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Physicochemical and Mineral properties of Cassava-cocoyam composite flours: Implications for Food security and nutrition

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Abstract

This study evaluated the physicochemical and mineral properties of cassava (Manihot esculenta) flour blended with cocoyam (Colocasia esculenta) flour at various ratios. The proximate composition, pH, water absorption capacity, and starch content were analyzed to determine the optimal blending ratios for enhanced nutritional value. Results showed that pure cassava flour had higher protein (12.76%), ash (4.86%), and crude fiber (1.80%) contents compared to pure cocoyam flour. Conversely, cocoyam flour exhibited higher moisture retention (8.82%) and carbohydrate content (76.64%). Blending the flours produced intermediate values that reflected the proportional contributions of each component. The 50:50 blend demonstrated balanced nutritional properties with protein content of 11.61%, carbohydrate of 74.39%, and moderate water absorption capacity. These findings suggest that cassava-cocoyam composite flours can provide nutritionally enhanced alternatives to pure cassava flour, addressing protein and micronutrient deficiencies in cassava-dependent populations while maintaining desirable functional properties for food processing applications.

Keywords: Composite flour, proximate analysis, cassava-cocoyam, physicochemical properties, food security.

Introduction

The agricultural sector remains a cornerstone in the economic and social fabric of many developing nations, underpinning food security by ensuring a steady supply of essential nutrients to the population[1]. Among the diverse array of crops cultivated in these regions, root crops such as cassava (*Manihot esculenta*) and cocoyam (*Colocasia esculenta*) are particularly significant, being well-suited to tropical and subtropical climates and thriving even in poor soil conditions[2].

Cassava is a vital food source for over half a billion people worldwide, primarily valued for its high carbohydrate content[3]. Cassava flour, also known as tapioca flour, is particularly popular in culinary applications such as bread, pastries, and traditional dishes. However, cassava is often criticized for its relatively low protein content (typically less than 2%) and limited mineral diversity, which can pose significant health risks in communities where cassava constitutes a major part of the diet[4].

Cocoyam, although less cultivated than cassava, is an important root crop with significant nutritional benefits. It is rich in dietary fiber, vitamins (such as vitamin C, vitamin E, and B vitamins), and essential minerals like potassium, magnesium, calcium, and iron[5]. Cocoyam's higher protein content compared to cassava makes it an excellent complementary crop for improving dietary intake, particularly in protein-deficient regions[6]. The concept of composite flour, which involves blending different types of flour to enhance nutritional and functional properties, has gained considerable attention as a strategy to improve food quality and address nutritional deficiencies[7]. Blending cassava with cocoyam can significantly improve the nutritional value of the resulting flour, benefiting from cocoyam's superior protein and mineral content while preserving cassava's desirable functional properties.

This study aims to evaluate the physicochemical and mineral properties of cassava-cocoyam composite flours at various blending ratios. The specific objectives are to analyze the proximate composition, determine the physicochemical properties, assess the mineral content, and evaluate the potential applications of the composite flours in food processing.

Materials and Methods

Sample preparation: Cassava flour and cocoyam were sourced from Bodija market in Ibadan, Oyo State, Nigeria. The samples were carefully selected based on criteria such as texture, color, and overall appearance. Upon acquisition, samples underwent thorough visual inspection to identify any defects or signs of spoilage. Products showing signs of deterioration were discarded to maintain study integrity.

Proximate analysis: The proximate composition including moisture content, ash content, crude protein, crude fat, crude fiber, and carbohydrate was determined using standard AOAC methods. Moisture content was determined by oven-drying at 105°C for 24 hours.

Ash content was determined by incineration in a muffle furnace at 550°C. Crude protein was determined using the macro Kjeldahl procedure with a conversion factor of 6.25. Crude fat was extracted using the Soxhlet method with petroleum spirit. Crude fiber was determined by acid and alkali digestion. Carbohydrate content was calculated by difference.

Physicochemical properties: The pH of flour samples was determined by mixing 10g of flour with 100 mL distilled water, stirring for 30 minutes, and measuring with a calibrated digital pH meter. Water absorption capacity was determined by the method described by Beuchat, L.R.[8]. Bulk density was measured by gently pouring flour into a 100mL graduated cylinder and calculating the ratio of weight to volume. Starch content was determined using an enzymatic method involving hydrolysis with alpha-amylase and measurement of glucose content.

Statistical analysis: All analyses were performed in triplicate. Data were expressed as mean ± standard deviation (SD). Descriptive statistics were calculated to summarize the central tendencies and variability of the data.

Results and Discussion

Proximate composition: The proximate composition of cassava flour, cocoyam flour, and their blends is presented in Table-1. Pure cassava flour (100K) showed a moisture content of 8.52 ± 0.33%, while pure cocoyam flour (100C) had a slightly higher moisture content of 8.82 ± 0.06%. The ash content was notably higher in cassava flour (4.86 ± 0.09%) compared to cocoyam flour (3.37±0.10%), indicating greater mineral content in cassava. Crude fiber content was higher in cassava flour (1.80 ± 0.02%) compared to cocoyam flour (1.52 ± 0.02%).

Fat content followed a similar pattern, with cassava flour containing 0.81 ± 0.02% fat compared to 0.46 ± 0.01% in cocoyam flour. Protein content was significantly higher in cassava flour (12.76 ± 0.08%) than in cocoyam flour (9.50 ± 0.04%). Conversely, carbohydrate content was higher in cocoyam flour (76.64 ± 0.08%) compared to cassava flour (72.57 ± 0.07%).

Protein and carbohydrate content: The protein and carbohydrate content of the composite flours showed clear trends based on blending ratios. As the proportion of cassava flour increased, protein content increased proportionally, ranging from 9.50% in pure cocoyam to 12.76% in pure cassava. The 50:50 blend provided a balanced protein content of 11.61 ± 0.03%. Carbohydrate content showed an inverse relationship, with higher values observed in cocoyam-rich blends.

Physicochemical properties: The pH values of the flour samples ranged from 4.22 to 6.48 (Table-2). Pure cassava flour had a pH of 6.43 ± 0.02, while pure cocoyam flour had a pH of 6.05 ± 0.02. The 50:50 blend showed the lowest pH value of 4.22 ± 0.02. Water absorption capacity (WAC) was highest in pure cassava flour (1.526 ± 0.002 g/g) and lowest in the 20K/80C blend (0.930 ± 0.004 g/g).

Starch content: Starch content varied significantly among the samples, ranging from 0.976 mg/g in pure cocoyam to 11.218 mg/g in the 40K/60C blend (Table-3). The highest starch content was observed in the 40K/60C blend, suggesting a synergistic effect at this particular ratio. Pure cassava flour contained 2.446 ± 0.004 mg/g starch.

Table-1: Proximate composition of cassava-cocoyam composite flours (%, dry weight basis).

Sample	Moisture	Ash	Fiber	Fat	Protein	CHO
100K	8.52±0.33	4.86±0.09	1.80±0.02	0.81±0.02	12.76±0.08	72.57±0.07
100C	8.82±0.06	3.37±0.10	1.52±0.02	0.46±0.01	9.50±0.04	76.64±0.08
50K/50C	8.48±0.06	4.41±0.08	1.63±0.01	0.70±0.02	11.61±0.03	74.39±0.04
90K/10C	8.21±0.04	4.84±0.11	1.77±0.02	0.76±0.02	12.42±0.03	73.02±0.07
10K/90C	8.86±0.09	3.92±0.05	1.60±0.01	0.55±0.01	9.90±0.03	74.23±0.06
80K/20C	9.63±0.04	3.87±0.06	1.70±0.02	0.62±0.01	10.77±0.02	73.18±0.06
20K/80C	8.65±0.03	3.48±0.03	1.66±0.01	0.54±0.01	10.05±0.03	74.49±0.07
60K/40C	9.49±0.09	4.26±0.10	1.74±0.02	0.68±0.02	11.07±0.02	73.45±0.07
40K/60C	10.73±0.06	4.32±0.09	1.71±0.02	0.62±0.02	10.68±0.02	73.17±0.07
30K/70C	9.26±0.08	3.82±0.04	1.65±0.01	0.60±0.02	9.95±0.03	74.15±0.07
70K/30C	8.56±0.08	4.44±0.07	1.75±0.02	0.71±0.02	11.38±0.02	72.76±0.07

Table-2: Physicochemical properties of cassava-cocoyam composite flours.

Sample	pH	Water Absorption (g/g)	Bulk Density (g/ml)
100K	6.43±0.02	1.526±0.002	0.72±0.01
100C	6.05±0.02	1.036±0.004	0.68±0.01
50K/50C	4.22±0.02	0.990±0.005	0.70±0.01
90K/10C	6.45±0.01	1.364±0.003	0.71±0.01
10K/90C	6.36±0.01	1.193±0.002	0.69±0.01
80K/20C	5.34±0.02	1.203±0.002	0.70±0.01
20K/80C	6.48±0.02	0.930±0.004	0.67±0.01
60K/40C	6.46±0.03	1.445±0.002	0.71±0.01
40K/60C	6.36±0.02	1.118±0.003	0.68±0.01
30K/70C	6.36±0.02	1.142±0.003	0.69±0.01
70K/30C	6.32±0.01	1.238±0.004	0.70±0.01

Table-3: Starch content of cassava-cocoyam composite flours.

Sample	Replication	Mean (mg/g)	Mean ± SD
100C	3	0.976	0.976±0.005
90K/10C	3	1.753	1.753±0.004
20K/80C	3	1.754	1.754±0.006
30K/70C	3	4.281	4.281±0.004
10/90C	3	6.193	6.193±0.004
40K/60C	3	11.218	11.218±0.005
50K/50C	3	6.654	6.654±0.005
100K	3	2.446	2.446±0.004
70K/30C	3	3.088	3.088±0.004
80K/20C	3	6.840	6.840±0.009

The results of this study demonstrate that blending cassava and cocoyam flours produces composite flours with distinct and complementary functional properties. The higher protein content in cassava flour (12.76%) compared to cocoyam flour (9.50%) is consistent with previous reports[9,5]. This finding is significant as protein-energy malnutrition remains a critical health concern in cassava-dependent regions.

The ash content results indicate that cassava flour contains higher mineral content than cocoyam flour. This is particularly important for addressing micronutrient deficiencies, which are prevalent in populations consuming cassava-dominant diets. The higher ash content in cassava suggests greater levels of essential minerals such as calcium, iron, and zinc, which are critical for various physiological functions including bone health, oxygen transport, and immune function[10].

The moisture retention properties of cocoyam flour (8.82%) compared to cassava flour (8.52%) suggest that cocoyam-rich blends would be more suitable for applications requiring higher water content, such as pastries and noodles. However, manufacturers should carefully consider moisture content in blends, particularly in humid environments where shelf life is a concern.

The water absorption capacity was highest in pure cassava flour (1.526 g/g), indicating its superior ability to absorb and retain water. This property is crucial for determining the functionality of flour in various food applications, affecting factors such as dough formation and baking quality. The lower WAC in cocoyam-rich blends may be attributed to differences in starch structure and protein composition.

The starch content analysis revealed interesting synergistic effects, with the 40K/60C blend showing the highest starch content (11.218 mg/g). This suggests that specific blending ratios may enhance the functional properties of the composite flour beyond what would be expected from simple proportional mixing. Such synergistic effects could be exploited in developing optimized flour formulations for specific food applications.

From a nutritional perspective, the 50:50 blend offers a balanced profile with moderate protein content (11.61%), high carbohydrate content (74.39%), and acceptable levels of ash (4.41%) and crude fiber (1.63%). This blend could serve as an effective strategy for improving the nutritional quality of cassava-based foods while maintaining desirable sensory attributes.

Conclusion

This study demonstrates that blending cassava and cocoyam flours yields composite flours with enhanced nutritional and functional properties. The key findings indicate that: i. Cassava flour contributes higher levels of protein, ash, crude fiber, and fat to the blends, making it vital for products requiring enhanced nutritional value. ii. Cocoyam flour enhances moisture retention and carbohydrate content, making it suitable for applications where higher water content is desirable. iii. The 50:50 blend provides a balanced nutritional profile suitable for addressing protein and micronutrient deficiencies in cassava-dependent populations. iv. Specific blending ratios (particularly 40K/60C) show synergistic effects on starch content that could be exploited for functional food applications.

These findings are critical for industries aiming to optimize flour blends for specific food products. The strategic use of cassava-cocoyam composite flours can significantly enhance the versatility and applicability of these flours in diverse food formulations while contributing to food security and nutritional improvement in developing regions. Further research should explore the sensory acceptability and storage stability of products made from these composite flours.

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