

Development and Analysis of 'Tsatsafa' Using Composite Flour Derived from Arrowroot (*Tacca leontiopetaloids*), green gram (*Vigna radiata*), and Tiger Nuts (*Cyperus esculentus*) for better family nutrition amidst global downturn

John Wukatda Darbe, Seyil Hannah Wadak & Makplang Taru

Abstract

This study explores the development and nutritional analysis of tsatsafa, a traditional snack, utilizing composite flour derived from arrowroot, green gram, and tiger nuts. As global economic challenges impact food security, enhancing family nutrition becomes paramount. Five samples were formulated using arrowroot, green gram, and tiger nut in the following ratios: 100:0:0, 50:25:25, 30:30:40, 30:40:30, 20:50:30 respectively. The flours were analyzed for proximate and functional properties using standard methods. Tsatsafa was prepared using modified traditional methods and sensory properties were evaluated. The findings revealed moisture content ranging from 10.00 to 11.30%, ash content between 1.30 and 2.60%, protein levels from 5.45 to 12.50%, fat content varying from 1.20 to 10.50%, crude fiber between 2.50 and 11.50%, and carbohydrates ranging from 58.20 to 79.55%, tannin content (1.5–8.1 mg/100), and phytate content (6.8–34.6 mg/100). The flour's functional properties, such as bulk density and absorption capacities, highlight its versatility for various food applications, showcasing its effective interaction with water and oil along with desirable texture. Significant fortification trends ($p < 0.05$) in tsatsafa samples revealed increased crude fat and protein, enhancing nutritional value, while moderate crude fiber and ash levels indicate balanced enrichment, with carbohydrates as the primary energy source. A significant difference ($p < 0.05$) in sensory qualities was observed, with sample AGT (50:25:25) achieving the highest acceptance score of 7.52, followed by 100% arrowroot flour at 7.23. Conversely, AGT (20:50:30) received the lowest score of 6.01 among consumers. This study highlights that tsatsafa can be a nutritious and culturally relevant snack, rich in protein, fiber, and essential nutrients, emphasizing the importance of innovative food solutions for enhancing nutritional resilience.

Key words: Food development, 'Tsatsafa', Composite Flour, Nutritional Analysis, Nutrient Enrichment

Introduction

The development of food products using composite flour has increased and is attracting much attention from researchers, especially in the production of bakery products and pastries. 'Tsatsafa'

is a popular deep-fried snack in Hausa cuisine made from starchy flours that holds cultural significance in Northern Nigeria and other parts of West Africa. It is typically made from starchy

ingredients, providing a source of energy and nutrition. The exploitation and development of potential non-conventional crop species offered a good scope to improve nutrition and household food security (Agulanna, 2020). The use of composite flours in food production has gained attention due to their potential to improve nutritional quality and functional properties. It is possible to consider the use of starch obtained from arrowroot, green gram and tiger nut flour blends to curb the existing problem of food insecurity, malnutrition and high cost of animal-based food to enrich the traditional formulations. *Tacca leontopetaloides*, also known as Polynesian arrowroot from the Taccaceae family, is a perennial herb that grows in Nigeria's tropical rainforests and guinea savannahs. Raw arrowroot tubers are toxic, but soaking and rinsing make them safe, providing a crucial food source for indigenous communities in Nigeria's Middle Belt, particularly in Plateau State during shortages (Amadi et al., 2021). The development of arrowroot flour, known for its high digestibility and low allergenic potential, presents a valuable opportunity to enhance nutrition and food security, particularly in gluten-free baked goods where it improves texture and moisture retention (Uachisso, et al., 2023). Green gram or mung beans (*Vigna radiata*) are a nutrient-dense legume, high in protein, fiber, vitamins, and minerals, while being low in calories and fat, making them great for heart health, digestion, and energy, along with antioxidants that combat oxidative stress (Mehta et al., 2021, Muchimapura et al., 2024). Tiger nuts (*Cyperus esculentus*), botanically a tuber but often classified as a nut, are rich in monounsaturated fats, fiber, and minerals like potassium and calcium, contributing to improved cholesterol levels and cardiovascular health (Edo et al., 2023).

Traditional food systems reflect cultural heritage and local availability, enhancing the nutrient density and appeal of community meals (Nkwonta et al., 2023). While *tsatsaba* holds cultural significance, concerns about its nutritional quality persist due to traditional recipes often lacking essential nutrients, and limited research on composite flours like those made from arrowroot, green gram, and tiger nuts hinders understanding their potential benefits. This study aims to develop a composite flour that enhances *tsatsaba*'s quality and evaluates its nutritional composition, functional properties and sensory acceptance.

Objectives

The study is guided by 3 objectives as follows:

1. Formulate a composite flour for '*tsatsaba*' production using specific ratios of arrowroot, green gram and tiger nuts flours,
2. Evaluate nutritional composition and functional properties of '*tsatsaba*'
3. Conduct sensory evaluations of '*tsatsaba*' made from the composite flour mix while exploring its potential health benefits.

Materials and Methods

Materials and sample collection: The polynesian arrowroot (*Tacca leontopetaloides*), green gram (*Vigna radiata*), and tiger nuts (*Cyperus esculentus*) were bought from Langtang market Plateau State, Nigeria. The market was chosen by the researcher because of proximity and affordability of the products in the said market. Other ingredients, including vegetable oil, granulated sugar, salt was purchased from a local supermarket. The tools used were clean and sharp kitchen knife, washing bowls, muslin cloth, and clean large metal trays.

Research design: The study utilized a Completely Randomized Design (CRD). Arrowroot, green gram, and tiger nut

flours were combined in five different ratios to create a 100g composite

Processing

procedure

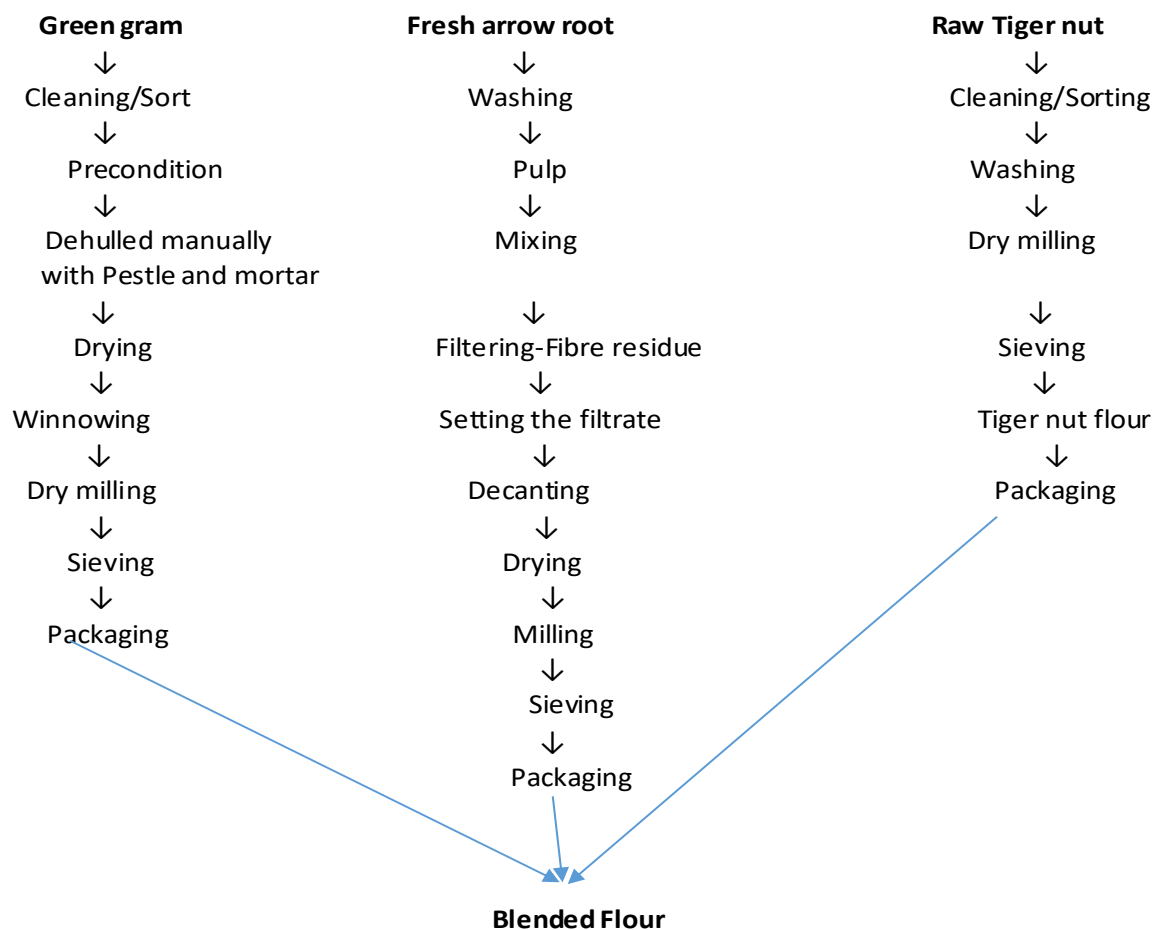


Fig. 1 Flow Diagram for the Preparation of Blended Arrow root, Green gram and Tiger nut Flour

Flour blend formulation

The polynesia arrowroot (A), green gram (G), and Tiger nut (T) flours were formulated as ternary flour blends, coded and separated at four different proportions in various proportions (B—50:25:25; C—30:30:40; D—30:40:30; E—20:50:30) A—100% polynesia arrowroot were used as the control samples. The flours were thoroughly mixed using universal spiral mixer at 400rpm for 25 minutes until uniform blends were formed. The different samples of the formulated blended flours and the control were packaged in small-sized Ziplock bags for further use.

Functional Properties analysis

The functional properties assessed included Oil Absorption Capacity (OAC), Bulk Density (BD), swelling power (SP), Swelling Index (SI), and Water Absorption Capacity (WAC), (Onwuka ,2018).

Proximate Composition Determination

The composite flour's crude protein, crude fiber, moisture, fat, and ash contents were measured in triplicate using standardized methods outlined by AOAC (2015). The carbohydrate content was calculated as the remainder of 100% after subtracting the values for moisture,

protein, fiber, ash, and fat. The determination of tannin and phytate was conducted following the methods outlined by AOAC (2015).

Preparation of 'Tsatsaba' from composite flours

The snack 'tsatsaba' was prepared using blends of arrowroot, green gram, and tiger nut flours in various ratios (50:25:25, 30:30:40, 30:40:30, and 20:50:30), along with 65 ml of water, 5 g of sugar, 1 g of salt, and a control made from 100% arrowroot. The preparation followed a traditional method with slight modifications. All ingredients were combined in a bowl and stirred until the mixture reached a dropping consistency. A metal mold called 'tawaita' was dipped into the slurry. The slurry was then deep-fried in a pot of boiling oil until the pieces separated and turned golden brown. The deep-fried creation was lifted from the oil, allowing any excess oil to drip off before being set aside to cool at room temperature and then packed in polyethylene bags for analysis.

Sensory Evaluation

Sensory evaluation of the snacks was conducted using simple hedonic tests, as described by Adegunwa et al. (2018), with a panel of 20 familiar staff and students from the Home Economics department. Participants rated attributes such as color, taste, flavor, texture, crispness, and overall acceptability on a 9-point hedonic scale, where 1 represented extreme dislike and 9 represented extreme like.

Statistical Analysis

The chemical analysis data were statistically evaluated using ANOVA, with mean separated by Duncan's test. The Statistical Package for Social Sciences (SPSS) software (version 13) was utilized to perform the Multiple Range Test with a significance level of $p < 0.05$. All

samples were analyzed in duplicate.



Arrow Root, green Gram and Tiger Nut



Flour Blends:



Tsatsaba Samples:

A – 100:0:0, B – 50:25:25, C – 30:30:40, D – 30:40:30, E – 20:50:30

Results

Table 1 presents the composition of the mixed flour. Moisture content of the composite mixes was similar (10.0%) with the highest in 100% arrowroot flour (11.3%). Carbohydrate, determined by difference varied from 58.2 to 79.55% among which mix 30:40:30 had highest (72.1%) and highest in 100% arrowroot flour (79.55%). This may be due to the effect of added green gram and tiger nut flour. Protein content of composite mixes ranges from 7.5 to 12.5% while 100% arrowroot flour had least 5.45% (Table 1). The difference is due to green gram and tiger nut contents. Crude fat content of composite mixes varied from 6.3 to 10.5% and least in arrowroot flour (1.2%). This could be due to presence of tiger nut in the former. Ash content was highest in mix

20:50:30 (2.0%) and least in mix 50:25:25(1.4%), and which may be due to the presence of seed coat in the tiger nut. Energy content ranged from 348.7kcal to 397.9kcal, thus indicating substantial change in nutritive value and energy content due to fortification. Phytic acid being an anti-nutrient, it lowers the bioavailability of minerals and inhibits the digestibility of proteins. Four different composite mixes varied from 17.6 to 34mg/100 phytic acid and 100% arrowroot had least (6.8mg/100). Tannin content in all the four different composite mixes varied from 3.5 to 8.1mg/100 and 100% arrowroot had least (1.5 mg/100) (Table 1). This may be due to the effect of supplemental level of green gram and tiger nut powder in the mixes.

Table 1: Proximate composition of composite flour derived from blends of arrowroot, green gram and tiger nuts in dry matter basis

AGT Sample	Moisture Content %	Crude Fat %	Crude Ash %	Crude Fibre %	Crude Protein %	Carbohydrate %	Calories Kcal	Phytate Mg/100	Tannin Mg/100
100:0:0	11.3 ^a ±0.01	1.2 ^a ±0.00	1.3 ^b ±0.00	2.5 ^d ±0.04	5.45 ^d ±0.02	79.55 ^a ±0.03	350.8	6.8±0.01	1.5±0.10
50:25:25	10.3 ^a ±0.00	6.3 ^b ±0.01	1.4 ^b ±0.02	9.0 ^b ±0.01	7.5 ^c ±0.01	65.5 ^c ±0.02	348.7	17.6±0.30	3.5±0.20
30:30:40	10.2 ^a ±0.02	10.5 ^a ±0.0	1.5 ^b ±0.00	11.5 ^a ±0.00	8.0 ^c ±0.03	58.3 ^d ±0.03	359.7	23.3 ±0.02	4.7±0.10
30:40:30	10.2 ^a ±0.01	7.5 ^b ±0.02	1.7 ^a ±0.01	7.0 ^c ±0.02	10.5 ^b ±0.01	72.1 ^b ±0.01	397.9	30.5 ±0.10	6.6±0.30
20:50:30	10.0 ^a ±0.02	7.3 ^b ±0.02	2.0 ^a ±0.00	10.0 ^b ±0.01	12.5 ^a ±0.02	58.2 ^d ±0.00	348.5	34.6 ±0.3	8.1±0.20

Values are expressed as means ± SD based on duplicate measurements. Means within the same column that have different superscripts indicate significant differences ($p < 0.05$).

Key, A stands for arrowroot flour, G represents green gram flour, and T denotes tiger nut flour.

Functional properties analysis

The functional properties of blends of arrowroot, green beans, and tiger nut flour were analyzed, as detailed in Table 2, which are crucial for determining their suitability in various food products. The bulk density values of the composite mixes were similar, ranging from 0.61 to

0.69 mg/cm³, with the lowest in 100% arrowroot flour at 0.58 mg/cm³. Water absorption capacity (WAC) was largely consistent at around 90%, except for sample 50:25:25 at 109%, while oil absorption capacity (OAC) ranged from 23.0% to 27.0%, with 100% arrowroot flour showing the least at 16.0%. The values of solubility power (SP) and swelling index (SI) for the composite mixes were similar at 13 g/mol and 5.2 to 5.8%, respectively, while 100% arrowroot flour had lower values of 12 g/mol and 4.7%; the higher values in the composite mixes are likely due to the inclusion of green gram and tiger nut flour.

Table 2: Functional properties of composite flour produced from blend of arrowroot, green gram, and tiger nuts

AGT Sample	BD (mg/cm ³)	WAC (%)	OAC (%)	SP (g/mol).	SI (%)
100:0:0	0.58 ^c ±0.00	120 ^a ±5.03	16 ^c ±6.01	12 ^a .6±0.02	4.7 ^a ±0.02
50:25:25	0.61 ^c ±0.01	109 ^b ±6.01	23 ^b ±3.03	13. ^a 2±3.01	5.2 ^a ±0.01
30:30:40	0.69 ^a ±0.00	90 ^c ±3.02	26 ^a ±4.00	13.4 ^a ±4.02	5.6 ^a ±0.00
30:40:30	0.68 ^a ±0.02	90 ^c ±5.00	26 ^a ±3.03	13.9 ^a ±3.50	5.3 ^a ±0.02
20:50:30	0.66 ^b ±0.01	90 ^c ±6.01	27 ^a ±4.20	13.5 ^a ±2.01	5.8 ^a ±0.00

Values are expressed as means ± SD from duplicate measurements. Means in the same column that have different superscripts are significantly different ($p < 0.05$). BD represents bulk density; WAC denotes water absorption capacity; OAC indicates oil absorption capacity; SP stands for swelling power; and SI refers to solubility index.

Table 3 presents the proximate composition analysis of 'tsatsafa' made

from composite flours and arrowroot, showing moisture levels between 7.11% and 7.89%. Crude fat content ranged from 10.89% to 17.85%, while ash content varied from 0.76% to 1.16% and fiber content from 2.23% to 8.82%. Notably, fortification significantly increased crude protein content to between 4.95% and 11.35%, while carbohydrate content decreased from 81.24% in 100% arrowroot flour to 57.91% in the 30:30:40 mix.

Table 3: Proximate composition of 'tsatsafa' made from blends of arrowroot - green gram - tiger nuts flours

AGT Sample	Moisture Content %	Crude Fat %	Crude Ash %	Crude Fibre %	Crude Protein %	Carbohydrate %
100:0:0	7.89 ^a ±0.03	2.3 ^c ±0.00	0.76 ^a ±0.00	2.23 ^c ±0.04	4.95 ^d ±0.02	81.24 ^a ±2.1
50:25:25	7.36 ^a ±0.00	10.89 ^b ±0.01	0.82 ^a ±0.02	7.30 ^b ±0.01	6.82 ^c ±0.01	66.81 ^b ±1.02
30:30:40	7.27 ^a ±0.02	17.85 ^a ±0.03	0.87 ^a ±0.00	8.82 ^a ±0.00	7.28 ^c ±0.03	57.91 ^d ±0.03
30:40:30	7.17 ^a ±0.10	12.75 ^b ±0.02	0.99 ^a ±0.01	7.89 ^b ±0.02	9.55 ^b ±0.01	61.65 ^c ±0.01
20:50:30	7.11 ^a ±0.02	12.41 ^b ±0.02	1.16 ^a ±0.00	8.05 ^a ±0.01	11.35 ^a ±0.02	59.92 ^c ±0.00

Values are expressed as means ± SD based on duplicate measurements. Means within the same column that have different superscripts indicate significant differences ($p < 0.05$). Key, A stands for arrowroot flour, G represents green gram flour, and T denotes tiger nut flour.

Sensory properties of the 'tsatsafa'

Table 4 summarizes the sensory evaluation results for the 'tsatsafa' samples, with the highest color score of

7.23 for the (50:25:25) ratio, while (20:50:30) had the lowest at 6.12. In terms of taste, the arrowroot sample scored 7.77, followed by (50:25:25) at 7.23, and (20:50:30) received the lowest score of 5.69. The texture score for sample (20:50:30) was 7.68, followed by 6.91 for (30:30:40) and 6.41 for (30:40:30), while (50:25:25) had the lowest at 6.39. In terms of overall acceptability, (50:25:25) was the most favored at 7.52, followed by the arrowroot sample at 7.23, with (20:50:30) receiving the lowest score of 6.01.

Table 4: Sensory evaluation of *tsatsafa* produced from arrowroot- green gram - tiger nuts flour blends

AGT Sample	Colour	Taste	Flavor	Texture	Cripsness	Overall acceptability
100:0:	7.65±0.01a	7.77±0.00a	7.31±0.02a	6.01±0.01c	5.56±0.02	7.23±0.03
50:25:25	7.23±0.00a	6.81±0.01b	7.12±0.00a	6.39±0.02b	5.68±0.01	7.69±0.02
30:30:40	6.86±0.02b	6.57±0.03b	6.93±0.01a	6.41±0.00b	6.01±0.01	6.53±0.03
30:40:30	6.86±0.01b	6.57±0.02b	6.84±0.00a	6.91±0.01b	6.00±0.03	6.57±0.01
20:50:30	6.12±0.02b	5.69±0.02c	6.21±0.00a	7.68±0.04a	7.28±0.01	6.01±0.00

Values are reported as means ± SD from duplicate measurements. Mean values in the same column that have different superscripts are significantly different ($p < 0.05$).). Key, A stands for arrowroot flour, G represents green gram flour, and T denotes tiger nut flour.

Discussion of findings

The moisture content in this study was within the range reported by Ibeogu (2020), indicating good storage quality and compliance with the Standard Organization of Nigeria's recommendation of 10% (ICS, 2007). Increasing the inclusion rate of green gram and tiger nut flour in AGT flours raised crude protein, ash, fat, and crude fiber levels, due to the higher nutrient content of these flours compared to 100% arrowroot flour, which is low in protein and insufficient for adult dietary needs. The low ash content in arrowroot flour reflects its low mineral content, while the increased ash level in composite mixes indicate nutrient enhancement from green gram and tiger nut flour, similar findings in other legume blends have been reported (Puspitasari et al., 2021; Ratnawati et al., 2019). The positive impact green gram and tiger nut had on the protein and fat contents of the composite mixed suggests nutrient enrichment in the flour blends because of green gram high protein and fat content of tiger nut flour combined. Increasing trend in fat with addition of green gram flour has also been reported by Bazaz et

al. (2016). Crude fat measures the amount of unrefined fatty substances in a product. A higher crude fat content indicates that the composite flour may serve as a good source of fat-soluble vitamins. The low level of carbohydrate content in the composite mixes was associated to additional effect of green gram flour as reported by Dabels et al. (2016). Adding green gram and tiger nut flour to arrowroot flour boosts protein, fat, and crude fiber content while reducing carbohydrates. This composite flour offers greater nutritional benefits, especially for those needing higher protein and fiber with lower carbs, compared to 100% arrowroot flour (Adegunwa et al., 2024). Variations in tannin levels in the composite mixes may offer antioxidant benefits to prevent certain diseases, but excessive intake can hinder nutrient absorption and protein digestion; higher phytic acid from increased green gram flour can impair mineral absorption (Cosme et al., 2025; Bello et al., 2022).

High bulk density (BD) makes the flour an effective thickener for food products, while significant variations in water absorption among composite blends ($p < 0.05$) indicate gelatinization; increased arrow root substitution enhances water-binding capacity and improves texture due to higher protein and fat content (Adegunwa et al., 2017). The high OAC in the samples likely due to the non-polar binding of green gram and tiger nut flours to oil's hydrocarbon chains, enhances

flavor retention and mouth feel in food products (Dada et al., 2023.) The samples showed no statistically significant differences ($p > 0.05$) in swelling power or solubility index at 100 °C.

Lower moisture content of *tsatsaba* samples is beneficial for extending shelf life, as moisture levels above 14% can encourage microbial growth and spoilage. The analysis of crude fat content in fortified samples showed a significant increase across all fortification levels. The higher fat content in *tsatsaba* samples likely stems from the composite mix's ability to absorb and retain oil, enhancing mouthfeel and flavor. Higher ash content typically indicates greater mineral richness, and the increase in ash was expected due to the higher ash content of green gram and tiger nut flour compared to arrow root. This supplementation may enhance the mineral intake for many individuals, helping to meet their daily nutritional needs (Dhillon et al., 2018). Crude fiber content of samples increased consistently with higher levels of fortification with significant increase in crude protein content. Similar trend was observed on composite flours (Shukla et al., 2016), suggesting that *tsatsaba* could help combat protein-energy malnutrition (PEM) in communities where it is prevalent. The decrease in carbohydrate content of the composite mixed flour aligns with findings from Adegunwa et al. (2019) regarding cookies made from unripe plantain, groundnut, and cinnamon composite flour. *Tsatsaba* made from composite flour of arrowroot, green gram, and tiger nuts can soothe gastrointestinal issues and is gentle on sensitive stomachs due to its high digestibility and balanced nutrition, promoting overall health. High-fiber content of the composite flour promote satiety for weight management and are rich in antioxidants and protein, helping

to reduce oxidative stress, inflammation, and stabilize blood sugar levels, making them ideal for diabetes management. The same characteristics was observed by other researcher in wheat and tiger nut flour binary blends (Nedviha, et al., 2024). The minerals in arrowroot and tiger nuts support bone health, while healthy fats in tiger nuts improve heart health and boost immunity; their versatile flour encourages diverse and nutritious meal options.

Conclusion and Recommendations

The development and analysis of '*tsatsaba*' using composite flour derived from arrowroot, green gram, and tiger nuts demonstrate a promising approach to enhancing family nutrition, especially during challenging economic times. The incorporation of these nutritious ingredients not only improves the dish's nutritional profile but also offers a gluten-free alternative that is easily digestible and rich in essential nutrients. This study highlights the potential of arrowroot, green gram and tiger nut flour ternary blends to address dietary needs and promote healthier eating habits. The following recommendations were made from the findings of the study.

1. Samples 20:50:30 and 30:30:40 are ideal for shelf-stable and protein-enriched products designed to combat malnutrition and promote digestive health, highlighting the benefits of fortifying with green gram and tiger nut flour
2. The low carbohydrate content in the composite mixes makes them suitable for diabetes-friendly foods, while those with a low swelling index are perfect for quick-cooking traditional recipes, enhancing their acceptance and versatility in various cuisines.

References

- Adegunwa, M.O.; Bamidele, B.O.; Alamu, E.O. & Adebajo, L.A. (2019). Production and Quality Evaluation of Cookies from Composite Flour of Unripe Plantain (*Musa paradisiaca*), Groundnut (*Arachis hypogaea* L.) and Cinnamon (*Cinnamomum verum*). *J. Culin. Sci. Technol.* 18, 413–427.
- Adegunwa, M.O.; Ogungbesan, B.O.; Adekoya, O.A.; Akinloye, E.E.; Idowu, O.D. & Alamu, O. E (2024). Production and Characterization of Snacks Utilizing Composite Flour from Unripe Plantain (*Musa paradisiaca*), Breadfruit (*Artocarpus altilis*), and Cinnamon (*Cinnamomum verum*). *Foods* 13, 852. <https://doi.org/10.3390/foods13060852>
- Agulanna F.T (2020). The Role of Indigenous and Underutilized Crops in The Enhancement of Health and Food Security in Nigeria. *Afr. J. Biomed. Res.* 23, 305- 31
- Amadi, C. O., Olojede, O.A., Ironkwe, A., Ebeniro, C.N, Nwokocha, C. C., Amadi, G. & Ejokwu, G. A (2021). Prospects of Domestication of Polynesian Arrowroot (*Tacca Leontopetaloides* L.) In Nigeria. *Nigerian Agricultural Journal* 52 (3) | pg. 184-196
- AOAC. Official Methods of Analysis. Association of Official Analytical Chemists. 18th Edition, AOAC, Arlington. 2015;806-814.
- Bazaz, R., Baba, N.W. & Masoodi, A. F. (2016). Development and quality evaluation of hypoallergic complementary foods from rice incorporated with sprouted green gram flour, *Cogent Food & Agriculture*, 2:1, 1154714, DOI: 10.1080/23311932.2016.1154714
- Bello, F. A., Oladeji, B. S. & Akpan, P. S. (2022). Effect of green gram flour addition on the chemical composition and pasting properties of cocoyam flour as potential ingredients in food product development. *Acta Sci. Pol. Technol. Aliment.*, 21(3), 329–336. <http://dx.doi.org/10.17306/J.AFS.2022.1066>.
- Cosme, F., Aires, A., Pinto, T., Oliveira, I., Vilela, A., & Gonçalves, B. (2025). A Comprehensive Review of Bioactive Tannins in Foods and Beverages: Functional Properties, Health Benefits, and Sensory Qualities. *Molecules*, 30(4), 800.
- Dada, M. A., Bello, F.A., Omobulejo, F.O. & Olukunle, F. E. (2023). Nutritional quality and physicochemical properties of biscuit from composite flour of wheat, African yam bean and tigernut. *Heliyon*. 2023 Nov 19;9(11): e22477. doi: 10.1016/j.heliyon.2023.e22477.
- Dhillon, B.; Chopra, N.; Rani, R. & Singh, A. (2018). Physico-nutritional and Sensory Properties of Cookies Formulated with Quinoa, Sweet Potato and Wheat flour blends. *Curr. Res. Nutr. Food Sci.* 6, 798–806.
- Edo, G. I., Onoharigho, F. O., Jikah, A. N., Oloni, G. O., Samuel, P. O., Rapheal, O. A., & Ojulari, A. E. (2023). *Cyperus esculentus* (tiger nut): An insight into its bioactive compounds, biological activities, nutritional and health benefits. *Food Chemistry Advances*, 3, 100511.
- Ibeogu, I. H. (2020). Production and Evaluation of Weaning Food Made from Mungbean(*Vignaradiata* (L.), Millet and Tigernut (*Cyperus Esculentus*) Flour Blends. *International Journal of Research and Scientific Innovation (IJRSI)* | Volume VII, Issue VII, July 2020 | ISSN 2321–2705.
- ICS: 664.68 (2007). Nigerian Industrial Standard for Biscuits. Standard Organization of Nigeria: Abuja, Nigeria, pp. 1–8.

- Mehta N, Rao, P. & Saini, R. (2021). A review on metabolites and pharmaceutical potential of food legume crop mung bean (*Vigna radiata* L. Wilczek). *BioTechnologia* (Pozn). 2021 Dec 22; 102(4):425-435. doi: 10.5114/bta.2021.111107.
- Muchimapura, S., Thukhammee, W., Phuthong, S., Potue, P., Khamseekaew, J., Tong-un, T. & Sangartit, W. (2024). Mung Bean Functional Protein Enhances Endothelial Function via Antioxidant Activity and Inflammation Modulation in Middle-Aged Adults: A Randomized Double-Blind Trial. *Foods*. 13(21):3427. <https://doi.org/10.3390/foods13213427>
- Nedviha, S. & Harasym, J. (2024). Functional and Antioxidative Characteristics of Soft Wheat and Tiger Nut (*Cyperus esculentus*) Flours Binary Blends. *Foods*. 13(4):596. doi: 10.3390/foods13040596.
- Nkwonta C. G., Auma, C.I & Gong, Y. (2023). Underutilised food crops for improving food security and nutrition health in Nigeria and Uganda – a review. *Front. Sustain. Food Syst.* 7:1126020. doi: 10.3389/fsufs.2023.112603
- Onwuka GI. Food analysis and instrumentation (2018). Theory and practices. Revised edition. Naphtali Prints Lagos, Nigeria. ;10-20
- Puspitasari, D., Noerhartati, E., Revitriani, M., F. S., Rejeki, F. S. & Wedowat, E. R. (2021). The concentration of sago flour to taro-mung bean composite flour on the quality of non- gluten biscuits. IOP Conf. Series: *Earth and Environmental Science* 733 012076 doi:10.1088/1755-1315/733/1/012076
- Ratnawati, L., Desnilasari, D., Surahman, N. D. & Kumalasa, R. (2019). Evaluation of Physicochemical, Functional and Pasting Properties of Soybean, Mung Bean and Red Kidney Bean Flour as Ingredient in Biscuit. IOP Conference Series: *Earth and Environmental Science*, 251, ID:012026. <https://doi.org/10.1088/1755-1315/251/1/012026>.
- Uachisso1, A., Nunes da Silva, M., Agostinho1, D., Pinho, O., Vasconcelos, W. M & Carvalho, P.M.S.(2023). Nutritional evaluation of flour obtained from *Tacca leontopetaloides* used as an alternative food in Muanza-Mozambique. *African Journal of Food Science*. 17(6), 122-129, DOI: 10.5897/AJFS2022.2186.