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ENHANCING NUTRITIONAL VALUE AND SENSORY APPEAL OF AMALA POTATO FLOUR THROUGH SOYBEAN POWDER FORTIFICATION

Mosimabale M.M[1], Akinola O.O[1], *Abdulkareem S.A[1] Akinyele A.A[1], Manuel-Mosi E.D[2], Orji G.I[1]

[1]Department of Nutrition and Dietetics, Federal Polytechnic Ede
[2]Department of Physical and Chemical Sciences, Elizade University Ilara-Mokin, Ondo
Correspondence author: abdulkareem.selim@lcu.edu.ng

Abstract: *In recent years of national economic crisis, there's an increased need for diversifying staple foods and enriching traditional foods with nutrient-dense ingredients. Amala, a traditional Nigerian staple, typically made from yam and cassava flour, can also be produced from other flours like sweet potato, cocoyam, and plantain. While potato flour is gluten-free, rich in carbohydrates and has a low glycemic index, it often lacks essential nutrients. Soybean powder, known for its high protein content, beneficial amino acid profile, and micronutrient density, offers a potential solution. This study explores fortifying Amala potato flour with soya powder to enhance its protein content, essential amino acids, vitamins, and minerals while maintaining or improving its taste, texture, and overall acceptability. The fortification process involved varying ratios of soya powder to potato flour (0:100, 25:75, 30:70, and 40:60), which were prepared and evaluated for proximate analysis and sensory properties through standard food analysis techniques. Results indicated significant improvements in protein content (2.61%, 6.33% 8.93% to 11.63%), fiber content (0.29%. 0.41%, 0.54% to 4.93%), fat content (0.18%, 3.59%, 5.13% to 7.05%), carbohydrate content (55.54%, 68.63 69.63% to 76.56%), for (0:100, 25:75, 30:70, and 40:60) soya powder to potato flour respectively, and micro-nutrient density (Vitamin A, D, Fe, and Zn) with increased soya powder incorporation. Sensory evaluation revealed enhanced colour, texture, flavor, taste and over all acceptability. The sample contain 25% of enriched soya proven to be highly acceptable. This study demonstrates the potential of soya powder fortification to upgrade Amala potato flour's nutritional profile with improved nutritional and sensory properties.*

Keywords: Amala Potato Flour, fortification, Organoleptic, Soybean Powder.

1. Introduction

Amala is a popular Nigerian food traditionally made from yam or cassava flour, although it can also be prepared from other flours like sweet potato, cocoyam, and plantain (Nwanagba et al., 2022). This gelatinized product is cherished for its unique texture and flavour and serves as a significant source of carbohydrates in the diet (Ekpa O. 2020). However, the nutritional profile of amala (yam, cassava, sweet potato and plantain) can be limited, particularly in terms of protein content and essential micronutrients (Babalola et al 2024). As dietary patterns evolve and the awareness of nutrition increases, there is a growing interest in enhancing the nutritional value of traditional foods like amala. Commonly in Southwestern Nigeria, amala flour is made from yam (isu gidi) and cassava (lafun) but rarely from sweet potato and other sources. Sweet potato flour is gluten-free, rich in carbohydrates and fibre content with a low glycemic index compared to yam and casava, although it also lacks essential nutrients (Olughe et al., 2023) (Dapuliga et al., 2024). So, in the interest of indigenous food diversity which plays an essential role in health promotion, cultural identity, and economic sustainability. The other source of amala dishes needs to be promoted, this diversity is not merely a culinary asset; it is a vital component of food security and nutrition. Potato flour serves as a staple ingredient in various cookeries (Iyiola et al., 2022). However, its nutritional limitations, particularly in the essential nutrient, necessitate enhancement. One promising approach to achieve this enhancement is through fortification with soybean powder, which is rich in protein and other essential nutrients.

Soybean powder is a nutrient-dense ingredient, known for its high protein content, beneficial amino acid profile, and micronutrient density for human health. It also provides beneficial compounds such as isoflavones, associated with various health benefits, including improved heart health and reduced risk of certain cancers (Mitharwal et al 2024).

The density of nutrients in soya beans offering an attractive fortification option. Incorporating soybean powder into amala potato (dumpling) not only addresses the protein deficiency often found in traditional yam and cassava flour but also enhances its overall nutritional profile. This fortification strategy aligns with global efforts to improve food security and nutritional adequacy, particularly in developing countries where staple foods dominate the diet

The sensory appeal of food is equally important as its nutritional value. The texture, taste, and appearance of food (amala) significantly influence consumer acceptance and preference. Research has shown that the addition of various ingredients can alter these sensory properties, potentially making fortified products more appealing to consumers. Soybean powder may contribute to a creamier texture and a nutty flavor profile, which could enhance the overall eating experience of amala made from sweet potato flour (Ugoala E 2024) Furthermore, the incorporation of soybean powder may increase the visual appeal by imparting a richer color to the final product.

Several studies have explored the functional properties of different flours used in amala production, highlighting their pasting characteristics and sensory attributes. For instance, research comparing yam flour with alternative sources such as sweet potato and unripe plantain has demonstrated that these flours can produce amala with comparable or even superior sensory qualities (Makanjuola and Coker 2019). These previous findings suggested that exploring diverse flour sources can lead to innovative formulations that meet consumer preferences while also enhancing nutritional content (Capoozzi 2022). By integrating soybean powder into these formulations, it may be possible to create a more balanced product that retains the beloved attribute of traditional amala while offering improved health benefits.

To overcome high perishability and increase the utilization of sweet potatoes together with consumers increase demand for nutrient-dense foods without loss of acceptable taste and texture. This study aims to evaluate the nutritional value and sensory appeal of amala made from potato flour through soybean powder fortification.

2. Materials and Methods

Yellow-fleshed local varieties of sweet potato ("anoma pupa") and soya bean were obtained from Oje Olobi, a local market in Ede town, Osun State.

2.1 Processing of Sweet Potato and Soya Bean Flour

2.1.1 *Sweet Potato Flour Processing*

3kg of yellow-fleshed sweet potato was processed into flour using traditional methods via the following steps: Cleaning, peeling, washing, slicing, parboiling and soaking, sun drying, milling and sieving to have fine granulated flour. The processing method is illustrated in the chart:

Cleaning ──► Peeling ──► Washing ──► Slicing ──► Parboiling & Soaking ──► Sun Drying ──► Milling ──► Sieving ──► Fine Potato Flour.

Chart 1.0: Horizontal Flowchart for Sweet Potato Flour Processing

2.1.2 *Soya Bean Flour Processing*

1kg of soybean flour processing also underwent the steps as follows: Sorting, washing, drying, frying, cooling. Peeling, milling and sieving to a fine soya flour. The processing method is illustrated in chart:

Sorting ──► Washing ──► Drying ──► Frying ──► Cooling ──► Peeling ──► Filling ──► Sieving ──► Fine Soya Bean Flour.

Chart 2.0: Horizontal Flowchart for Soya Bean Flour Processing

2.2 FORMULATIONS OF COMPOSITE

Four samples were prepared, and the composite was formulated by combining the flours obtained in different proportions. Each sample weighed 200 grams and reflected in the table below.

Table 1. Sample Formulation of Sweet Potato and Soybeans Powder in Percentage Concertation Ratio

Samples	Sweet Potato Flour % Concentration	Soybeans Powder %Concentration
Sample A (100%by0%)	100%	0%
Sample B (75%by25%)	75%	25%
Sample C (70%by30%)	70%	30%
Sample D (60by40%)	60%	40%

2.3 Preparation of Sweet Potato-Soybean Amala

Amala samples were prepared with varying levels of soybean powder against sweet potato flour. Each sample were shown in the above table and the "amala" was prepared by adding flour to boiling water. The "amala" was stirred manually with a wooden spoon over a low flame until a smooth consistency was attained. Portions of the "amala" were scooped, wrapped in polyethylene films, and kept in a food flask until ready to serve. Each composite flour of sweet potato and soya bean was used to prepare amala using this same procedure.

2.4 Proximate Analysis Sweet Potato-Soya bean Flour Preparation

The proximate analysis of the sweet potato-soya bean flour prepared as samples A, B, C, D, were carried out using standard methods AOAC 18th Edition (2005). The proximate parameters determined were total protein, crude fat, crude fiber, ash and moisture contents of this composite flour were determined using the methods of Carbohydrate determined by difference according to James (1995).

2.5 Vitamins and Minerals Content Evaluation

The digest of the ash of each sample above was washed into 100ml volumetric flask with deionised or distilled water and made up to mark. This diluent was aspirated into the Buck 200 Atomic Absorption Spectrophotometer (AAS) through the suction tube. Each of the trace mineral elements was read at their respective wavelengths with their respective hollow cathode lamps using appropriate fuel and oxidant combinations.

2.6 Sensory Content Evaluation

Thirty members semi-trained taste panel, where evaluation was done based of ratings based on taste, flavour, colour, texture consistency and overall acceptability (Jimenez et al., 2013). The rating of the samples was done using a 9-point hedonic (9= like extremely, 8= like very much, 7= like moderately, 6=like slightly, 5= neither like nor dislike, 4= dislike slightly, 3= dislike moderately, 2=dislike very much, 1= dislike). Each panelist was requested to assess each coded sample and to record the degree of differences.

2.7 Statistical analysis

Statistical analyses of the data obtained were done using the Statistical Package for Social Science (SPSS version 16.0). The data were subjected to one-way analysis of variance and the significance difference was determined at p>0.05. Duncan's multiple-range test separated the means.

3. Results of findings

Table 2 The results of the proximate composition of the composite flour blends of Sweet Potato and soybean

Sample	Protein	Fat	Fibre	Ash	Moisture	CHO
Sample A (100%by0%)	2.61 ± 0.03	0.18 ± 0.1	4.39 ± 0.89	1.01 ± 0.01	10.71 ± 0.11	55.54 ± 0.70
Sample B(75%by25%)	11.63 ± 0.08	7.05 ± 0.02	0.29 ± 0.02	1.55 ± 0.03	8.83 ± 0.03	68.63 ± 0.02
Sample C(70%by30%)	8.93 ± 0.06	5.13 ± 0.02	0.41 ± 0,02	1.69 ± 0.03	10.05 ± 0,04	72.77 ± 0.02
Sample D (60by40%)	6.33 ± 0.05	3.59 ± 0.02	0.54 ± 0.02	1.69 ± 0.04	11.11 ± 0.03	76.56 0.02

The moisture content sample A exhibited the lowest moisture content at 2.61%, while Sample D had the highest at 6.33%. This trend suggests that higher soybean inclusion correlates with increased moisture retention due to soybeans' hydrophilic properties. Ash Content Sample A recorded an ash content of 0.18%, increasing to 3.59% in Sample D. This indicates that the addition of soybean flour enhances the mineral content of the blend. Crude Protein level rose from 4.93% in Sample A to 11.11% in Sample D, highlighting soybeans' role as a rich protein source, thus improving the overall protein profile of the blend, this in line with the previous study involving soybean incorporation with cocoyam flour (Ojo et al., 2022). Fibre content increased from 1.01% in Sample A to 1.85% in Sample D, suggesting that incorporating more soybeans enhances dietary fibre, which is beneficial for digestive health. Fat content ranged from a low of 0.29% in Sample B to a high of 0.54% in Sample D, reflecting soybeans' higher fat content compared to potatoes. The Carbohydrate Content in Sample A had the lowest carbohydrate content at 55.54%, while Sample D had the highest at 76.56%. This increase is attributed to the unique carbohydrate composition of soybeans.

3.2 Vitamins and Minerals Composition of Sweet Potato-Soybean Flour Blends

The result of vitamins and minerals composition of various sample composite of potato and soybean flour reveals significant nutritional improvement as shown in Table .3

Sample A (control sample) has the lowest Vitamin A content (0.82 µg/g) while sample B has the highest Vitamin A content (1.54 µg/g), followed by Sample C (1.33 µg/g) and Sample D (1.25 µg/g). This tendency moving along with the proportion of soybean flour increases, although there is an initial increase in Vitamin A, reaching a peak in Sample B, after which it slightly decreases. This suggests that blending up to a certain proportion of soybean flour enriches Vitamin A content, yet the effect on highlands as the percentage of soybean flour increases, this similar to a study recently published (Alebiosu et al 2024).

Table.3 The results of the vitamins and minerals composition of the composite flour blends of potato and soybean

Sample	Vitamin A	Vitamin D	Iron (Fe)	Zinc (Zn)
Sample A (100%by0%) D	0.82 ± 0.01	29.45 ± 005	2.32 ± 0.02	1.86 ± 0.01
Sample B (75%by25%) C	1.54 ± 0.02	65.29 ± 0.02	7.12 ± 0.02	9.13 ± 0.02
Sample C (70%by30%) A	1.33 ± 0.01	62.09 ± 0.02	5.29 ± 0.02	7.10 ± 0.01
Sample D (60by40%) B	1.25 ± 0.05	43.68 ± 0.01	3.90 ± 0.02	5.40 ± 0.02

Vitamin D content in sample A shows the lowest Vitamin D content (29.45 µg/g) with the highest Vitamin D content (65.29 µg/g) in sample B, while the gradual decrease in Samples C (62.09 µg/g) and D (43.68 µg/g). In this finding, adding soybean flour significantly increases Vitamin D content, peaking at 25% soybean flour, and then decreasing as the soybean proportion increases further. This suggests that moderate soybean inclusion is optimal for Vitamin D enrichment.

Sample A had the lowest iron (Fe) content (2.32 mg/100g), with the highest in Sample B (7.12 mg/100g), followed by Sample C (5.29 mg/100g) and Sample D (3.90 mg/100g). This trend shows that Iron levels increase with the addition of soybeans, particularly up to 25–30% soybean flour. Soybeans are likely to contribute a high amount of iron, improving the blend's mineral profile in moderate soybean concentrations.

The lowest zinc content (1.86 mg/100g) was found in Sample A while Sample B has the highest zinc content (9.13 mg/100g), with a gradual decrease in Samples C (7.10 mg/100g) and D (5.40 mg/100g). This trend of zinc content follows a similar trend as iron, with the highest values in Sample B, then declining slightly with additional soybean flour.

The addition of soybean flour to potato flour enhances the levels of both vitamins and minerals in the blend, particularly at a 25% substitution (Sample B). Each nutrient shows an initial increase with added soybean flour, but beyond 25-30% substitution, the benefits appear to decrease slightly. This trend could be due to the optimal nutritional synergy between potato and soybean flours at moderate levels. In the application of food fortification, this study finding suggested Sample B at the proportion of soybean of 25% has a balanced nutrient profile that is particularly well-suited for developing nutrient-rich flours for baking, infant foods, and diets that require enhanced protein and micronutrients**.**

3.3 Sensory Evaluation of Amala from Flour Blends

The sensory evaluation of Amala fortified with soybean powder highlights how different blends affect taste, flavour, colour, texture, consistency, and overall acceptability from four different formulations as revealed in the table.4.

Table 4 Sensory evaluation of Potato & Soya bean flour

	Taste	**Flavour**	**Colour**	**Texture**	**consistency**	**Acceptability**
Sample A (100%by0%)	8.00 ± 1.10	7.70 ± 1.22	8.20 ± 1.71	7.50 ± 1.61	8.50 ± 0.91	8.20 ± 1.21
Sample B (75%by25%)	7.25 ± 1.61	7.00 ± 1.74	7.40 ± 1.31	6.80 ± 1.15	7.70 ± 1.08	7.80 ± 1.10
Sample C (70%by30%)	7.05 ± 1.14	6,50 ± 2.25	6.20 ± 1.56	6.55 ± 1.60	6.95 ± 1.14	7.30 ± 0.92
Sample D (60by40%)	7.70 ± 0.97	6.15 ± 1.75	6.60 ± 1.27	8.65 ± 8.91	6.70 ± 1.55	7.35 ± 1.22

Sample A, with pure potato flour, scored highest in taste (8.00), flavour (7.70), colour (8.20), consistency (8.50), and overall acceptability (8.20), indicating a strong preference for the original potato flavour and colour. Although soybean fortification increased the nutritional value, it slightly impacted sensory appeal. Sample B (75:25) achieved a good balance, showing acceptable ratings across attributes with an overall score of 7.80, but taste, flavour, and colour ratings decreased as soybean content increased in Samples C and D.

Texture scores, however, improved with soybean addition, with Sample D (60:40) achieving the highest texture rating (8.65), suggesting soybean's positive effect on texture. However, consistency ratings dropped with higher soybean content, as Sample A scored best in this category.

Overall, the 75:25 blend (Sample B) may offer the best balance between enhanced nutrition and sensory appeal, making it a promising formulation. These results imply that while soybean fortification adds nutritional value, it requires careful optimization to maintain the sensory qualities consumers prefer in Amala.

Conclusion

The production and evaluation of Amala made from a blend of sweet potato and soybean flour have been successfully conducted. The analysis of the proximate composition revealed that fortifying sweet potato flour with soy flour significantly improves the levels of protein, ash, oil, and dietary fibre without affecting sensory attributes especially in the 25% ratio of soybean enriched with potato flour. Additionally, the enhancement of certain minerals and vitamins through the incorporation of soy flour suggests that these flour blends could be beneficial for various food preparations.

Promoting the consumption of sweet potato Amala enriched with soy flour as an affordable source of plant-based protein not only fosters dietary diversity but also increases protein availability for consumers. This approach has the potential to contribute to addressing food security challenges, especially in developing regions around the globe.

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