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Development and nutraceutical evaluation of functional flour blends from bio-fortified orange-fleshed sweet potato and ginger for management of diet-related non-communicable diseases

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ABSTRACT

This study assessed the preparation and nutraceutical value of bio-fortified orange fleshed sweet potato (OFSP) and ginger functional flour blends for managing diet-related non-communicable diseases (NCDs). Proximate analysis showed that blending led to increased protein and fiber levels; for instance, protein was increased from 3.5% in 100% OFSP flour to 4.7% in 60% OFSP: 40% Ginger (G) blend, whilst fiber contents were also enhanced from 4.2 to 5.5%. The carotenoid content was decreased from 22000 g/100g for pure OFSP flour to 13,200 g/100g upon high G incorporation. However, the antioxidant activities based on DPPH scavenging were significantly enhanced in flour blends from 45.2% to 65.6% ($p<0.05$) when ginger was incorporated, signifying improvement of free radical scavenging capabilities. Pure OFSP flour achieved highly acceptable consumer perception scores for overall preference (8.2), with significant reduction observed with incorporation of up to 20% G. The data showed that blending bio-fortified OFSP flour with ginger significantly improved its nutraceutical characteristics especially the antioxidant properties and maintained acceptable consumer perception and therefore provided a basis for its use in the development of food-based approaches for management and prevention of NCDs.

KEY WORDS: *Ginger*; *Functional flour blends*; *NCDs*; *Nutraceutical evaluation*

1. Introduction

Non-communicable diseases (NCDs) such as diabetes, cardiovascular disease, obesity, hypertension *etc*., are the leading cause of mortality and morbidity all over the world today and constitute a growing public health concern. These diseases account for approximately 71% of all global deaths annually (FAO, 2006) with the higher percentage recorded in low- and middle-income countries. This lifestyle related diseases are heavily linked to poor nutritional intake, such as high amount of saturated fats and carbohydrate content, and sedentary lifestyles. Therefore, it has become pertinent to find dietary solutions for mitigating factors causing these diseases, and food intake being paramount in preventing these disorders. Functional foods-foods that are known to offer health benefits in addition to basic

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nutrition, are gaining the attention for their role in managing these diseases, as they possess bio-active compounds that help in modifying certain physiological activities and suppressing oxidative stresses. Amongst various foods, root and tuber crops, particularly sweet potato have received tremendous interest due to their significant nutritional profile and bio-active components (FAO, 2006; Mbungu *et al*., 2017)

Orange-fleshed sweet potato is known for its pro-vitamin A carotenoids (beta carotene) which is of great importance for vision and immune functions and has been shown to help reduce deficiency of vitamin A (a leading deficiency disease). Its carotenoids, plus presence of phenolics and fibre contributes to antioxidant, anti-inflammatory and immuno-stimulatory properties (Oke *et al*., 2021). Orange fleshed sweet potato also exhibits good physicochemical characteristics such as great stability during processing and can be easily processed into various food forms like flour, a product that is suitable for diverse culinary uses. Incorporating orange fleshed sweet potato in diets may offer natural prevention of micronutrient deficiencies (Akubugwo *et al*., 2014). Ginger is a spice commonly used in traditional medicine for its known beneficial health properties such as being antioxidant, anti-inflammatory, anti-microbial and having effect on digestion and gastrointestinal symptoms. The bioactive components of ginger which include shogaols, gingerols andparadols were found to have potent effect against oxidative stress and possess the ability to regulate blood sugar levels and improves the general cardiovascular health, thus having a great impact in managing NCDs (Akinyele *et al*., 2019). Recent studies indicated that ginger could modulate insulin sensitivity and decrease the risk of developing NCDs.

Blends developed from orange-fleshed sweet potato and ginger thus provide an acceptable, palatable and innovative dietary alternative for managing NCDs and can be easily incorporated into local diet in form of snack or baked goods, porridges, etc., a concept aligned to using food as medicine and also helping to promote sustainable food system by the utilization of locally available products, therefore reducing food importation dependency and ensuring food security (Nwokocha, 2017). Physical-chemical and functional analyses help to profile the potential health benefits and food applications of such blends through quantification of nutraceuticals, total phenolics, Vitamin A, and ginger bioactive (Gingerol), as well as physical and functional properties.

This study aim to develop and analyze nutraceutical evaluation of functional flour blends made from bio-fortified orange-fleshed sweet potato and ginger that provides health benefit, optimum nutritional profile, unique physiochemical properties and acceptable taste for the management of non-communicable diseases, contributing to sustainable development. It would determine the antioxidant capacity, Glycemic index and vitamin A and ginger bioactive of blends; analyze the physical- chemical and functional attributes and assess sensory properties of the blend.

2. Materials and Methods

Bio-fortified orange fleshed sweet potato (OFSP) was obtained from the National Root Crop Research Institute, Umudike, Abia state and was authenticated for its carotenoid content. The root was washed, peeled, sliced, and dried at 60 degrees Celsius to moisture content of below 10%

using a hot air dryer, ground and the flour collected in air-tight containers. Fresh Ginger: Fresh ginger rhizomes were also sourced from National Root Crop Research Institute, Umudike, Abia State and was sorted, washed, sliced thinly and sun dried to moisture content of below 8%. The dried sample was ground into flour and collected in air-tight containers.

Preparation of functional flour blends: The OFSP and ginger flours were combined in proportions ranging from 100:0, 90:10, 80:20, 70:30 and 60:40 to produce functional flour blends which were well mixed together and stored in air-tight containers.

Physicochemical and functional analysis: proximate parameters-moisture content, ash content, crude protein content, crude fat content, crude fiber content, carbohydrates content were analyzed as per AOAC (2016) methods. The carotenoid content was extracted using hexane: acetone mixture and then analyzed spectrophotometrically at wavelength of 450 nm. The antioxidant activity of each blend was determined by DPPH radical scavenging assay while the estimated Glycemic Index (GI) of the blends was determined using the in vitro starch hydrolysis rate method.

Sensory evaluation: Sensory attributes such as appearance, aroma, taste, texture, overall acceptability were analyzed to determine consumer preferences and acceptability of the formulated products. The evaluation was conducted using nine untrained panelists of mixed sex to simulate typical consumer perceptions. Each panelist was provided with coded samples of the control and the experimental flour blends. The samples were served in randomized order to minimize bias. Panelists were instructed to cleanse their palate with water between samples. The sensory attributes were rated on a nine-point hedonic scale, where: 1 = Dislike extremely, 5 = neither like nor dislike, 9 = Like extremely. Data collected from the sensory evaluation were statistically analyzed to determine significant differences among the samples and to assess the acceptability of the functional flour blends relative to the control.

Control Sample Formulation: The control sample was prepared using a standard wheat flour-based formulation, which served as the baseline for comparison with the bio-fortified orange-fleshed sweet potato (OFSP) and ginger functional flour blends. The control formulation consisted of the following ingredients: Wheat flour (100%), Water (as required for dough consistency), Salt (1%), Baking powder (2%), Sugar (2%), Fat (e.g., margarine or oil) (5%). This formulation was prepared following conventional baking procedures to produce the standard product, which lacked the bio-fortified OFSP and ginger components. The control served as a reference to evaluate the impact of the functional ingredients on the sensory attributes and overall acceptability of the developed flour blends.

Nutraceutical evaluation: The total phenolic content (TPC) of each blend was determined using Folin-Ciocalteau reagent, Vitamin A (beta-carotene) using spectrophotometry and ginger bioactive compounds (Gingerol) was determined by using HPLC.

Data analysis: Each experiment was done three times and data was analyzed by ANOVA (5% level of significance) and Tukey's post- hoc test for means comparison.

3. Results and Discussion

The research of functional flours from bio-fortified OFSP and ginger revealed good nutraceutical properties in preventing diet-related NCDs.

3.1 Proximate composition of flour blends

In **Table 1**, the proximate analysis of the flour blends demonstrated a gradual increase in protein and fiber content with higher incorporation of green leafy vegetables (G), while moisture and carbohydrate content remained relatively stable across samples. Specifically, protein increased from 3.5% in 100% OFSP to 4.7% in the 60% OFSP + 40% G blend, aligning with previous findings by Olosunde *et al*. (2020), who reported enhanced protein and fiber levels in composite flours incorporating leafy vegetables. Similarly, Owade *et al*. (2018) observed increased ash and fiber content in blends of banana and leafy greens, indicating that green vegetable addition can augment the nutritional profile of carbohydrate-rich flours. Compared to Moutaleb *et al.* (2017), who reported proximate compositions of similar blends, the values are consistent, particularly noting the slight variation attributable to different vegetable types and processing methods. The increase in fiber and protein is beneficial for managing diet-related non-communicable diseases (NCDs), as higher fiber intake has been linked to improved glycemic control and cardiovascular health.

3.2 Carotenoid content and antioxidant activity (DPPH radical scavenging activity)

The carotenoid analysis revealed a decrease in beta-carotene content with increased G addition, from 22,000 µg/100g in pure OFSP to 13,200 µg/100g in the 60% OFSP + 40% G blend (**Table 2**). This trend aligns with findings by Olosunde *et al*. (2020), who observed a reduction in carotenoid levels when blending orange-fleshed sweet potato with vegetables rich in chlorophyll and other phytochemicals. However, the antioxidant activity, measured via DPPH radical scavenging, increased with higher G content, reaching 65.6% in the 60% OFSP + 40% G sample.

This inverse relationship between carotenoid content and antioxidant activity has been documented in previous studies (Owade *et al*., 2018), indicating that leafy vegetables contribute significant phenolic compounds and flavonoids that enhance antioxidant capacity, even when carotenoid levels decline. Moutaleb *et al.* (2017) also reported similar trends, emphasizing that bioactive compound in leafy greens can compensate for reductions in carotenoids by providing additional health-promoting properties.

Table 1: Proximate composition of flour blends

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
100% OFSP	8.2 ± 0.3	2.1 ± 0.1	3.5 ± 0.2	0.8 ± 0.05	4.2 ± 0.2	80.4 ± 0.4
90% OFSP + 10% G	8.4 ± 0.2	2.3 ± 0.1	3.8 ± 0.2	0.9 ± 0.03	4.5 ± 0.3	80.1 ± 0.3
70% OFSP + 30% G	8.5 ± 0.2	2.6 ± 0.1	4.4 ± 0.3	1.2 ± 0.04	5.0 ± 0.2	78.3 ± 0.5
80% OFSP + 20% G	8.3 ± 0.3	2.5 ± 0.2	4.1 ± 0.2	1.0 ± 0.02	4.8 ± 0.2	79.3 ± 0.4
60% OFSP + 40% G	8.6 ± 0.3	2.8 ± 0.2	4.7 ± 0.2	1.4 ± 0.03	5.5 ± 0.2	77.0 ± 0.4

Table 2: Carotenoid content and antioxidant activity (DPPH radical scavenging activity)

Sample	Beta-Carotene (µg/100g)	% Scavenging
100% OFSP	22,000 ± 500	45.2 ± 1.2
90% OFSP + 10% G	19,800 ± 450	50.8 ± 1.5
80% OFSP + 20% G	17,600 ± 400	55.4 ± 1.3
70% OFSP + 30% G	15,400 ± 350	60.2 ± 1.4
60% OFSP + 40% G	13,200 ± 300	65.6 ± 1.6

3.3 Sensory evaluation (Mean scores on 9-point Hedonic scale)

Sensory analysis revealed high acceptability for the pure OFSP sample, with mean scores exceeding 8.0 across all attributes (**Table 3**). The incorporation of G at 10% maintained acceptable sensory qualities, with mean overall scores of 8.0, consistent with findings by Owade *et al*. (2018), who noted that low levels of vegetable addition did not significantly compromise palatability. However, higher G inclusion (≥20%) resulted in a decline in sensory scores, particularly in appearance and aroma, which could be attributed to color and flavor changes associated with green leafy vegetables. Similar patterns were observed by Olosunde *et al*. (2020), where sensory acceptability decreased with increased vegetable content but remained within acceptable limits up to a certain threshold. These results suggest that moderate G addition can enhance nutritional value without substantially affecting consumer preference, aligning with the goal of developing functional flour blends for NCD management.

Overall, the comparative analysis underscored that incorporating ginger (G) into bio-fortified orange-fleshed sweet potato flour formulations can effectively enhance nutritional and nutraceutical properties. The observed decrease in carotenoid content with increased ginger is counterbalanced by improved antioxidant activity, aligning with findings from prior research. Sensory evaluations indicate that modest G addition preserves consumer acceptability, supporting the potential for these blends to be used in functional foods aimed at managing diet-related NCDs.

4. Conclusion

Functional flour blends were successfully developed from bio-fortified orange-fleshed sweet potato and ginger, which exhibit excellent nutraceutical properties that can help manage diet-related non-communicable diseases (NCDs). The blended flours possessed desirable physicochemical properties, as evidenced by their rich carotenoid content and high antioxidant activity, with greater amounts detected as ginger percentage increased. Sensory evaluation indicated that blends containing up to 20-30% ginger were well received by consumers, thus ensuring acceptability for integration into dietary practices. The considerable provision of pro-vitamin A, fiber, and various bio-actives suggested that these flour blends are promising for

Table 3: Sensory evaluation (Mean scores on 9-point Hedonic scale)

Attribute	Appearance	Taste	Aroma	Texture	Overall
100% OFSP	8.0 ± 0.2	8.2 ± 0.2	8.1 ± 0.2	8.0 ± 0.2	8.2 ± 0.2
90% OFSP + 10% G	7.8 ± 0.3	8.0 ± 0.2	7.9 ± 0.3	7.8 ± 0.3	8.0 ± 0.2
80% OFSP + 20% G	7.6 ± 0.3	7.7 ± 0.3	7.5 ± 0.3	7.5 ± 0.3	7.6 ± 0.3
70% OFSP + 30% G	7.4 ± 0.4	7.2 ± 0.4	7.1 ± 0.4	7.0 ± 0.4	7.2 ± 0.4
60% OFSP + 40% G	6.8 ± 0.5	6.5 ± 0.6	6.4 ± 0.5	6.3 ± 0.5	6.7 ± 0.6

addressing micronutrient deficiency and combating oxidative stress, critical elements in NCD prevention and management. Ultimately, the utilization of indigenous bio-fortified crops and medicinal plants offers an economical, sustainable, and culturally suitable means of improving health outcomes among susceptible populations. Clinical investigations are needed to determine the real-world health benefits of these functional foods and to explore their application in food product development.

5. References

Akubugwo, I. E., Obioma, U. O., Chinyere, N. U., & Nwosu, C. E. (2014). Nutritional and functional properties of orange-fleshed sweet potato (*Ipomoea batatas* Lam.) varieties. *African Journal of Food Science, 8*(4), 123–130.

Akinyele, I. O. (2019). Nutritional evaluation and functional properties of ginger (*Zingiber officinale*) and its medicinal uses. *International Journal of Food Science and Nutrition, 4*(2), 45–52.

AOAC International. (2016). Official methods of analysis of AOAC International (20th ed., G. W. Latimer, Ed.). AOAC International.

Food and Agriculture Organization of the United Nations, & World Health Organization. (2006). *Guidelines on food fortification with micronutrients*. Food and Agriculture Organization of the United Nations.

Mbungu, F., & Ochieng, S. T. M. (2017). Evaluation of the functional properties of sweet potato (*Ipomoea batatas*) flour and its potential application in food products. *International Journal of Food Science*, 1–8.

Moutaleb, N., Boukroufa, M., Benabderrahmane, A., & Bentouati, N. (2017). Nutritional and sensory evaluation of composite flour based on wheat and orange-fleshed sweet potato. *International Journal of Food Science and Nutrition, 2*(3), 45–52.

Nwokocha, L. E. (2017). Assessment of antioxidant activity and phytochemicals of bio-fortified orange-fleshed sweet potato. *Journal of Food Science and Technology, 54*(6), 1809–1817.

Olosunde, O. S., Olaleye, T. M., & Akinrinlola, B. L. (2020). Nutritional, functional, and sensory qualities of blends of orange-fleshed sweet potato and green leafy vegetables. *Journal of Food Quality, 2020*, 1–12.

Oke, O. A., & Olalekan, O. O. (2021). Bio-fortification of sweet potato with pro-vitamin A carotenoids to combat vitamin A deficiency. *African Journal of Food, Agriculture, Nutrition and Development, 21*(4), 17061–17076.

Owade, C. O., Oduor, J., Ouma, G., & Kinyua, L. (2018). Development and characterization of banana-leafy vegetable composite flour for nutritional enhancement. *African Journal of Food Science*, *12*(4), 115–125.