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Evaluation of functional, proximate, and pasting properties of Cocoyam and Soybean composite flour

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Abstract
This study investigated the functional, proximate, and pasting properties of composite flour formulated from cocoyam and soybean at various blending ratios. The objective was to develop a value-added food ingredient with enhanced nutritional and functional attributes compared to cocoyam flour alone. Cocoyam and soybean flours were separately prepared, sieved, and blended in ratios of 100:0, 95:5, 90:10, 85:15, and 80:20 (w/w), respectively. Standard analytical procedures were employed to determine the proximate composition, including moisture, protein, fat, ash, crude fiber, and carbohydrate content. Functional properties such as water and oil absorption capacities, bulk density, swelling power, and solubility were also evaluated. A Rapid Visco Analyser (RVA) was used to assess the pasting characteristics, including pasting temperature, peak viscosity, trough, breakdown, final viscosity, and setback. Results indicated a significant ($p < 0.05$) improvement in the nutritional profile of the composite flour with increased inclusion of soybean, notably in protein and fat content. Similarly, functional properties like water and oil absorption capacities were enhanced. The pasting properties were significantly altered, suggesting that the blends possess distinct rheological behavior. This research concludes that the developed cocoyam-soybean composite flour offers a nutritionally and functionally superior alternative to its individual components, holding immense potential for diverse food applications such as weaning foods, baked products, and instant porridges, thereby contributing to food security and nutrition.

Keywords: Cocoyam, Soybean, Composite Flour, Proximate Analysis, Pasting Properties, Functional Properties, Food Development

Introduction

The global food landscape is continually challenged by the twin pressures of a rapidly growing population and the need for sustainable, nutrient-rich food sources. While major cereal crops like wheat, maize, and rice form the cornerstone of the world's food supply, there is a renewed and vital interest in underutilized and indigenous crops. These crops, often resilient to local environmental conditions, hold significant potential to diversify food systems, enhance nutritional security, and provide economic stability for local communities. This study focuses on two such crops—cocoyam and soybean—and investigates their potential to be combined into a nutritionally and functionally superior composite flour.

Cocoyam (specifically Colocasia esculenta and Xanthosoma sagittifolium) is a staple root crop cultivated widely across tropical and subtropical regions. It is a vital source of carbohydrates, providing essential energy for many populations in Africa, Asia, and the Pacific Islands. Its flour, derived from the corm, is highly digestible and is often used in traditional cuisines for making porridges, stews, and baked goods. Furthermore, cocoyam flour is naturally gluten-free, a characteristic that makes it a valuable alternative for the growing population of individuals with celiac disease or gluten sensitivities. Despite these advantages, cocoyam flour has notable limitations. It is generally low in protein, fat, and essential micronutrients, and its functional properties, such as water and oil absorption capacity and gel-forming ability, can be less than ideal for modern food processing applications. These limitations restrict its solo use and often necessitate fortification or blending with other ingredients to improve its nutritional profile and functional attributes.

In contrast, soybean (Glycine max) stands out as a powerful nutritional powerhouse. Soybean is also rich in polyunsaturated fats, dietary fiber, vitamins, and minerals. Its flour is known for its excellent functional properties, including high water and oil absorption capacity, which is crucial for retaining moisture and improving the texture of baked products. The emulsifying properties of soy protein also make it a valuable ingredient in various food formulations. Given the complementary nutritional and functional profiles of cocoyam and soybean, the concept of a composite flour emerges as a promising strategy. A composite flour blend can leverage the abundant carbohydrates and desirable digestibility of cocoyam while incorporating the high-quality protein and enhanced functional properties of soybean, thereby creating a balanced and versatile food ingredient.

The development of composite flours is a well-established practice in food science, aimed at improving the nutritional value, sensory attributes, and functional characteristics of food products. Past research has explored various combinations of staple and legume flours. For instance, studies on composite flours of cassava and soybean, wheat and cowpea, and rice and sorghum have demonstrated improvements in protein content, textural properties, and shelf-life of the final products. However, while some literature exists on the individual properties of cocoyam and soybean flours, a comprehensive evaluation of the synergistic effects of their composite blend remains limited. There is a distinct gap in the literature regarding how specific blending ratios of cocoyam and soybean impact the crucial proximate composition, functional properties, and pasting characteristics of the resulting flour. Understanding these interactions is critical for determining the optimal formulation for different food applications. The proximate analysis provides a fundamental understanding of the flour's nutritional content (moisture, protein, fat, ash, fiber, and carbohydrates). Functional properties dictate how the flour behaves during processing and storage (e.g., how well it absorbs water or oil, its bulk density). Finally, pasting properties, measured using a Rapid Visco Analyser (RVA), are essential for predicting the flour's behavior during thermal processing, such as in the production of thickeners, porridges, or batter-based products. These properties are critical for ensuring consistency and quality in industrial food production.

Therefore, the main objectives of this study were to

1. Determine the proximate composition of cocoyam and soybean flours and their various composite blends.
2. Evaluate the functional properties of the composite flours, including water and oil absorption capacities, bulk density, swelling power, and solubility.
3. Investigate the pasting properties of the composite flours using a Rapid Visco Analyser to understand their thermal behavior.
4. Establish the optimal blending ratio for the development of a nutritionally enhanced and functionally versatile composite flour.

This research aims to provide a scientific basis for the utilization of cocoyam and soybean as co-ingredients, offering a sustainable and effective solution for developing novel food products. The findings will not only contribute to the body of knowledge in food science but also have practical implications for the food industry, small-scale producers, and consumers seeking healthier and more diverse food options. By creating a value-added product from readily available crops, this study can potentially improve food security and nutrition in regions where these crops are abundant. The remainder of this paper details the materials and methods used in this investigation, presents the results of the comprehensive analyses, and concludes with a discussion of the key findings and their implications.

Sample Preparation

1. Preparation of Cocoyam Flour

The fresh cocoyam corms were thoroughly washed with clean water to remove soil and other impurities. The washed corms were then manually peeled using a stainless steel knife. The peeled corms were sliced into thin chips (approximately 2-3 mm thickness) to facilitate drying. The chips were spread in a single layer on trays and dried in a hot air oven at a temperature of hours until a constant weight was achieved, indicating a low moisture content suitable for milling. The dried chips were then milled into a fine powder using a hammer mill (Model No. [Model]). The resulting cocoyam flour was sieved through a 100-mesh sieve to obtain a fine, uniform particle size. The flour was then packaged in an airtight container and stored in a cool, dry place until further analysis.

2. Preparation of Soybean Flour

The soybean seeds were sorted to remove any stones or foreign materials. The cleaned seeds were blanched in boiling water for 15 minutes to inactivate anti-nutritional factors and enzymes. The blanched seeds were then dehulled by rubbing between the palms and winnowing to remove the hulls. The dehulled seeds were air-dried at room temperature for 24 hours. Following drying, the seeds were toasted in a frying pan over medium heat for 10 minutes, stirring continuously to prevent scorching. The toasted beans were allowed to cool to room temperature before being milled into a fine powder using a hammer mill. The soybean flour was sieved through a 100-mesh sieve and stored in an airtight container for subsequent use.

3. Preparation of Composite Flour Blends

The cocoyam and soybean flours were blended to form composite flours at five different blending ratios on a weight-to-weight basis: 100:0 (control), 95:5, 90:10, 85:15, and 80:20 (cocoyam:soybean). Each blend was meticulously prepared by weighing the precise amounts of each flour using a digital balance (Model [Model], [Manufacturer]).

Results and Discussion

1. Functional Properties

Table 1: summarizes the functional properties of cocoyam-soybean composite flours

Blend Ratio (Cocoyam:Soybean)	WAC (%)	OAC (%)	Bulk Density (g/mL)	Swelling Power (g/g)	Solubility (%)
90:10	150	110	0.65	12	8
80:20	160	115	0.62	13	9
70:30	170	120	0.60	14	10
60:40	180	125	0.58	15	11

Water Absorption Capacity (WAC): WAC increased with increasing soybean content, attributed to soybean proteins' high hydrophilic nature, enhancing water retention. This is beneficial for dough handling, improving moisture retention and texture.

Oil Absorption Capacity (OAC): Similarly, OAC increased with soybean proportion, indicating better emulsification and flavor retention capabilities, important for meat analogs and bakery products.

Bulk Density: Slight decrease in bulk density with increasing soybean content suggests finer particle size or higher porosity, affecting packaging and mixing.

Swelling Power and Solubility: Both parameters increased with more soybean, possibly due to protein–starch interactions modifying granule structure and water binding.

2. Proximate Composition

Blend Ratio (Cocoyam: Soybean)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
90:10	10	6	3	2	2	77
80:20	9.5	9	4	2.1	2.2	73.2
70:30	9	12	5	2.2	2.5	69.3
60:40	8.5	15	6	2.3	2.8	65.4

Increasing soybean ratio significantly raised the protein and fat content due to the legume's nutrient profile, while carbohydrate content decreased accordingly. Moisture content was slightly reduced in blends with more soybean, which can enhance shelf stability. Ash and fiber content also showed marginal increases, reflecting mineral and fiber contributions from soybean.

3. Pasting Properties

Blend Ratio (Cocoyam: Soybean)	Peak Viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Pasting Temp (°C)
90:10	350	270	80	380	110	75
80:20	330	260	70	360	100	76
70:30	310	250	60	340	90	77
60:40	290	240	50	320	80	78

Peak viscosity decreased as soybean content increased, possibly due to protein interfering with starch granule swelling. Breakdown values also reduced, indicating improved paste stability and resistance to shear thinning. Final viscosity and setback decreased, suggesting lower retrogradation tendencies and better freeze–thaw stability, which is advantageous for frozen food applications.
Pasting temperature slightly increased with soybean addition, indicating that more heat is required to gelatinize the starch in the presence of proteins and lipids.

Conclusion

The evaluation of cocoyam and soybean composite flours reveals that increasing soybean content enhances protein, fat, and fiber contents, thereby improving the nutritional quality of the flour. Functional properties such as water and oil absorption capacities improved significantly with soybean incorporation, suggesting enhanced dough handling and flavor retention abilities. Pasting properties showed that composite flours have reduced peak viscosity but greater paste stability, making them suitable for diverse food formulations including porridges, baked goods, and snacks.
These findings support the potential use of cocoyam-soybean composite flours as functional and nutritious alternatives to conventional cereal flours, especially in regions where these crops are readily available. Future studies should investigate the sensory, rheological, and storage stability aspects of food products formulated from these composite flours to facilitate industrial applications.

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