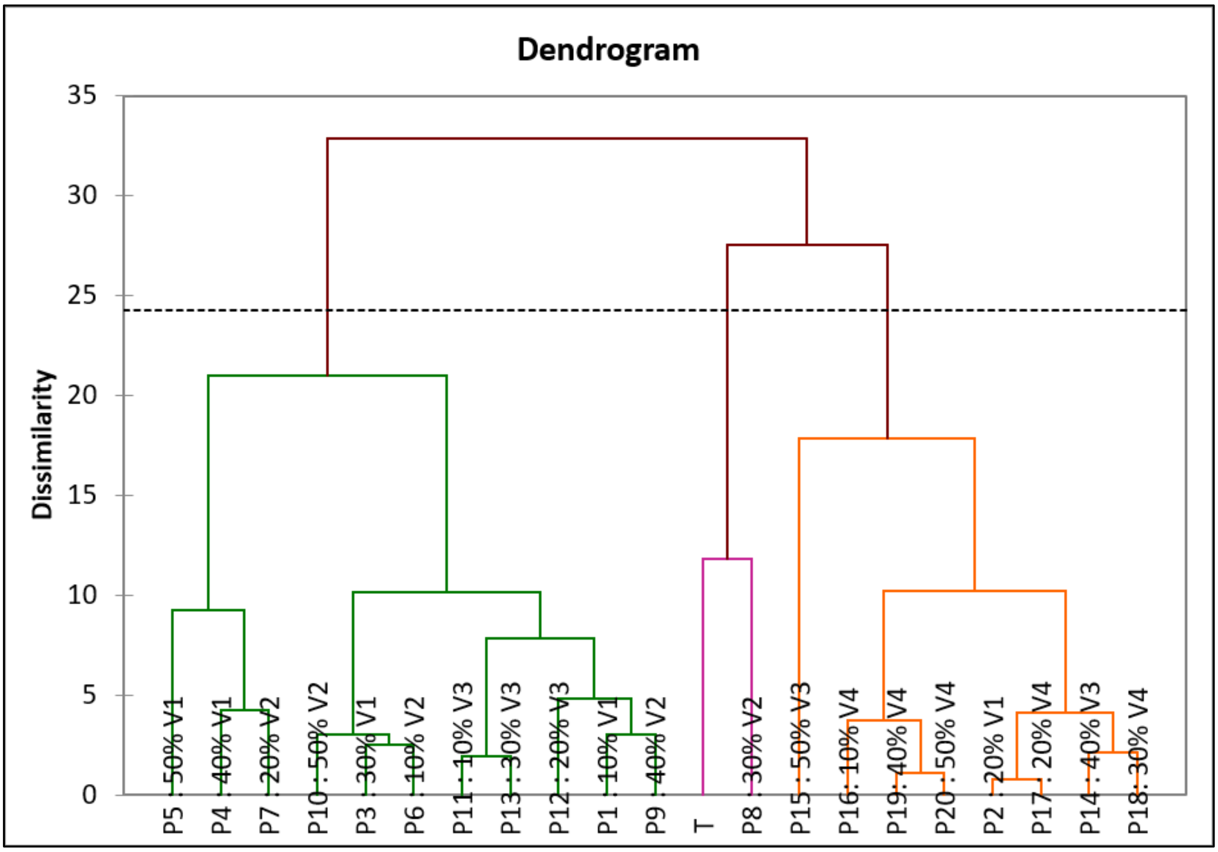

Figure 2 Hierarchical cluster analysis dendrogram of bread formulations

4. Conclusion

This study demonstrated that partial substitution of wheat flour with sweet potato flour significantly influences the nutritional, functional, and physicochemical properties of bread. Increasing the incorporation rate generally resulted in higher ash (0.87 to 3.66%), starch (up to 31.04%), and fiber (up to 12.87%) contents, while moisture tended to decrease. Protein content ranged from 9.06 to 15.62 g/100 g dry weight, with the best values observed for P8 (30% V2). The enriched formulations also showed marked increases in carotenoids (0.58 to 2.72 g/kg) and total polyphenols (307.03 to 952.58 mg GAE/100 g), confirming the functional potential of sweet potato flour. However, digestibility was substantially reduced in formulations rich in fiber and polyphenols, with notable exceptions for P8: 30% V2 (84.55%) and P7: 20% V2 (74.00%). Multivariate analysis confirmed a positive correlation between carotenoids and polyphenols and a negative relationship between polyphenols and digestibility. Substitution levels of 30–40% represent the best compromise between nutritional enrichment and acceptable digestibility. These findings support the potential of sweet potato flour as a functional ingredient for improving bread nutritional quality in Guinea and similar West African contexts, where vitamin A deficiency and wheat import dependency remain pressing public health and economic challenges.

Compliance with Ethical Standards

Acknowledgements

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Conflict of Interest Statement

The authors declare no conflict of interest.

Statement of Ethical Approval

The present research work does not contain any studies performed on animals or human subjects by any of the authors.

References

[1] Ruvette M. Avantages de la patate douce pour la production de farine et de pain — considérations économiques et agroalimentaires. [Report]. 2012.

[2] Li M, Zhang J, Wang H, et al. Effect of dietary fiber from wheat bran on bread quality and glycaemic index. Food Science & Technology. 2023; 45(3): 112–120.

[3] Olapade AA, Oluwole OB. Bread making potentials of composite flours of wheat and cowpea flours. Nigerian Food Journal. 2013; 31(1): 6–13.

[4] Johnston CR, Bennett C, Hammons D, et al. Protein enrichment of wheat bread with fava bean flour: impact on nutritional and sensory properties. Journal of Cereal Science. 2023; 105: 103482.

[5] Meng H, Xu C, Wu M, Feng Y. Effects of potato and sweet potato flour addition on properties of wheat flour and dough, and bread quality. Food Science & Nutrition. 2022; 10: 689–697.

[6] Idolo I. Sensory and nutritional quality of 'Madiga' produced from wheat/sweet potato composite flour. Pakistan Journal of Nutrition. 2011; 10(11): 1004–1007.

[7] Ssentongo P, Ssentongo AE, Ba DM, et al. Vitamin A deficiency and associated factors in sub-Saharan Africa: a systematic review and meta-analysis. Nutrients. 2021; 13(3): 872.

[8] Sluiter A, Hames B, Ruiz R, et al. Determination of structural carbohydrates and lignin in biomass. NREL Technical Report NREL/TP-510-42618. Golden, CO: National Renewable Energy Laboratory; 2008.

[9] Ayeni AO, Omole KO, Hymore FK, et al. Consideration of effects of process parameters on the pretreatment of grass using phosphoric acid: Recovery of hemicellulose and cellulose. Bioresource Technology. 2015; 189: 394–400.

[10] Kourouma, V., Mu, T., Zhang, M., & Sun, H. (2020). Comparative study on chemical composition, polyphenols, flavonoids, carotenoids and antioxidant activities of various cultivars of sweet potato. *International Journal of Food Science & Technology*, *55*(1), 369-378. https://doi.org/10.1111/ijfs.14336

[11] Balla A, Blecker C, Oumarou M, Paquot M, Deroanne C. Mise au point de pains composites à base de mélanges de farines de sorgho-blé et analyse texturale. Biotechnologie, Agronomie, Société et Environnement. 1999; 3(2): 69–77.

[12] Mitiku DH, Abera S, Bussa N, Abera T. Physico-chemical characteristics and sensory evaluation of wheat bread partially substituted with sweet potato (Ipomoea batatas L.) flour. British Food Journal. 2018; 120(5): 1148–1163. doi:10.1108/BFJ-01-2018-0015.

[13] Sihachakr D, Haïcour R, Cavalcante Alves JM, Umboh I, Nzoghe D, Servaes A, et al. Plant regeneration in sweet potato (Ipomoea batatas L., Convolvulaceae). Euphytica. 1997; 96(1): 143–152.