Chemical Composition of Cassava Starch Flour and Sensory Evaluation of Soup Made with the Flour

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Abstract

Although cassava (and its derivatives) is widely recognized as a global staple, its chemical characteristics and culinary performance can vary significantly, affecting both its nutritional value and its acceptance as an ingredient in meal preparation. This study evaluated the chemical composition of cassava starch flour derived from *Manihot esculenta* and assessed its sensory performance as a thickening agent in Nigerian Oha soup. The study design was quasi-experimental, and standard methods were used for chemical analysis. Data were analysed in IBM SPSS, version 23.0, using means and standard deviations. Proximate analysis revealed that cassava starch flour contained lower total carbohydrates (70.13%), but higher moisture (12.78%), crude fat (3.10%), crude protein (8.65%), ash (2.09%), and crude fiber (3.25%) when compared to the conventional thickener, cocoyam flour. Cassava starch flour demonstrated higher levels of vitamin B1 (0.15mg/100g), B2 (11.45mg/100g), B9 (0.50µg/100g), and E (15.75mg/100g) compared to cocoyam flour. Mineral analysis revealed a higher iron content (6.62mg/100g) in cassava starch flour compared to cocoyam flour. Although within stipulated standards, cassava starch flour contained higher levels of anti-nutrients such as, tannins (128.25 ± 0.21 mg) and cyanogenic glycosides (5.35 ± 0.07 mg), but lower amounts of phytates (159.15 ± 0.21 mg). The sensory evaluation indicated that soup thickened with cassava starch flour received higher scores for taste, colour, flavour, texture, and general acceptability, comparable to soups prepared with cocoyam flour (control). This study concludes that cassava starch flour contains lower carbohydrates but has higher vitamins and iron content and is more generally acceptable than cocoyam flour. The high content of anti-nutrients in the cassava starch flour suggests the need to optimize processing methods to reduce anti-nutritional components while maintaining their functional and sensory properties.

Keywords: cassava starch flour, proximate composition, sensory evaluation, soup thickener

Introduction

Soups have long served as a cornerstone of global culinary traditions, offering both nutritional sustenance and cultural significance. From ancient broths to modern gastronomic innovations, their preparation reflects regional agricultural practices, dietary customs, and socio-economic conditions (Famakinwa et al., 2024). In Nigeria, soups such as egusi, oha, and bitter leaf are deeply embedded in cultural rituals and daily diets, often thickened with starchy agents like cocoyam flour (Lawal & Enujiugha, 2018). However, total reliance on this conventional thickener without exploring other options can be hindered by the high cost of purchasing when it is not in season and limited availability in some areas, which may be due to a poor road network (Sabença et al., 2021). These constraints necessitate the exploration of alternative, locally sustainable thickeners, such as cassava derivatives, that preserve sensory quality while meeting nutritional needs.

Cassava (*Manihot esculenta*) is a cornerstone of food security in sub-Saharan Africa, owing to its resilience to drought, high yield potential, and diverse applications (Wambua et al., 2024), and offers a promising solution through its derivative, cassava starch flour. As a pure starch extracted from cassava roots, cassava starch flour is gluten-free, functionally versatile, and economically viable for large-scale production (Verma et al., 2022). Cassava flour has a high carbohydrate content (84.86%) with a low proportion of crude fat and protein, as well as traces of calcium, iron, and zinc, along with a wide variation in phytates. Additionally, meals derived from cassava induce prolonged satiety, a characteristic of the type and quantity of starch in cassava flour (Wambua et al., 2024). Its high amylopectin content confers superior thickening properties, yielding smooth textures and stability under prolonged heating, a critical attribute for traditional soups requiring extended simmering (Rashwan et al., 2024). Despite these potentials, cassava starch flour remains underutilised in Nigerian cuisine, partly due to limited empirical data on its nutritional profile and sensory performance in savoury applications.

The nutrient composition of food is a crucial concept in nutritional science, focusing on the precise chemical components that comprise a food item. According to Okoye et al. (2023), nutrients, including both micronutrients and macronutrients, are essential to life because they provide energy, serve as building blocks, and regulate various chemical processes. It is important to comprehend the components of these nutrients in food, as their proper balance affects a food's ability to deliver health benefits (Espinosa-Salas & Gonzalez-Arias, 2023; Otoo et al., 2024). Healthy diets can enhance overall health, improve general well-being, and reduce the risk of developing certain diseases (Oguejiofor et al., 2022; Okoye et al., 2023). Chemical analysis is supplemented by sensory evaluation, a scientific discipline that evokes, measures, analyzes, and interprets human reactions to the sensory features of food and materials (Stone & Sidel, 2004). This evaluation considers appearance, scent, texture (mouthfeel), and flavour, providing critical insights into consumer acceptability, preference, and overall product quality, hence connecting chemical makeup to real-world consuming experience (Saleh & Lee, 2023).

This notwithstanding, existing research on cassava starch flour has

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predominantly emphasized industrial uses, such as adhesives or gluten-free baking, with scant attention to its role in traditional food systems (Breuninger et al., 2009). For instance, there is limited research on the chemical composition of cassava starch flour and its impact on the sensory properties of soups. Furthermore, there is also a limited comparative study on cassava starch flour and the commonly used traditional thickener. By addressing these gaps, this study provided evidence-based recommendations for the use of cassava starch flour in both household and industrial contexts, promoting food security and dietary inclusivity, while also offering insights into its potential applications and acceptability in different culinary contexts. While cassava contains antinutritional compounds, such as cyanogenic glycosides, proper processing, including fermentation or thorough washing, can reduce these to safe levels (Montagnac et al., 2009). This study also provided standardised guidelines for using cassava starch flour in soup thickening, since there were none. Specifically, the study aimed to characterize the proximate composition, vitamin and mineral content, and antinutritional factors of cassava starch flour, and evaluate the sensory acceptability of oha soup prepared with the flour compared to a cocoyam flour-based control.

Objectives of the study: The specific objectives of the study were to determine the:

1. proximate composition (moisture, crude fat, protein, ash, fibre, and carbohydrate) of cassava starch flour in comparison with cocoyam flour;
2. vitamin and mineral content of cassava starch flour in comparison to cocoyam flour;
3. levels of antinutritional factors (tannins, phytates, and cyanogenic glycosides) in cassava starch flour relative to cocoyam flour; and
4. sensory properties (taste, colour, flavour, texture, and overall acceptability) of soups thickened with cassava starch flour compared to cocoyam flour.

Materials and methods

Study design: The study adopted a quasi-experimental research design.

Procurement of samples: Four hundred kilograms of TMS 30572 (a species of cassava) was procured from Orie Orba Market in Udenu LGA, Enugu State, Nigeria. The roots were firm, fresh, and 12 months old.

Preparation of the sample: The cassava roots were thoroughly cleaned to remove soil and debris, manually peeled, and washed to eliminate surface contaminants. The peeled roots were grated into a pulp using a mechanical grinder, and the resulting mash was sieved through a muslin cloth (diameter 150-200 micrometres) to separate the liquid starch from fibrous solids. The starch slurry was allowed to sediment for 24 hours. This is to have a higher quality starch free from impurities, after which the supernatant was decanted. The settled starch was washed multiple times with distilled water to reduce cyanogenic glycosides and other impurities. The purified starch was then air-dried at a controlled temperature (40-50^{0}C, humidity: 60-70٪) room temperature (28±2°C) for 20 hours to achieve a moisture content below 15%, as recommended by WHO/FAO (2004) standards. The dried starch was milled into a fine flour, packaged in airtight zip-lock pouches, and stored under ambient conditions until further analysis. Already made cocoyam flour was purchased from a food stuff vendor in Ogige market, Nsukka LGA, Enugu state, Nigeria.

Preparation of oha soup: Oha soup, a traditional Nigerian dish, was prepared using two thickeners: cassava starch flour (experimental) and cocoyam flour (control) in two different pots. The ingredients included 300 g of fresh Oha leaves, 2 tablespoons each of the thickeners (cassava starch flour and cocoyam flour), 500g of assorted meats (goat meat, beef, and chicken), 100g of dry fish, 250mL of palm oil, 2 tablespoons of ground crayfish, 1 tablespoon of ground pepper, 3 seasoning cubes, ¼ tablespoon of salt, 1200ml of water and 1 tablespoon of ogiri (a traditional flavor enhancer). The meat was cleaned, cut into bite-sized pieces, and boiled with seasoning cubes and salt until tender. Dry fish was added toward the end of the meat cooking process. Palm oil was introduced and allowed to boil for 10 minutes to integrate flavors. The thickeners: cassava starch flour (experimental) and cocoyam flour (control) were mixed with cold water to form a slurry and added to each pot of soup respectively. Ground crayfish, pepper, and ogiri were incorporated, and the mixture was simmered. Finally, chopped Oha leaves were added and cooked for 5–10 minutes before serving.

Chemical analysis: All chemical analyses were performed in duplicate using standard methods outlined by the Association of Official Analytical Chemists (AOAC, 2010).

Proximate composition: The moisture content was determined by oven-drying (AOAC, 2010) 2g of sample at 105°C for 6 hours until a constant weight was achieved. Crude fat was extracted using petroleum ether in a Soxhlet apparatus using the Kjeldahl method (AOAC, 2010), while crude protein was quantified via the micro-Kjeldahl method, with nitrogen conversion to protein using a factor of 6.25. Ash content was measured by incineration in a muffle furnace at 550°C for 3 hours. Crude fibre was determined by sequential acid and alkali digestion, and total carbohydrates were calculated by difference.

Vitamin and mineral analysis: Fat-soluble vitamins (e.g., vitamin E) were extracted using organic solvents and quantified via high-performance liquid chromatography (HPLC) with fluorescence detection (AOAC, 2010). Water-soluble vitamins (B1, B2, B9) were analyzed using spectrophotometric and enzymatic methods. Minerals (calcium, iron, magnesium, sodium) were measured using atomic absorption spectrophotometry (AAS) and complexometric titration with EDTA (AOAC, 2010).

Anti-nutrient determination: Tannins were quantified spectrophotometrically at 510 nm after reaction with ferric chloride (Makkar et al., 2003). Phytate content was determined using HPLC with a reverse-phase C18 column, while cyanogenic glycosides were assessed colourimetrically following solvent extraction and complex formation.

Sensory evaluation: A 9-point hedonic scale (1 = "dislike extremely," 9 = "like extremely") was employed to evaluate the sensory attributes of the soups, including taste, colour, flavour, texture, and overall acceptability. A panel of 50 trained judges, recruited from the Staff and students of the University of Nigeria, Nsukka, participated in the evaluation. Samples were presented in randomized order under controlled lighting and temperature conditions. Panelists were given water to cleanse their palate between evaluations, ensuring that successive samples were assessed without carry-over effects. The scores were collected from the panelists and the mean score for each attribute and sample were calculated.

Statistical analysis: Data were analyzed using IBM-SPSS, version 25.0. Results are presented as mean ± standard deviation.

Results

Proximate composition of cassava starch flour and cocoyam flour

The proximate analysis of cassava starch flour (TC2) and cocoyam flour (TC1, control) revealed differences in nutritional composition (Table 1). Cassava starch flour exhibited higher moisture (12.78 ± 0.00), crude fat (3.10 ± 0.14), crude protein (8.65 ± 0.07), ash (2.09 ± 0.00), and crude fiber (3.25 ± 0.07) compared to cocoyam flour that exhibited 5.48 ± 0.00 moisture, crude fat (1.15 ± 0.12), crude protein (2.10 ± 0.00), ash (0.19 ± 0.00), and crude fiber (2.00 ± 0.14). However, cocoyam flour had a higher carbohydrate content (89.08 ± 0.36) than cassava starch flour (70.13 ± 0.29). The low moisture content (<15%) in both flour samples aligns with WHO/FAO (2004) standards for shelf-stable products, suggesting suitability for long-term storage.

Table 1: Proximate composition of cassava starch and cocoyam flours (%/100g)

Parameter	Cassava starch flour (TC2)	Cocoyam flour (TC1)
Moisture	12.78 ± 0.00	5.48 ± 0.00
Crude Fat	3.10 ± 0.14	1.15 ± 0.12
Crude Protein	8.65 ± 0.07	2.10 ± 0.00
Ash	2.09 ± 0.00	0.19 ± 0.00
Crude Fiber	3.25 ± 0.07	2.00 ± 0.14
Total Carbohydrate	70.13 ± 0.29	89.08 ± 0.36

Values are mean ± SD of duplicate determinations

Vitamins and minerals profiles of cassava starch and cocoyam flours

Cassava starch flour demonstrated superior vitamin content, with higher levels of vitamin B1 (0.15 ± 0.07 mg), B2 (11.45 ± 0.07 mg), B9 (0.50 ± 0.00 µg), and E (15.75 ± 0.07 mg) compared to cocoyam flour (0.07 ± 0.01, 0.20 ± 0.14 mg, 0.05 ± 0.01 µg, and 0.20 ± 0.14 mg, respectively (Table 2). Mineral analysis indicated that cassava starch flour had higher iron content (6.62 ± 0.72 mg) but lower calcium (51.39 ± 1.97 mg) and sodium (7.81 ± 0.29 mg) than cocoyam flour.

Table 2: Vitamins and mineral contents of cassava starch and cocoyam flours

Vitamins (per 100g)	Cassava starch Flour (TC2)	Cocoyam Flour (TC1)
B1 (mg)	0.15 ± 0.07	0.07 ± 0.01
B2 (mg)	11.45 ± 0.07	0.20 ± 0.14
B9 (µg)	0.50 ± 0.00	0.05 ± 0.01
E (mg)	15.75 ± 0.07	0.20 ± 0.14
Minerals (mg/100g)		
Calcium	51.39 ± 1.97	56.78 ± 1.73
Iron	6.62 ± 0.72	4.34 ± 0.36
Magnesium	36.31 ± 0.95	36.92 ± 0.08
Sodium	7.81 ± 0.29	8.25 ± 0.30

Values are mean ± SD of duplicate determinations

Anti-nutritional factors

Cassava starch flour contained higher tannins (128.25 ± 0.21 mg) and cyanogenic glycosides (5.35 ± 0.07 mg) but lower phytates (159.15 ± 0.21 mg) than cocoyam flour (Table 3). The cyanogenic glycoside levels, though detectable, were below the FAO/WHO safety threshold (10 mg/100g) for processed cassava products.

Table 3: Anti-nutrient content of cassava starch and cocoyam flours (mg/100g)

Anti-Nutrient	Cassava starch flour (TC2)	Cocoyam flour (TC1)
Tannins	128.25 ± 0.21	0.60 ± 0.14
Cyanogenic Glycosides	5.35 ± 0.07	1.95 ± 0.21
Phytates	159.15 ± 0.21	182.05 ± 0.07

Values are mean ± SD of duplicate determinations

Sensory evaluation of soup

Table 4 shows the sensory evaluation of cassava starch flour and cocoyam flour as a control. Cassava starch flour had a higher mean score for taste (8.20 ± 0.81), colour (8.23 ± 0.82), flavour (8.13 ± 0.90), and texture (8.20 ± 0.80) compared to cocoyam flour (Table 4). The soup made with cassava starch flour (8.13 ± 1.11) was also more generally acceptable compared to the soup made with cocoyam flour (8.07 ± 0.91).

Table 4: Sensory scores of soups thickened with cassava starch vs. cocoyam flour

Attribute	Cassava starch flour soup (TC2)	Cocoyam flour soup (TC1)
Taste	8.20 ± 0.81	8.03 ± 1.10
Colour	8.23 ± 0.82	7.90 ± 1.18
Flavour	8.13 ± 0.90	7.80 ± 1.21
Texture	8.20 ± 0.80	7.87 ± 1.20
General Acceptability	8.13 ± 1.11	8.07 ± 0.91

Scale: 1 (Dislike extremely) to 9 (Like extremely). Values are mean ± SD of duplicate determinations

Discussion

The findings of this study highlight the nutritional properties of cassava starch flour and its acceptability in culinary applications. Below, we discuss these findings in the context of existing literature, their implications, and future research directions.

Proximate composition analysis measures the major nutrients (moisture, protein, fat, ash, and carbohydrate) to provide a nutritional profile, helping to assess the stability, quality, and functionality of food materials (Akonor et al., 2017). This analysis is particularly useful when comparing flours from starchy roots, such as cassava and cocoyam. Findings showed that cassava starch flour exhibited higher moisture, crude fat, crude protein, ash, and crude fibre compared to cocoyam flour, while cocoyam flour had a higher carbohydrate content. The higher protein, fat, fibre, and ash content in cassava starch flour suggests it may provide a more balanced nutrient profile compared to cocoyam flour, which is predominantly carbohydrate-dense. Supporting the present study's results, Akonor et al. (2017) observed that cassava flour contributed more protein and fibre in composite blends, while, similarly, Abel et al. (2023) highlighted cocoyam flour's carbohydrate-rich nature but lower protein and fat, collectively reinforcing the comparative advantage of cassava starch flour in terms of nutrient diversity. In addition, Obinna-Echem and Ogbuagha (2023) reported cocoyam's limited protein and fat contributions, consistent with the present study's findings. The low moisture content in the samples suggests stability during storage, as microbial activity is minimized in low-water-activity foods (Tapia et al., 2020). However, the low fibre content (<14%) raises concerns about its role in digestive health, as dietary fibre is critical for gut motility and metabolic regulation (Bulsiewicz, 2023). These findings underscore the importance of dietary diversification to potentially enhance the functional and nutritional qualities of the food products (Imoisi et al., 2024; Olanrewaju et al., 2024).

The vitamin and mineral composition of food materials is a critical determinant of their nutritional quality, influencing physiological functions, dietary adequacy, and overall health outcomes (Tardy et al., 2020). Findings showed that cassava starch flour demonstrated superior vitamin content, with higher levels of vitamin B1, B2, B9, and E compared to cocoyam flour. Mineral analysis indicated that cassava starch flour had higher iron content but lower calcium and sodium than cocoyam flour. The higher levels of vitamin B2, B9, and E in cassava starch flour suggest it may contribute more significantly to metabolic functions, antioxidant defense, and red blood cell formation compared to cocoyam flour (Mrowicka et al., 2023). The higher vitamin E in cassava starch flour suggest better antioxidant protection, potentially lowering risks for chronic diseases (National Institute of Health, 2021). The elevated iron content in cassava starch flour highlights its potential role in addressing iron-deficiency anemia, a common nutritional challenge in sub-Saharan Africa. Supporting these findings, Akonor et al. (2017) and

Ogundele et al. (2022) reported cassava's richer micronutrient profile, particularly in B-vitamins and iron, while Obinna-Echem and Ogbuagha (2023) emphasized cocoyam's higher calcium contribution, corroborating the current study's observation. These complementary micronutrient profiles suggest the blending of cassava and cocoyam flours to achieve adequate nutrition (Samuel et al., 2012), with cassava enhancing vitamin and iron intake, and cocoyam supporting calcium and electrolyte balance. Such integration aligns with FAO/WHO (2004) recommendations on dietary diversification to ensure adequate micronutrient intake.

The anti-nutrient composition of food materials is a crucial consideration in nutritional evaluation, as compounds such as tannins, phytates, and cyanogenic glycosides can interfere with protein digestibility, mineral bioavailability, and the overall safety of consumption. However, when present at controlled levels or reduced through processing, they may also contribute functional properties such as antioxidant activity (Okaiyeto et al., 2025; Salim et al., 2023). Findings showed that cassava starch flour contained higher tannins and cyanogenic glycosides but lower phytates than cocoyam flour, although in safe amounts. The fact that the level is detectable but safe demonstrates that the specific processing method used to produce the cassava starch flour was largely effective. The tannin content, though high, may confer antioxidant benefits at moderate levels (Ozogul et al., 2025). Cocoyam flour's higher phytate content could inhibit mineral absorption (e.g., iron, calcium), whereas cassava starch flour's lower phytate levels may improve bioavailability of these nutrients (Ndubuisi & Chidiebere, 2018; Ayele et al., 2021). The finding that cassava starch flour contained higher tannins and cyanogenic glycosides but lower phytates than cocoyam flour is consistent with prior research. For instance, Ezeocha & Ojimelukwe (2012) reported similar patterns, noting cassava's elevated tannin and cyanide levels compared to cocoyam's higher phytate content. These underscore the importance of efficient processing methods, as cassava starch flour, when prepared safely, provides a nutritionally viable thickener with manageable antinutritional risks.

Sensory evaluation is important as it links the chemical and nutritional composition of food materials to consumer perception, thereby providing valuable insights into product quality and market potential (Lawless & Heymann, 2010; Stone et al., 2012). Findings showed that cassava starch flour had a higher mean score for taste, colour, flavour, and texture compared to cocoyam flour. The soup made with cassava starch flour was also more generally acceptable than the soup made with cocoyam flour. Cassava starch flour's higher sensory scores suggest that it produces soups with a more appealing taste, colour, flavour, and texture than cocoyam flour, although the literature shows that consumer preferences can vary by processing method, product type, and cultural context (Shavitt & Cho, 2016). This study's findings suggest that cassava starch flour's smoother mouthfeel, mild flavour, lighter colour, and consistent viscosity collectively enhance palatability, visual appeal, and texture, resulting in higher overall sensory acceptability compared to cocoyam flour, consistent with its use in gluten-free products (Olanrewaju et al., 2023). Cassava starch flour's higher sensory scores for taste, colour, flavour, and texture align with prior studies (Akonor et al., 2017; Udoudoh et al., 2020), who reported cassava's positive impact on sensory attributes in applicable products. Additionally, Abel et al. (2023) noted that cocoyam flour alone can lower sensory scores, which aligns with the lower ratings for soups made with cocoyam flour observed in this study. This highlights the importance of consumer education in promoting cassava flour as a viable alternative, particularly for individuals with gluten sensitivity (AL-Othman et al., 2022).

Conclusion

This study provides a comprehensive evaluation of cassava starch flour's chemical composition and its performance as a soup thickener, yielding several key findings with important implications. The proximate analysis confirms cassava starch flour's role as a high-carbohydrate, moderate protein ingredient, consistent with its traditional use as an energy-dense food source. While its mineral profile shows nutritionally relevant iron content, the presence of anti-nutritional factors, particularly cyanogenic glycosides and tannins, necessitates careful processing to ensure food safety and optimal nutrient bioavailability. The sensory evaluation demonstrates that cassava starch flour performs comparably to traditional cocoyam flour in terms of taste, texture, and overall acceptability when used in oha soup preparation. This finding is particularly significant given the growing demand for gluten-free alternatives in global markets. The flour's neutral flavour profile and thickening properties make it a viable option for diverse culinary applications beyond traditional uses.

Recommendations

Some important recommendations that emerge from the findings of this study are as follows.

1. Nutritionists and food manufacturers should collaborate to develop and optimize processing techniques that effectively reduce cyanogenic glycosides and tannins while maintaining the desirable functional properties of cassava starch flour.
2. Nutritionists should investigate opportunities for nutritional enhancement through fortification or blending cassava starch flour with protein-rich ingredients to improve dietary value.
3. Stakeholders and extension services should promote awareness of cassava starch flour's potential as a reliable soup thickening alternative, particularly during periods when cocoyam is out of season.

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