



Quality Assessment of Cupcake Produced from Wheat-Garri Flour Blends

Chioma Cecilia Aniemena ^a, Ernest Eguono Emojorho ^{b*},
Love Nchekwube Onuoha ^c, Chioma Ngozi Okoronkwo ^a,
Comfort Chinenye Nwagbo ^d
and Ifeoma Ogomegbunam Ugwu ^a

^a Department of Food Science and Technology, University of Nigeria, Nsukka, Nigeria.

^b Department of Food Science and Technology, Delta State University of Science and Technology Ozoro, Delta State, Nigeria.

^c Department of Agricultural Education, Federal College of Education Technical, Asaba, Nigeria.

^d Department of Food Science and Technology, Chukwuemeka Odumegwu Ojukwu, Igbariam Campus, University, Anambra State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/ajarr/2024/v18i7692>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/118344>

Original Research Article

Received: 06/04/2024

Accepted: 09/06/2024

Published: 17/06/2024

ABSTRACT

Cupcakes were created with composite flour, which included garri and wheat flour blends. The wheat and garri flours were combined in the following ratios: 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, and 0:100, with designations A, B91, C82, D73, E64, F55, and G, respectively. The functional qualities of the composite flours were investigated, whereas the sensory and

*Corresponding author: Email: emojorhoeguono@yahoo.com;

Cite as: Aniemena, Chioma Cecilia, Ernest Eguono Emojorho, Love Nchekwube Onuoha, Chioma Ngozi Okoronkwo, Comfort Chinenye Nwagbo, and Ifeoma Ogomegbunam Ugwu. 2024. "Quality Assessment of Cupcake Produced from Wheat-Garri Flour Blends". *Asian Journal of Advanced Research and Reports* 18 (7):159-66. <https://doi.org/10.9734/ajarr/2024/v18i7692>.

micronutrient aspects of the cupcakes were examined. The moisture, crude fibre, fat, carbohydrate and protein of the wheat, wheat and garri flour blends, and garri flour ranged from 13.45% to 14.41%; 2.6% to 7.81%; 0.16% to 0.92%; 67.31% to 70.38% and 10.61% to 7.65% respectively. It was observed that as the quantity of garri increased, the moisture content, protein, ash and fat content decreased while the crude fibre and carbohydrate content increased. Bulk density, water absorption capacity, oil absorption capacity and swelling capacity of the flour blends ranged from 0.635g/cm³ to 0.765g/cm³, 11.32% to 26.05%, 13.34% to 15.89%, and 10.43% to 25.39% respectively. Sensory scores of the cupcake demonstrated that acceptable cakes can be made from wheat-garri mixes, particularly at 50% wheat flour and 50% garri flour and 90% wheat flour and 10% garri flour substituting levels.

Keywords: Cake; composite flour; garri; sensory properties; wheat.

1. INTRODUCTION

Cake is a renowned bakery product known for its delicious flavor. Cake has become one of Nigeria's most popular non-indigenous snack. Wheat flour is one of the most common ingredients used in cake making. Wheat flour is important in baking items because it contains gluten, which is necessary for bakery product quality. However, because wheat production in Nigeria is low, wheat flour is imported to suit the local need of bakers. As a result, wheat imports consume a large amount of foreign exchange yearly. To reduce the demand for imported wheat, efforts are being made to encourage the use of composite flour, in which flour derived from locally cultivated goods replaces some of the wheat flour used in bakery items [1-3]. Cassava (*Manihot esculenta crantz*) is an important food crop growing in tropical areas [4]. Garri is Africa's most popular cassava-based dishes. Garri is a creamy-white, partly gelatinized, roasted, free-flowing granular flour that is widely accepted and enjoyed by Nigerians from all socioeconomic levels because to its high carbohydrate content. Micronutrients (vitamins and minerals) are required for the body's correct operation because the body cannot synthesize them. Micronutrients are required in trace levels and must therefore be obtained through diet (Emojorho et al., 2023a). Composite flour can be made from plantains, cassava, soybeans, and other locally cultivated products (Emojorho et al., 2024a). Attempts have been made to encourage the use of composite flour, which entirely or partially replaces wheat flour in baked goods with flours generated from locally grown crops with high nutritional value. Composite flour technology is the process of combining various forms of flour in a precise quantity with other ingredients, such as cereals and legumes, to produce high-quality food products that completely or partially replace wheat flour in baked goods and pastries. This

minimizes the level of imported wheat and creates more nutrient-rich products (Emojorho et al., 2024). Composite flour is created with the goal of increasing the nutritional composition while also encouraging the use of locally available food crops. Composite flour made from grain, legumes, or tubers has been shown to have more nutritional content than flour made from a single food crop (Emojorho et al., 2024). By employing composite flour, we may reduce our reliance on wheat imports for baked goods production, conserve foreign exchange, and engage our youth in productive activities (Anene et al., 2023; Aphiar et al., 2024). The purpose of this study was to develop and test the feasibility of substituting garri with wheat flour, as well as to determine the appropriate substitution level for wheat-garri flour blends in cup cakes.

2. MATERIALS AND METHODS

2.1 Materials

The cassava tubers, wheat flour, margarine, vanilla, eggs, sugar and baking powder were purchased from Nkwo-Ibagwa at Nsukka. Analytical chemicals used for analysis were purchased from a chemical supplier at Nsukka.

2.2 Methods

2.2.1 Production of garri flour from cassava tubers

The cassava tubers were peeled, washed, and grated. This was followed by pressing, fragmentation (fermentation for 3 days at room temperature), granulation (sifting), then drying (roasting/frying), with suitable heat treatment (mostly frying). The roasted (fried) garri was sieved after cooling in order to realize fine particles. Composite flour from wheat and garri flour in different ratio of 100:0, 90:10, 80:20,

70:30, 60:40, 50:50 and 0:100 were blended and designated A, B₉₁, C₈₂, D₇₃, E₆₄, F₅₅ and G respectively.

2.2.2 Production of cupcake from composite flour

The Ceserani and Kinton [4] method was used to prepare the cake. After cooking, the cakes were allowed to cool in the tin for 5 minutes before being transferred to a steel tray for additional cooling and analysis.

2.3 Proximate Analysis

The samples were evaluated for proximate analysis using the method as described by AOAC [5].

2.4 Functional Properties

Bulk density was determined by the method of Nyarayana and Narasinga-Rao (1984). Water absorption capacity (WAC) and oil adsorption capacity (OAC) of samples were determined following method of Adebowale et al [6], Swelling Capacity was determined using the method of Abbey and Ibeh (1988).

2.4.1 Determination of selected micronutrient content of the cake samples

Determination of zinc and calcium using atomic absorption spectrophotometer (AAS) as described by AOAC [5].

2.5 Vitamin Determination

Vitamin B₁ (Thiamine) content was determined according to the method of Onwuka, [7]. Beta-carotene content was determined using the method Pearson [8].

2.6 Sensory Evaluation

The cake samples were evaluated for colour, flavor, taste, mouthfeel, texture and overall acceptability using a nine-point hedonic scale.

2.7 Experimental Design and Data Analysis

All experiments used a completely randomized design (CRD). The obtained data was analyzed using the analysis of variance (ANOVA) at the 0.05 probability level. Means were compared using Duncan multiple range tests in SPSS

version 20.0, with significance considered at $p \leq 0.05$.

3. RESULTS AND DISCUSSION

Table 1 show the proximate composition (%) of wheat, wheat-garri flour blends and garri flour.

Sample A (100% wheat flour) and sample G (100% garri flour) had 13.62% and 11.01% for moisture; 0.94 and 0.26% for fat; 0.92% and 6.09% for ash; 0.62% and 1.29 for fibre; 10.61% and 1.04% for protein and 73.31% and 86.29 % for carbohydrate content while the blends ranged from 11.01 to 13.23% for moisture; 0.41- 0.81% for fat; 0.40 – 0.88% for ash; 0.75 -1.01% fibre; 6.16 – 10.03% for protein and 74.66 – 86.29% for carbohydrate. The protein content was comparable to the results of composite flours produced from rice, pigeon pea, and African yam bean reported by Anene et al. (2023) and 3.37% to 11.70% for plantain, rice bran, and mesquite composite flours stated by Emojorho et al. (2024a), but lower than the 18.51% to 36.65% revealed by Emojorho and Okonkwo, (2022). While the ash level was slightly lower than 1.00% to 2.00% for pigeon pea, African yam bean, and rice composite flour reported by Anene et al. (2023) and 1.35 to 1.75% for plantain, rice bran, and mesquite composite flours reported by Emojorho et al. (2024). Increased garri quantity resulted in lower moisture, protein, and fat content ($p < 0.05$), but higher crude fiber, ash, and carbohydrate levels. Cassava is low in fat and protein, which could be the reason for decrease in fat and protein levels [9]. According to Ihekoronye and Ngoddy [10], flour typically includes approximately 14% moisture absorbed from the atmosphere. However, the moisture content of the samples was below the amount that would promote mold formation.

Table 2 compares the functional qualities of wheat, wheat-garri flour blends, and garri flour. The general attributes and industrial applications of food materials are heavily influenced by their functional features [11]. The functional properties of the sample A (100% wheat flour) and sample G (100% garri flour) were 0.635g/cm³ and 0.765g/cm³ for bulk density (BD); 11.23% and 26.05% for water absorption capacity (WAC); 15.89% and 10.52 % for oil absorption capacity (OAC) and 10.43% and 25.39% for swelling capacity (SC). Samples A and G recorded the lowest and highest scores respectively in all the

Table 1. Proximate composition (%) of wheat-garri flour blends

Samples	Moisture	Fat	Ash	Fibre	Protein	Carbohydrate
A	13.62 ^a ±0.007	0.94 ^a ±0.098	0.92 ^a ±0.000	0.60 ^e ±0.014	10.61 ^a ±0.00	73.31 ^b ±0.080
B ₉₁	13.23 ^a ±0.007	0.81 ^b ±0.049	0.88 ^a ±0.000	0.75 ^d ±0.000	10.03 ^a ±0.014	74.66 ^b ±0.007
C ₈₂	13.01 ^a ±0.001	0.72 ^c ±0.049	0.79 ^a ±0.000	0.81 ^c ±0.014	9.01 ^b ±0.007	75.58 ^b ±0.084
D ₇₃	12.67 ^b ±0.035	0.63 ^d ±0.035	0.61 ^b ±0.014	0.87 ^c ±0.021	8.89 ^c ±0.007	76.83 ^b ±0.028
E ₆₄	12.25 ^b ±0.005	0.52 ^e ±0.070	0.53 ^b ±0.049	0.96 ^b ±0.049	7.28 ^d ±0.028	78.46 ^b ±0.041
F ₅₅	12.01 ^b ±0.030	0.41 ^f ±0.014	0.40 ^c ±0.007	1.01 ^b ±0.141	6.16 ^e ±0.021	80.01 ^a ±0.028
G	11.01 ^c ±0.010	0.26 ^c ±0.014	0.11 ^d ±0.007	1.29 ^a ±0.021	1.04 ^f ±0.063	86.29 ^a ±0.06

Values are means of ± S.D of duplicate determinations. Means with different superscript within the same column are significantly different ($p < 0.05$). Keys: A= wheat flour 100:0, B₉₁ = wheat-gari blends 90:10, C₈₂= wheat-gari blends 80:20, D₇₃= wheat-gari blends 70:30, E₆₄= wheat-gari blends 60:40, F₅₅= wheat-gari blends 50:50, G= Garri flour 0:100

Table 2. Functional properties of wheat, wheat-garri flour blends and garri flour

Samples	Bulk Density g/cm ³	Water Absorption Capacity %	Oil Absorption Capacity %	Swelling Capacity%
A	0.635 ^c ±0.007	11.32 ^d ±0.01	15.89 ^c ±0.010	10.43 ^c ±0.028
B ₉₁	0.657 ^{bc} ±0.021	12.15 ^c ±0.04	14.56 ^c ±0.010	11.29 ^{bc} ±0.035
C ₈₂	0.665 ^{bc} ±0.007	12.24 ^c ±0.08	14.23 ^c ±0.020	12.48 ^b ±0.030
D ₇₃	0.685 ^b ±0.007	12.53 ^c ±0.02	13.84 ^b ±0.010	12.88 ^b ±0.004
E ₆₄	0.689 ^b ±0.070	13.10 ^b ±0.09	13.12 ^b ±0.010	13.41 ^b ±0.007
F ₅₅	0.691 ^b ±0.000	13.51 ^b ±0.07	12.66 ^b ±0.580	14.12 ^b ±0.021
G	0.765 ^a ±0.007	26.05 ^a ±0.05	10.52 ^a ±0.077	25.39 ^a ±0.020

Keys: Keys: A= wheat flour 100:0, B₉₁ = wheat-garri blends 90:10, C₈₂= wheat-garri blends 80:20, D₇₃= wheat-garri blends 70:30, E₆₄= wheat-garri blends 60:40, F₅₅= wheat-garri blends 50:50, G= Garri flour 0:100

Table 3. Vitamins and minerals contents of the cakes samples

Samples	Vitamin B ₁ (mg/100g)	Vitamin A (IU)	Zn (mg/100g)	Ca (mg/100g)
A	0.315 ^a ±0.012	7.795 ^a ±0.212	0.245 ^a ±0.245	12.583 ^a ±0.118
B ₉₁	0.285 ^b ±0.007	7.580 ^b ±0.0282	0.226 ^b ±0.226	12.020 ^b ±0.212
C ₈₂	0.245 ^c ±0.012	7.440 ^{bc} ±0.056	0.211 ^{bc} ±0.245	11.845 ^c ±0.063
D ₇₃	0.195 ^d ±0.007	6.020 ^c ±0.028	0.160 ^c ±0.160	10.895 ^d ±0.134
E ₆₄	0.170 ^e ±0.0041	5.570 ^d ±0.424	0.095 ^d ±0.095	9.020 ^e ±0.141

Samples	Vitamin B ₁ (mg/100g)	Vitamin A (IU)	Zn (mg/100g)	Ca (mg/100g)
F ₅₅	0.13 ^d ±0.0041	4.020 ^e ±0.014	0.057 ^e ±0.047	4.685 ^f ±0.212
G	0.035 ^f ±0.007	0.995 ^f ±0.007	0.018 ^f ±0.07	1.156 ^g ±0.070

Values are means of ± S.D of duplicate determinations. Means with different superscript within the same column are significantly different ($p < 0.05$). Keys: A= Cake produced from wheat flour 100:0, B₉₁= Cakes produced from wheat-gari blends 90:10, C₈₂= Cakes produced from wheat-gari blends 80:20, D₇₃= Cakes produced from wheat-gari blends 70:30, E₆₄= Cakes produced from wheat-gari blends 60:40, F₅₅= Cakes produced from wheat-gari blends 50:50, G= Cakes produced from gari flour 0:100

Table 4. Sensory scores of cup cakes made from garri flour, wheat flour and wheat-garri flour blends

Samples	Taste	Color	Flavor	Mouth Feel	Finger Feel	After Taste	Overall Acceptability
A	7.9 ^a ±0.99	8.2 ^a ±1.23	8.0 ^a ±0.64	7.9 ^a ±1.07	7.25 ^a ±1.68	7.75 ^a ±0.91	8.0 ^a ±0.94
B ₉₁	7.3 ^{ab} ±0.34	7.7 ^b ±1.08	7.7 ^b ±0.80	7.3 ^b ±1.08	6.96 ^c ±1.63	7.2 ^a ±1.15	7.6 ^b ±1.23
C ₈₂	7.0 ^{ab} ±0.25	7.45 ^b ±1.05	7.3 ^{bc} ±0.80	7.4 ^b ±0.88	7.05 ^b ±1.09	7.15 ^a ±0.81	7.25 ^b ±0.85
D ₇₃	7.2 ^{ab} ±0.05	7.35 ^b ±0.87	7.55 ^b ±0.94	7.1 ^b ±1.16	7.15 ^b ±1.30	7.25 ^a ±1.01	7.3 ^b ±0.80
E ₆₄	6.55 ^c ±0.07	7.55 ^b ±0.9	6.7 ^d ±1.30	6.65 ^c ±1.38	6.85 ^c ±1.30	6.65 ^b ±0.98	7.2 ^b ±1.05
F ₅₅	7.45 ^{ab} ±0.39	8.0 ^{ab} ±0.94	7.65 ^b ±0.87	7.4 ^b ±1.35	7.30 ^b ±1.49	7.45 ^a ±1.46	7.55 ^b ±1.60
G	4.45 ^d ±0.76	6.4 ^c ±1.56	5.6 ^e ±1.53	4.7 ^d ±1.89	5.3 ^d ±1.89	4.45 ^c ±1.76	5.0 ^c ±1.29

Values are means of ± S.D. Keys: A= Cake produced from wheat flour 100:0, B₉₁= Cakes produced from wheat-gari blends 90:10, C₈₂= Cakes produced from wheat-gari blends 80:20, D₇₃= Cakes produced from wheat-gari blends 70:30, E₆₄= Cakes produced from wheat-gari blends 60:40, F₅₅= Cakes produced from wheat-gari blends 50:50, G= Cakes produced from gari flour 0:100

functional properties evaluated. This implies that garri absorbs more water and oil than wheat flour. Those of the flour blends that ranged from 0.635(g/cm³) to 0.765(g/cm³) for BD; 11.32% to 26.05% for WAC; 13.34% to 15.89% For OAC, and 10.43% to 25.39% for SC significantly ($p > 0.05$) increased as the quantity of garri flour increased. The bulk density of the flours were similar to 0.66 to 0.76% for pigeon pea, black gram, and composite flour reported by Anene et al. (2023), 0.64 to 0.66 g/cm³ for Afzelia Africana and composite wheat flour reported by Emojoorho et al. (2024), and also 0.42 to 0.72 g/cm³ for orange seed flours reported by Emojoorho and Akubor, [12], but higher than 0.40 to 0.44 g/cm³ for plantain, rice bran, and mesquite seed flours reported by Emojoorho. The high carbohydrate content of the garri flour could account for the observed rise in bulk density of the blends. Bulk density is essential in package design and food handling. According to Malomo et al. [13], -the capacity to absorb water rises as carbohydrate content increases. WAC measures the product's ability to associate with water in water-limited situations, and it is significant in product bulking and consistency, as well as baking applications [14]. Increased garri flour ratio resulted in considerably lower OAC ($p < 0.05$). This could be due to the gluten in wheat flour's inability to bind oil after it was diluted during the substitution procedure. OAC measures the rate at which protein binds to fat in food formulations [15]. However, the SC of the blends improved as garri flour was added as a substitute, with sample G having the highest SC (25.39%). This could be related to the starch in the garri flour, as SC is evidence of noncovalent interaction between molecules with starch granules as well as an indicator of amylose to amylopectin ratios [16].

Table 3 shows the mineral and vitamin composition of the cake samples. The values of vitamin B₁, vitamin A, zinc and calcium content of the wheat flour, wheat-garri blends and garri flour ranged from 0.035 to 0.315mg/100g, 7.795 to 0.995 IU, 0.245 to 0.018 mg/100g and 12.583 to 1.156 mg/100g respectively. The vitamin B1 results were higher than 0.03 to 0.07 mg/100g reported for orange seed biscuits by Emojoorho et al. [17] and 0.01 to 0.07 mg/100g for snaks produced from composite flour reported by Aphiar et al., [18]. The calcium content was higher than 3.08 to 4.00 calcium content for composite flour from plantain, rice bran and mesquite seed reported by Emojoorho et al., (2024a) but lower than 419.42 to 686.33 mg/100g for biscuits from composite flour

reported by Emojoorho et al. [19] and 114.01 to 875.41 mg/100g Calcium reported by Emojoorho et al., (2022) for orange seed flours. Since garri flour was low in the above analysed vitamins and minerals, it was observed that increase in garri flour generally led to decrease of these micronutrients of the wheat-garri flour blends. This could be attributed to garri having little or no vitamin B₁ content. The unstable nature of vitamin B₁ to heat may have equally affected it negatively. The reasonable quantity of vitamin A observed may be attributed to other component such as eggs added. It was also observed that vitamin A and the minerals (Zn and Ca) were not drastically reduced during baking. This could be attributed to the fact that they are not readily destroyed when exposed to heat [20].

Table 4 shows the sensory scores for cakes made with wheat flour, wheat-garri flour mixes, and garri flour [21,22]. Samples containing wheat-garri flour blends had similar acceptance ranges across all parameters. Sample (A) was the most desired in terms of overall acceptability, with high ratings in all attributes. This could be due to individual preferences. Overall, the high organoleptic ratings indicate that the cake was well received by the panelists, with the exception of sample G, which had the lowest mean scores [23,24].

4. CONCLUSION

This study indicates the feasibility of using garri and wheat flour blends for cake baking, with improved carbohydrate and fiber level. Acceptable cakes were created, however cake even up to 50 % of garri substitution were accepted by consumers. As a result, adopting up to to 50% garri flour in cake production might drastically reduce foreign spending on wheat imports while also producing new cake product varieties.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nassef SL, Hafez HH. Determining quality attributes of cupcakes by watermelon puree and stevia sweetener. *Asian J. Food Res. Nutri.* 2024;3(1):1. Available: <https://journalajfrn.com/index.php/AJFRN/article/view/104> [Accessed on 2024 May 30]
2. Raj R, Singh SP, Murarka S. Study the Functional and Nutritional Assessment of Sorghum (*Sorghum bicolor* L.) Based Muffins. *Curr. J. Appl. Sci. Technol.* 2023; 42(15):28-36. Available: <https://journalcjast.com/index.php/CJAST/article/view/4124> [Accessed on 2024 May 30].
3. Mirani A, Goli M. Optimization of cupcake formulation by replacement of wheat flour with different levels of eggplant fiber using response surface methodology. *Food Science and Technology.* 2021;42:e52120.
4. Ceserani, V. and Kinton, R. (2008). *Practical cookery*, 10th edition. London: Holder and Stoughter.
5. AOAC: Official Methods of Analysis, Association of Official Analytical Chemist, Washington D. C. U.S.A, 18th edition; 2010.
6. Adebawale YA, Adeyemi IA, Oshodi AA. Functional and physicochemical properties of flours of six *Mucuna species*. *African Journal of Biotechnology.* 2005;4:1461.
7. Onwuka GI. Food analysis and instrumentation. Theory and practice. Naphtali prints. A Division of HG Support Nigeria Limited, Surulere, Lagos, Nigeria. 2005;199-121
8. Pearson DA. *The Chemical Analysis of Foods* (7th Edition) Churchill and living stone, Eduinburgh, London. 1976;355 – 356.
9. Enwere JN *Foods of plant origin.* afro-orbis publication LTD, Nsukka, Nigeria. 1998;24-152
10. Ihekoronye AI, Ngoddy PO. *Integrated Food science and technology for the tropics.* Macmillian Education Limited, London. 1985;293-307
11. Adeleke RO, Odedeji JO. Functional properties of wheat and sweet potato flour blends. *Pakistan Journal of Nutrition.* 2010;9:535
12. Emojorho EE, Akubor PI Effect of debittering methods on the proximate composition sensory and functional properties of orange (*Citrus sinensis*) Seed Flour/IOSR. *Journal of Environmental Science, Toxicology and Technology (IOSR-JESTFT).* 2016;10(9)134-139.
13. Malomo SA, Eleyinmi AF, Fashakin JB. Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit. *African Journal of Food Science.* 2011;5(7):400 – 410.
14. Niba LL, Bokonga MM, Jackson EL, Schlimme DS, Li BW. Physicochemical properties and starch granular characteristics of flour from various *Manihot esculenta* (cassava) genotypes. *Journal of Food Science.* 2001;67(5): 1701-1705.
15. Onimawo IA, Akubor PI. *Food Chemistry: Integrated Approach with Biochemical Background.* 2nd Edition. Joytal printing press, Agbowo, Ibadan, Nigeria. 2012;287 – 29
16. Rasper V. Investigation on starches from major starch crop grown in Ghana. II. Swelling and solubility patterns and amyloplastic susceptibility. *Journal of Science Food and Agriculture.* 1969;20: 642–646.
17. Emojorho EE, Okonkwo TM, Anene MN. Effect of Debittering Methods on the Minerals Composition of Sweet Orange Seeds Flour. *Food Proc Nutr Sci.* 2023;3(1): 1-7.
18. Aphiar A, Emojorho EE, Anene MN, Udeh CC, Nwosu AN, Ochimana TO. Chemical, functional, physical and microbial properties of snack from blends of rice, bambara groundnut incorporated with african egg plant leaves (anara). *Global Scientific Journal.* 2024;12(1):2790-2811.
19. Emojorho EE, Anene MN, Udeh CC. Minerals vitamins and anti-nutritional properties of biscuits produced from defatted and undefatted debittered orange seed flours. *American Journal of Food Sciences and Nutrition.* 2023;5(2) 67 – 82
20. Fennema RO. *Food Chemistry.* Third edition. Marcel Dekker, Inc. USA; 1996.
21. Abbey BW, Ibeh GO. Functional properties of raw processed cowpea (*vigna uguiculata*) flour. *Journal of Food Science.* 1998;53:1775-1777.
22. Anene MN, Emojorho EE, Chiedu UC, Anyaiwe UC Rheological, micronutrients and microbial quality of idli produced from blends of rice (*Oryzasativa*), african yam bean (*Sphenostylis sternocarpa*) and

- pigeon pea (cajanuscajan). Global Scientific Journals. 2023b;11(11):1941 - 1962.
23. Emojoorho EE, Udeh CC, Anene MN, Aphiar A, Nwosu AN, Ochimana TO. Chemical and Functional Properties of Pasting Producing from Plantain, Mesquite Seed Flours and Rice Bran. Asian Journal of Research in Agriculture and Forestry. 2024b;10(2):1–11. Available:<https://doi.org/10.9734/ajraf/2024/v10i2279>
24. Narayana, K. and Narasinga-Rao, M.S. Effect of partial proteolysis on the functional properties of winged pea (*Psophocarpus tetragonolobus*) flour, Journal of Food Science. 1984;49:944-947.

© Copyright (2024): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/118344>