GSC Biological and Pharmaceutical Sciences
eISSN: 2581-3250 CODEN (USA): GBPSC2
Cross Ref DOI: 10.30574/gscbps
Journal homepage: https://gsconlinepress.com/journals/gscbps/

(RESEARCH ARTICLE)

Check for updates

Proximate and nutritional evaluation of West-African okra leaf and its cookie product

Samuel Folarin Olaniran [1,*], Ayodeji Adekunle Folorunso [2], Favour Damilola Obogbayiro [2], Blessing Abraham Ogungbe [1] and Oluyemi Jacob Oladiran [3]

[1] *Department of Pharmacology, Faculty of Pharmacy, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.*
[2] *Department of Family Nutrition and Consumer Sciences, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.*
[3] *Department of Pharmacognosy, Faculty of Pharmacy, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.*

GSC Biological and Pharmaceutical Sciences, 2026, 34(03), 269-275

Publication history: Received on 12 February 2026; revised on 25 March 2026; accepted on 27 March 2026

Article DOI: https://doi.org/10.30574/gscbps.2026.34.3.0113

Abstract

Background and Aim: Fortification of food materials with essential nutrients is an effective strategy for combating malnutrition, particularly in low- and middle-income countries where access to nutrient-dense foods is limited. This study evaluated the proximate, mineral, and vitamin composition of *Abelmoschus caillei* leaves (ACL), and assessed the nutritional composition alongside the sensory properties of cookies fortified with okra leaf flour.

Materials and Methods: Proximate, mineral, and vitamin analyses of ACL and ACL-fortified cookies were conducted using standard analytical procedures. Cookies were produced from wheat flour blended with varying proportions of ACL flour. Sensory evaluations of the cookies were carried out by 50 panelists using a 9-point hedonic scale to assess appearance, texture, taste, and overall acceptability.

Results: The dried ACL contained moisture (16.44 ± 0.16%), ash (18.47 ± 0.40%), crude fiber (9.89 ± 0.14%), crude protein (23.41 ± 0.22%), crude fat (2.75 ± 0.08%), and digestible carbohydrate (30.04%), with an estimated energy value of 344.50 kcal/100 g. Mineral analysis revealed the presence of calcium (2324.5 mg/100 g), magnesium (832.23 mg/100 g), potassium (3060.80 mg/100 g), sodium (414.45 mg/100 g), manganese (34.53 mg/100 g), iron (128.65 mg/100 g), copper (1.04 mg/100 g), and zinc (7.19 mg/100 g). The leaf also contained vitamin C (5320 ± 49 mg/L) and vitamin A (414.80 ± 1.20 mg/L). Proximate analysis of the fortified cookies indicated improved nutritional composition compared with the control sample, while sensory evaluations showed good acceptability in terms of appearance, texture, and taste.

Conclusion: *Abelmoschus caillei* leaves are rich in essential nutrients and can be effectively incorporated into wheat-based cookies to enhance their nutritional quality. The use of ACL-fortified cookies may therefore represent a promising dietary strategy for addressing malnutrition.

Keywords: Proximate; Minerals; *Abelmoschus caillei*; Nutrition; Okra; Cookies

1. Introduction

Abelmoschus caillei (ACL), a robust and high-yielding plant, is increasingly replacing *Abelmoschus esculentus* as a major source of okra pods in West Africa. According to an ethnobotanical survey, the crushed fruit and mucilage from the leaf and other parts of the plant are used ethnomedicinally to enhance childbearing and child labor among the Bini, Igbo, Urhobo, and Isoko people [1]. Its leaves are consumed as a vegetable, particularly in the Ibarapa area of Oyo State, Nigeria, where they are linked to a high prevalence of twin births [2]. It has been reported that the methanol leaf extract of ACL enhanced the serum concentrations of gonadotropic hormones in female Wistar rats [3].

* Corresponding author: Samuel Folarin Olaniran

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0.

Malnutrition remains a pressing issue in developing countries, where access to nutrient-dense foods is limited. To reduce cases of malnutrition, especially in poor populations that do not have access to good health facilities and cannot afford nutraceuticals usually prescribed in clinical settings, fortifying common foods with locally sourced, nutrient-rich ingredients offers significant potential in combating this menace [4]. Wheat flour is a staple ingredient in many foods and snacks but it lacks essential micronutrients such as iron and zinc; hence, fortifying it with other nutritious food materials will provide improved health benefits to consumers [5].

Despite its global consumption and reported nutritional benefits, there is a dearth of information on the proximate, mineral, and vitamin composition of ACL leaves, as well as food materials fortified with the leaf powder. This study aimed at evaluating the nutritional composition of ACL, assessing the sensory properties of cookies fortified with ACL, and conducting a comparative evaluation of cookies containing different percentages of ACL.

2. Materials and methods

2.1. Plant material and preparation

The young leaves of *Abelmoschus caillei* were collected from Igboora, Oyo state, Nigeria and transported to Obafemi Awolowo University, Ile-Ife. Mr. G. A. Ademoriyo of the Ife Herbarium, Department of Botany, Obafemi Awolowo University, Ile – Ife, identified and authenticated the plant, which was given the voucher number IFE-17637. The leaves were air-dried at room temperature for two weeks and pulverized. Thereafter, the powdered sample was analyzed for proximate, mineral and vitamin analyses. In preparing the fortified cookies, the following ingredients and tools were used: wheat flour, baking powder, sugar, eggs, flavors, trays, weighing scales, an oven, mesh screens (60 µm and 250 µm), chopping boards, rolling pins, and cookie cutter. The preparation took place at the Food, Nutrition and Dietetics Laboratory, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife. The ACL leaves were thoroughly washed to eliminate contaminants, followed by manual removal of damaged leaves. The clean leaves were air-dried on trays for five days at room temperature before being ground into a fine powder using an electric blender. The resulting okra leaf powder was then sieved through a 0.315 mm mesh to ensure uniformity and fineness, making it suitable for incorporation into the cookie dough.

2.2. Determination of Proximate Analysis

The proximate analysis of ACL for percentage moisture content, ash content, crude fibre, crude protein, and ether extract (crude fat) was determined using the standard method of the Association of Official Analytical Chemists [6]. The carbohydrate content was determined by difference according to AOAC procedures [6].

2.3. Determination of Mineral and Vitamin Analysis

The minerals and vitamins A and C in ACL were determined using the method of the Association of Official Analytical Chemists [5].

2.3.1. Cookie Formulation

The cookie dough was formulated using four different blends of wheat flour and okra leaf flour:

- WOC 1: 100% wheat flour (control)
- WOC 2: 17% okra leaf flour, 83% wheat flour
- WOC 3: 33% okra leaf flour, 67% wheat flour
- WOC 4: 50% okra leaf flour, 50% wheat flour

Cookies were prepared by mixing flour blends with sugar, baking powder, eggs, and flavors, followed by baking at 180°C for 15 minutes.

2.3.2. Sensory Evaluation

A sensory panel of 50 women aged 18-49 years evaluated the cookies for appearance, taste, texture, and overall acceptability. The panelists used a 9-point hedonic scale, with higher scores indicating higher preference.

2.3.3. Proximate and Mineral Analysis

Proximate analyses were performed on both the okra leaf samples and the cookie blends to determine moisture, protein, fat, ash, crude fiber, and carbohydrate content. The analyses followed AOAC methods. Mineral composition (iron, zinc, and folate) was determined using Atomic Absorption Spectrophotometry (AAS).

2.4. Statistical Analysis

Data were analyzed using SPSS version 20, with results presented as means ± standard deviation. One-way analysis of variance (ANOVA) was employed to determine significant differences among the cookie blends.

3. Results

Table 1 Proximate Analysis of *Abelmoschus caillei* Leaf

The proximate analysis of Abelmoschus caillei leaf revealed the following: moisture content - 16.44 ± 0.16%; ash content - 18.47 ± 0.40%; crude fiber - 9.89 ± 0.14%; crude protein - 23.41 ± 0.22%; ether extract (crude fat) - 2.75 ± 0.08%; digestible carbohydrate - 30.04%.

Nutrient	Composition (%)
Moisture	16.44±0.16
Ash	18.47 ± 0.40
Crude Fiber	9.89. ± 0.14
Crude Protein	23.41 ± 0.22
Ether Extract (Crude fat)	2.75 ± 0.08
Digestible carbohydrate	30.04

The following minerals were found in *Abelmoschus caillei* leaf: potassium - 3,060.80 ± 0.0221 mg/100 g; calcium - 2,324.50 ± 0.0022 mg/100 g; magnesium - 832.23 ± 0.0022 mg/100 g; Sodium - 414.45 ± 0.0270 mg/100 g; iron - 128.65 ± 0.0222 mg/100 g; zinc - 7.19 ± 0.0221 mg/100 g and copper - 1.04 ± 0.0029 mg/100 g. Lead and cadmium were not detected in the leaf.

Table 2 Mineral Composition of *Abelmoschus caillei* Leaf

Mineral	Mean Composition (mg/100 g)
Calcium	2,324.50 ± 0.0022
Magnesium	832.23 ± 0.0022
Potassium	3,060.80 ± 0.0221
Sodium	414.45 ± 0.0270
Iron	128.65 ± 0.0222
Copper	1.04 ± 0.0029
Zinc	7.19 ± 0.0221
Lead	N. D.
Cadmium	N. D.

Table 3 Vitamins C and A Composition of *Abelmoschus caillei* Leaf

Vitamin	Concentration (mg/L)
Vitamin C	5,320 ± 49
Vitamin A	414.80 ± 1.20

The *Abelmoschus caillei* leaf contained vitamin C - 5,320 ± 49 mg/ L and vitamin A - 414.80 ± 1.20 mg/L

3.1. Assessment of The Sensory Properties

The WOC 1 was rated highest for appearance, color, and overall acceptability, however, WOC 2 was preferred in terms of taste and texture. Detailed sensory scores are presented in Table 4.

Table 4 Sensory Properties of Cookies Produced from ACL and Wheat Flour Blend

Sample	Appearance	Color	Taste	Texture	Flavour	Overall Acceptability
WOC 1	8.02 ± 1.12	8.08 ± 0.90	7.90 ± 1.02	7.52 ± 1.30	8.04 ± 0.78	8.10 ± 0.82
WOC 2	5.56 ± 1.97	5.28 ± 2.04	5.58 ± 1.75	5.59 ± 1.79	6.00 ± 1.80	5.68 ± 1.71
WOC 3	5.30 ± 1.93	5.18 ± 2.22	4.90 ± 1.62	5.28 ± 1.65	5.52 ± 1.90	4.98 ± 1.76
WOC 4	4.08 ± 2.09	4.54 ± 2.21	3.38 ± 1.64	4.44 ± 1.89	3.58 ± 1.92	3.66 ± 1.97

3.2. Evaluation of The Nutritional Composition of Cookies Produced from ACL and Wheat Flour

The WOC 4 showed the highest protein content (14.89%), followed by WOC 3 (14.24%), and WOC 1 had the highest carbohydrate content (56.71%). The highest folate, iron, and zinc concentrations were observed in WOC 4 (Table 5).

Table 5 Nutritional Composition of Cookies Produced from ACL and Wheat Flour

Sample	Moisture (%)	Ash (%)	Crude Fiber (%)	Fat (%)	Crude Protein (%)	Carbohydrate (%)	Zinc (%)	Iron (%)	Folate (%)
WOC 1	10.2 ± 0.02	1.55 ± 0.43	0.016 ± 0.01	17.89 ± 0.02	13.80 ± 0.028	56.71 ± 0.02	6.40 ± 0.009	54.00 ± 0.001d	0.68 ± 0.058
WOC 2	8.67 ± 0.04	2.58 ± 0.04	0.032 ± 0.02	20.06 ± 0.02c	13.05 ± 0.021	55.616 ± 0.03	8.20 ± 0.001	62.00 ± 0.0012b	12.75 ± 0.267
WOC 3	9.80 ± 0.02	3.55 ± 0.03	1.05 ± 0.03	20.99 ± 0.04	14.24 ± 0.029	50.37 ± 0.01	8.00 ± 0.001	60.00 ± 0.0011c	13.87 ± 0.058
WOC 4	9.85 ± 0.03	4.76 ± 0.03	2.155 ± 0.04	20.88 ± 0.03	14.89 ± 0.035	47.47 ± 0.05	10.20 ± 0.0012a	87.00 ± 0.0015a	19.64 ± 0.179

4. Discussion

The moisture content of a sample is an important indicator of its shelf stability and susceptibility to microbial spoilage [6]. The moisture content of *Abelmoschus caillei* leaf (16.44%) obtained in this study was higher than values reported for several Nigerian leafy vegetables such as *Vernonia amygdalina*, *Basella alba*, *Gongronema latifolium*, and *Ocimum gratissimum* [7]. The relatively high moisture content may be attributed to the air-drying method used, which tends to retain more moisture compared with oven or sun drying [8]. Nevertheless, appropriate drying methods must be employed to prevent deterioration of phytoconstituents during storage [9].

Ash content is commonly used as an index of mineral composition in plant materials. The ash content of ACL (18.47%) observed in this study was higher than those reported for several commonly consumed Nigerian vegetables [7], suggesting that the leaf is a rich source of minerals.

Dietary fibre plays a significant role in gastrointestinal health and in the prevention of metabolic disorders. The crude fibre content of ACL (9.89%) was comparable with values reported for some Nigerian leafy vegetables but lower than those reported for certain high-fibre vegetables such as *Hibiscus sabdariffa* and *Telfairia occidentalis* [7]. However, the fibre content of the leaf was lower than that reported for the fruits of *A. caillei* and *A. esculentus* at different stages of maturity [10].

Protein is essential for tissue growth, repair, and enzyme synthesis. The crude protein content of ACL (23.41%) indicates that the leaf can serve as a valuable plant-based protein source. Although this value is lower than those reported for some Nigerian leafy vegetables [7], it is higher than the protein content reported for the fruits of *A. caillei* and *A. esculentus* [8]. Plant foods providing more than 12% of their caloric value from protein are considered good protein sources [11].

Fat serves as a major source of energy and facilitates the absorption of fat-soluble vitamins. The crude fat content of ACL (2.75%) was relatively low compared with some Nigerian leafy vegetables [7], which may be beneficial for individuals requiring low-fat diets.

Carbohydrates are a primary source of metabolic energy. The digestible carbohydrate content of ACL (30.04%) was lower than that reported for certain vegetables but higher than values reported for several Nigerian leafy vegetables [7,11], indicating that the leaf may contribute moderately to dietary energy intake.

Mineral analysis revealed that ACL is particularly rich in calcium, magnesium, potassium, iron, and zinc. Calcium plays a critical role in bone formation and neuromuscular function, while magnesium is involved in enzyme activation and energy metabolism [12]. The calcium and magnesium contents observed in this study exceed the recommended dietary allowances for adults [13], indicating that the leaf could contribute significantly to dietary mineral intake.

Potassium and sodium are essential electrolytes involved in maintaining osmotic balance, nerve transmission, and muscle contraction [12]. The high potassium content observed in ACL suggests that it may contribute meaningfully to daily potassium requirements.

Zinc is important for immune function and reproductive health [12], while iron is essential for hemoglobin synthesis and prevention of anemia. The high iron content recorded in ACL suggests that the leaf could be useful in combating iron-deficiency anemia, particularly among women of reproductive age.

Vitamin C plays an essential role in collagen synthesis, antioxidant defence, and iron absorption [12], while vitamin A is important for vision, immune function, and reproductive health. The high concentrations of vitamins A and C detected in ACL indicate that the leaf may provide important nutritional benefits.

The nutritional evaluation of cookies fortified with ACL demonstrated improved micronutrient composition compared with the control sample. Cookies containing higher proportions of ACL showed increased levels of iron, zinc, and folate. Folate is particularly important for fetal neural tube development during early pregnancy [9,14]. Thus, the fortified cookies may represent a functional food product beneficial for women of reproductive age.

Sensory evaluation revealed that cookies containing 17% okra leaf flour (WOC2) had the highest overall acceptability among the fortified samples. This suggests that moderate inclusion of ACL in wheat flour formulations provided an optimal balance between improved nutritional value and consumer acceptability. This aligns with the findings of Ezegbe *et al* (2024) which showed that moderate substitution levels of alternative flours in cookies often result in the highest overall acceptability, as excessive inclusion may negatively affect taste, texture, and appearance [15]. Similar findings have been reported in studies on okra–wheat composite flour products [16].

List of Abbreviations

ACL — *Abelmoschus caillei* Leaf
AAS — Atomic Absorption Spectrophotometer
ANOVA — Analysis of Variance
AOAC — Association of Official Analytical Chemists
RDA — Recommended Dietary Allowance
SPSS — Statistical Package for the Social Sciences
WOC — Wheat–Okra Cookie Blend
WOC1 — 100% Wheat Flour Cookie (Control)
WOC2 — Cookie Containing 17% Okra Leaf Flour and 83% Wheat Flour
WOC3 — Cookie Containing 33% Okra Leaf Flour and 67% Wheat Flour
WOC4 — Cookie Containing 50% Okra Leaf Flour and 50% Wheat Flour
µg — Microgram
mg — Milligram
g — Gram
µm — Micrometer
mm — Millimeter
°C — Degree Celsius

5. Conclusion

In conclusion, *Abelmoschus caillei* leaf demonstrated appreciable nutritional potential, characterized by high protein, mineral, and vitamin contents, alongside moderate fibre and carbohydrate levels, making it a valuable plant-based ingredient for improving dietary quality. Despite its relatively high moisture content, which may affect shelf stability, appropriate drying and storage methods can help preserve its nutritional integrity. The incorporation of ACL into cookie formulations significantly enhanced micronutrient composition, particularly iron, zinc, and folate, highlighting its potential in developing functional foods aimed at addressing micronutrient deficiencies. Notably, sensory evaluation indicated that a 17% inclusion level provided the best balance between nutritional enhancement and consumer acceptability. Overall, ACL-fortified cookies represent a promising, affordable, and nutritionally beneficial food product with potential applications in improving public health, especially among vulnerable populations such as children and women of reproductive age.

Compliance with ethical standards

Acknowledgments

The samples generated in this research work were analysed in different laboratories and the authors would like to appreciate the researchers and/or technologists in charge of the laboratories: Mr. Emmanuel Kayode Ogunyemi of the Poultry Meat Research Laboratory, Department of Animal Sciences, Faculty of Agriculture; Mr. E. A. Akinola of the Central Science Laboratory; Dr. Akinsola of the Department of Food Science and Technology, Faculty of Technology and Dr. Makinde. All the analyses were done at Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Osawaru ME, Dania-Ogbe FM. Ethnobotanical studies of West African okra (*Abelmoschus caillei*) from some tribes of South-Western Nigeria. *Sci World J*. 2010;5(1).

[2] Omonkhua AA, Okonofua FE, Ntoimo LFC, Aruomaren AI, Adebayo AM, Nwuba R. Community perceptions on causes of high dizygotic twinning rate in Igbo-Ora, South-West Nigeria: A qualitative study. *PLoS One*. 2020;15:e0243169.

[3] Olaniran SF, Ilesanmi OR. Methanol leaf extract of *Abelmoschus caillei* increased the serum levels of hormones involved in follicle maturation in female Wistar rats. *GSC Biol Pharm Sci*. 2022;20(2):87–94.

[4] Thakur, S., Singh, A., Insa, B., & Sharma, S. (2023). Food fortification in India as a strategy to address malnutrition: A global perspective. *Sustainable Food Technology, 1*, 681–695. https://doi.org/10.1039/D3FB00079F

[5] Agbangnan C, Ludewig U, Hawkesford MJ. Anti-nutritional factors in grain legumes and their impact on human health. *Front Plant Sci*. 2018;9:1490.

[6] Olasebikan, Y. O., Bamisaye, V. J., & Ajayi, F. E. (2025). *Equilibrium moisture content and thermodynamic properties of garri*. *J Food and Nutr Sci.* 13(3), 150–155. https://doi.org/10.11648/j.jfns.20251303.15.

[7] Asaolu SS, Adefemi OS, Oyakilome IG, Ajibulu KE, Asaolu MF. Proximate and mineral composition of Nigerian leafy vegetables. *J Food Res*. 2012;1(3):214–281.

[8] Muthuvairavan G, Manikandan S, Elangovan E, Natarajan SK. Assessment of solar dryer performance for drying different food materials: a comprehensive review. In: *Drying Science and Technology*. London: IntechOpen; 2023. doi:10.5772/intechopen.100307

[9] Zaharuddin SA, Ahmad S, Omar A, Haque MT. Study of effects of different drying methods on drying kinetics and quality attributes of okra. *Int Food Res J*. 2014;21(4):1693–1700.

[10] Firmin NY, Konan BR, Fernande AE. Phytochemical properties and proximate composition of two varieties of dried okra (*Abelmoschus caillei* and *Abelmoschus esculentus*) during maturation. *Int J Sci Eng Res*. 2018;9(1).

[11] Ali A. Proximate and mineral composition of *Asparagus officinalis*. *World J Dairy Food Sci*. 2009;4(2):142–149.

[12] Stanfield PS, Hui YH. Nutrition and diet therapy: Self-instructional approaches. 5th ed. Burlington (MA): Jones & Bartlett Publishers; 2010.

[13] US Department of Health and Human Services. Dietary Guidelines for Americans 2020–2025. Washington DC: US Government Publishing Office; 2020.

[14] Morsy FM, El Sohaimy AM. Okra: Traditional uses, phytochemistry, pharmacology and toxicology. *J Food Drug Anal*. 2011;19(5):587–603.

[15] Ezegbe CC, Okpalanma FE, Okocha SK, Odoh EN, Ohuche JC, Orjiakor SN, et al. Physicochemical and sensory evaluation of biscuits produced from composite flour of wheat and fermented cowpea hull. *Asian Food Sci J.* 2024;23(8):69–79. doi:10.9734/afsj/2024/v23i8736

[16] Alawode T, Lajide L, Owolabi BJ, Olaleye MT, Ogunyemi BT. Influence of blending and storage conditions on the acceptability of okra–wheat composite flour. *J Food Sci Technol*. 2017;54(2):845–853.