

Evaluation of Functional Characteristics of Cassava and Bambara Nut Flour Blends for Baking and Extruded Products

Akintola, A. ¹; and Anifowose, M. T. ²

¹Department of Agricultural and Bio-Environmental Engineering, Oyo State College of Agriculture and Technology, Igboora. ²Department of Post-Harvest Technology, Oyo State College of Agriculture and Technology, Igboora.

Corresponding author: akintunde.akintola@yahoo.com

DOI: <https://doi.org/10.62154/ajasfr.2025.019.01019>

Abstract

This research focused on developing an alternative flour blend that is functionally diverse and nutritionally superior to the existing ones in baking industries. In order to evaluate the potential of composite flours made from different proportions of cassava (*Manihot esculenta*) and Bambara nut (*Vigna subterranea*) in food applications, this study examines their functional characteristics. Five ratios of flour mixes (30:70, 40:60, 50:50, 60:40, and 70:30) were created, with 100% cassava flour acting as the control. Using standard procedures, functional characteristics such as bulk density, solubility, swelling ability, oil absorption capacity (OAC), and water absorption capacity (WAC) were evaluated. The results showed that WAC varied from 75.67 g/g (BC 70:30) to 87.00 g/g (BC 40:60), with the control having the highest value (88.23 g/g). Higher Bambara nut inclusion led to an increase in swelling ability, with maximum value at 8.47% (BC 50:50) and then slightly decreased at higher levels. OAC increased from 70.67 g/g (BC 70:30) to 76.00 g/g (BC 30:70) when the amount of Bambara nuts increased. As Bambara flour was added, solubility ranged from 4.20 to 6.20%, and bulk density dropped, favouring aeration in food preparation. These results imply that adding Bambara nut to cassava flour improves its ability to retain water and oil while maximising swelling at a 50:50 ratio. The functional properties of the composite flour show that it is appropriate for use in bakeries and extruded foods, which helps to increase food security.

Keywords: Bambara Nut, Cassava Flour, Functional Properties, Composite Flour, Food Applications.

Introduction

Major global challenges are nutrition and food security, particularly in underdeveloped nations where a high reliance on staple foods with little nutritional diversity exists. According to Adebayo and Olatunji (2018), composite flour is a mixture of two or more different flours and it has drawn interest as a way to reduce the demand on wheat flour while enhancing the nutritional and functional qualities of food products. Bambara nuts (*Vigna subterranea*) and cassava (*Manihot esculenta*) are two underutilized but nutritious crops that could be turned into composite flour with improved functional qualities.

One leguminous crop that is high in protein, carbs, and vital amino acids is the bambara nut (Oyedemi *et al.*, 2021). Due to its high nutritional value and ability to withstand drought, it is a crop that can be used for food purposes in sub-Saharan Africa (Oyeyinka *et al.*, 2019; Aremu *et al.*, 2022). However, issues including low industrial processing and hard-to-cook qualities continue to limit its use. In contrast, cassava is a popular root crop that is processed easily and has high carbohydrate content (Ugbajah *et al.*, 2020). Although cassava flour is frequently substituted for wheat flour, its nutritional value is limited due to its insufficient protein content.

When Bambara nut and cassava flour are combined in the right amounts, the resulting composite flour may have better functional qualities and be used in a wider range of food applications. The performance of flour in food formulation and processing is influenced by functional qualities such as swelling power, oil absorption capacity, and water absorption capacity (Adebowale *et al.*, 2017). Legume-enriched composite flours have been found to improve food items' texture, protein content, and stability, making them appropriate for use in bakery, snack, and weaning food formulations (Oluwajuyitan and Ijarotimi, 2021).

The main aim of this study is to assess some selected functional qualities of cassava and bambara nut composite flour in order to ascertain its acceptability for use in food applications. By lowering dependency on wheat flour and improving food security, the results will help create nutrient-rich and functional composite flour that may be used in baking industries.

Problem Statement

Major global challenges are nutrition and food security, particularly in underdeveloped nations where a high reliance on staple foods with little nutritional diversity exists. Composite flours have attracted a lot of interest in baking industries in order to reduce the great dependency on wheat flour. Although cassava flour is frequently substituted for wheat flour, its nutritional value is limited due to its insufficient protein content. Hence, the inclusion of Bambara nut in various proportions and evaluation of the functional properties in order to select the best blend.

Methodology

Materials and Sample Preparation

The Bambara nut and cassava chips were purchased at a nearby market. After being sorted, cleaned, and dried for 24 hours at 60°C, the Bambara nuts were dehulled and ground into flour using a Hammer Mill (Model: HM-3100, Perten Instruments, Sweden). Using the same hammer mill, pre-dried cassava chips were ground to produce the cassava flour. Multiple proportions of the two flours (30:70, 40:60, 50:50, 60:40 and 70:30) were mixed together in order to evaluate their functional characteristics with 100% cassava flour as control. Samples were coded based on the ratio of Bambara nut (B) to cassava (C), for example, 30:70 indicates 30% Bambara nut flour and 70% cassava flour.

Determination of Functional Properties

Water Absorption Capacity (WAC)

The method outlined by Adebowale *et al.* (2021) was used to determine the water absorption capacity. 10 mL of distilled water and approximately 1.0 g of the flour sample were combined in a centrifuge tube, and the mixture was centrifuged at 3,000 rpm for 20 minutes using a Centrifuge (Model: Hettich Universal 320, Germany). The supernatant was then decanted, and the weight of the hydrated flour was observed. The WAC was calculated using equation (1):

$$\text{WAC (g/g)} = \frac{\text{Weight of hydrated sample} - \text{Weight of dry sample}}{\text{Weight of dry sample}} \quad (1)$$

Swelling Ability

Swelling ability was determined using a modified version of Udeh and Okonkwo (2020) methodology. In a graduated test tube, about 1.0 g of the sample was combined with 10 mL of distilled water, and it was heated for 30 minutes at 80°C in a water bath (Model: Grant SUB6, UK). After the tube had cooled to room temperature, the sample's ultimate volume was measured and recorded as shown in equation (2) below:

$$\text{Swelling Index} = \frac{\text{Final volume of sample}}{\text{Initial weight of sample}} \quad (2)$$

Oil Absorption Capacity (OAC)

The approach outlined by Ayo *et al.* (2018) was used to calculate the oil absorption capacity. In a centrifuge tube, 1.0 g of the flour sample and 10 mL of refined vegetable oil were mixed together and the mixture was vortexed for one minute using a Vortex Mixer (Model: Vortex-Genie 2, Scientific Industries, USA). After centrifuging the mixture for 20 minutes at 3,000 rpm, the supernatant was decanted. The weight difference was used to calculate the absorbed oil as shown in equation 3.

$$\text{OAC (g/g)} = \frac{\text{Weight of oil absorbed}}{\text{Weight of dry sample}} \quad (3)$$

Solubility

The procedure outlined by Yeboah *et al.* (2019) was used to determine solubility. 50 mL of distilled water was used to disperse around 2.0 g of the sample, which was then stirred for 30 minutes and centrifuged for 20 minutes at 3,000 rpm. After carefully decanting the supernatant, it was oven-dried for four hours at 105°C using a Memmert UN110 oven (Germany). After the dried residue was weighed, equation (4) was used to determine its solubility:

$$\text{Solubility (\%)} = \frac{\text{Weight of dried supernatant}}{\text{Initial weight of sample}} \times 100 \quad (4)$$

Bulk Density

Bulk density was calculated using the method described by Akubor and Ukwuru (2017). After weighing a 50 mL measuring cylinder (W_1), 10 g of the sample was added. After 20

taps on the cylinder, the new volume was measured. Bulk density was computed using equation (5) after the weight of the cylinder containing the sample (W_2) was recorded:

$$\text{Bulk Density } \left(\frac{\text{g}}{\text{cm}^3} \right) = \frac{(W_2 - W_1)}{\text{Volume of sample after tapping}} \quad (5)$$

Statistical Analysis

Three replicates of each measurement were obtained, and the mean $\pm$ standard deviation was used to express the results. One-way Analysis of Variance (ANOVA) in SPSS software (Version 26.0, IBM, USA) was used for analysing the statistical differences, and Duncan's Multiple Range Test was used to separate means at a 5% significant level ($p < 0.05$).

Results and Discussion

The functional characteristics of blends of bambara and cassava flour at various mixing ratios are shown in Table 1.

Table 1: Functional properties of Bambara-cassava flour blends

Treatment (%)	Water Absorption Capacity (g/g)	Swelling Ability (%)	Oil Absorption (g/g)	Solubility (%)	Bulk Density (g/cm ³)
Control	88.23 $\pm$ 0.33 ^{ab}	6.18 $\pm$ 0.02 ^a	79.40 $\pm$ 1.16 ^b	5.46 $\pm$ 0.03 ^b	0.78 $\pm$ 0.33 ^{ab}
BC 30:70	84.33 $\pm$ 2.89 ^{ab}	7.99 $\pm$ 1.06 ^a	76.00 $\pm$ 1.00 ^a	5.53 $\pm$ 0.81 ^{ab}	0.76 $\pm$ 0.02 ^{ab}
BC 40:60	87.00 $\pm$ 2.00 ^a	8.26 $\pm$ 0.52 ^a	74.33 $\pm$ 5.51 ^a	4.20 $\pm$ 0.35 ^b	0.74 $\pm$ 0.03 ^b
BC 50:50	81.33 $\pm$ 1.16 ^b	8.47 $\pm$ 0.29 ^a	71.33 $\pm$ 6.51 ^a	5.67 $\pm$ 0.58 ^{ab}	0.74 $\pm$ 0.03 ^b
BC 60:40	83.33 $\pm$ 2.08 ^{ab}	7.44 $\pm$ 0.33 ^{ab}	72.33 $\pm$ 3.51 ^a	6.20 $\pm$ 0.35 ^a	0.76 $\pm$ 0.02 ^{ab}
BC 70:30	75.67 $\pm$ 2.31 ^c	6.55 $\pm$ 0.35 ^b	70.67 $\pm$ 0.58 ^a	5.53 $\pm$ 1.36 ^{ab}	0.79 $\pm$ 0.02 ^a

*All values are given as Mean $\pm$ Standard deviation

*Values with different alphabets shows significant difference at $p < 0.05$

Water Absorption Capacity (WAC)

Figure 1 shows the WAC of bambara and cassava flour at various mixing ratios.

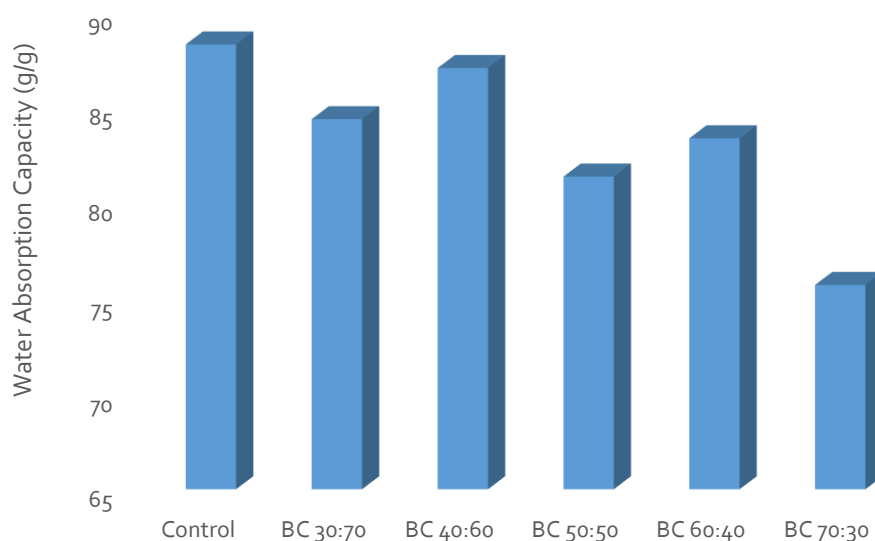


Figure 1: Water absorption capacity of the composite flours.

The findings showed that the control sample recorded 88.23 g/g, while the cassava–Bambara flour blends had water absorption capacities ranging from 75.67 g/g (BC 70:30) to 87.00 g/g (BC 40:60). The control sample unexpectedly had the highest WAC, this indicated that the lack of Bambara flour improved the sample's capacity to bind water, maybe as a result of pure cassava flour's higher starch content. So, WAC generally decreases with increasing Bambara, except for an uptick at 40% Bambara, indicating that the entire mixture maintained strong hydration qualities (Adebowale *et al.*, 2022). This could be advantageous in food applications which require high water retention, such as baking and extruded items.

Swelling Ability

Figure 2 shows the swelling ability of bambara and cassava flour at various mixing ratios.

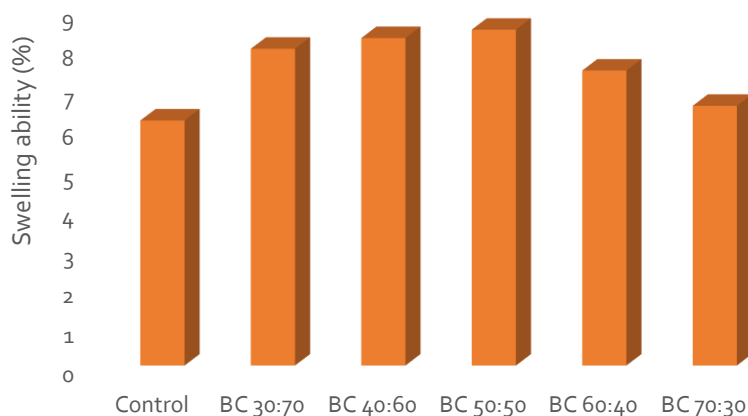


Figure 2: Swelling ability of the composite flours.

The swelling ability increased as the percentage of Bambara flour increased, with BC 50:50 (8.47%) having the highest value. The increase implies that the proteins in Bambara flour and cassava starch interacted to improve the hydration and swelling of starch granules, which is essential for modifying texture in food processing (Eke-Ejiofor and Owuno, 2012). But when Bambara inclusion was increased above 50%, there was a minor decrease, which might have been caused by protein and starch competing for water molecules, which reduced the swelling ability (Adeoti *et al.*, 2021).

Oil Absorption Capacity (OAC)

Figure 3 shows the OAC of bambara and cassava flour at various mixing ratios.

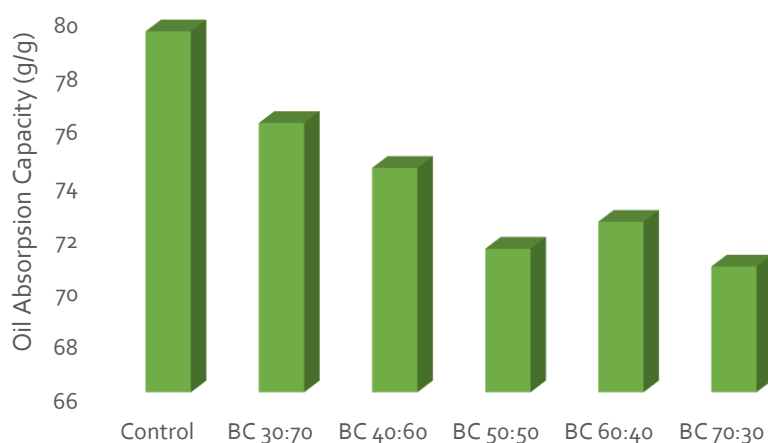


Figure 3: Oil absorption capacity of the composite flours.

Oil absorption ranged from 70.67 g/g (BC 70:30) to 76.00 g/g (BC 30:70) while the control was slightly higher. In general, OAC increased with increasing Bambara flour, suggesting that Bambara proteins include hydrophobic amino acids that improve lipid binding. According to Oluwamukomi *et al.* (2011), the higher OAC of the control indicates that pure cassava flour, being starchy, has a greater capacity to trap oil inside its matrix. Comparable patterns were observed in similar investigations on composite flours, where the existence of protein networks with the ability to store oil led to a modest improvement in OAC with higher legume integration (Akanbi *et al.*, 2020).

Solubility

Figure 4 shows the solubility of bambara and cassava flour at various mixing ratios.

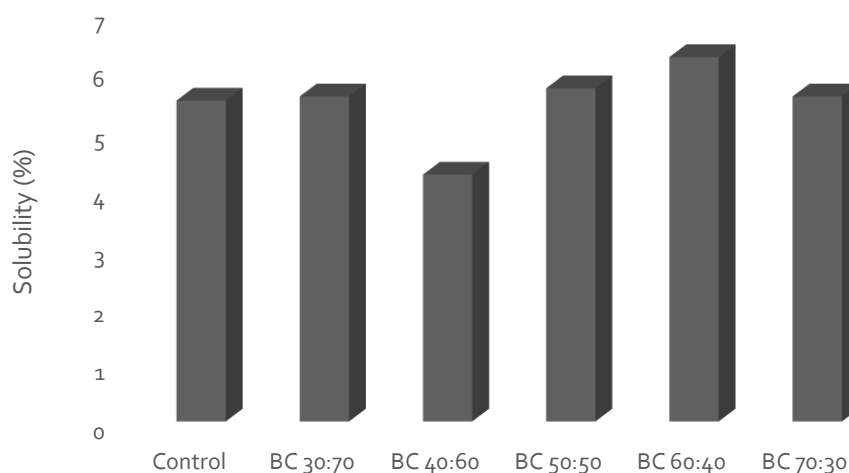


Figure 4: Solubility of the composite flours.

Solubility varied between 4.20% (BC 40:60) and 6.20% (BC 60:40), with 5.46% being recorded for the control. The decreased solubility at greater Bambara levels raises the possibility that the protein concentration limited the rate of solubility by forming a more complicated matrix. The control exhibited moderate solubility, which may be explained by the fact that cassava starch is more soluble than legume proteins (Fasuan *et al.*, 2017). The current results are in line with a related work by Ajibola *et al.* (2023), which discovered that protein-starch interactions can decrease solubility because of protein gel formation.

Bulk Density

Figure 5 shows the bulk density of bambara and cassava flour at various mixing ratios.

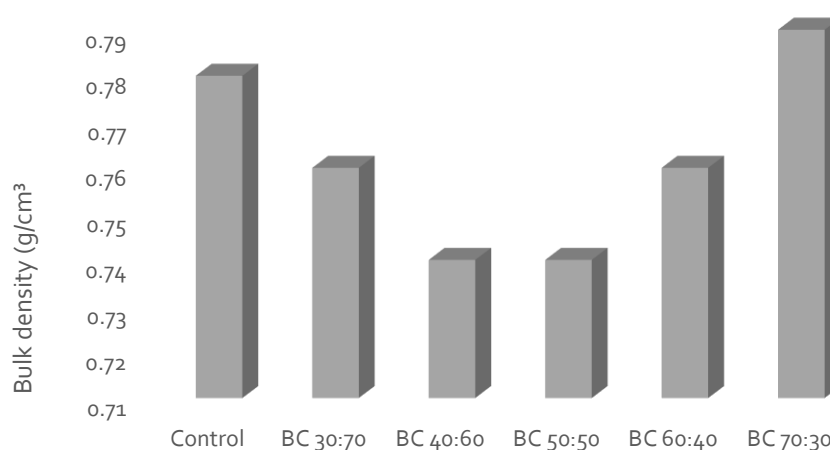


Figure 5: Bulk density of the composite flours.

Bulk density ranged from 0.74 g/cm³ (BC 50:50 and BC 40:60) to 0.79 g/cm³ (BC 70:30), with 0.78 g/cm³ serving as the control. Protein-enriched blends are often less dense because of

increased porosity, as indicated by the decrease in bulk density with increasing Bambara flour. For flour mixes meant for baking, a lower bulk density is beneficial since it enhances leavening capacity and encourages aeration.

Conclusion

The functional characteristics of cassava-Bambara blends showed that adding less Bambara flour improves the blend's ability to absorb water and oil, while 50% inclusion optimizes swelling and solubility. However, functionality may be limited if Bambara flour content exceeds 60%. The observed patterns support the usefulness of Bambara-cassava blends for a variety of food uses and are consistent with earlier studies.

Acknowledgments

The Authors are grateful to TETFUND for the provision of the research grant to undertake this research project under the Institution Based Research (IBR) programme. We are also grateful to the Directorate of Research and Collaborations and the Management of Oyo State College of Agriculture and Technology, Igboora, for the support given during the course of this research.

Conflict of Interest

The authors declare that there is no conflict of interest with regard to this research article.

References

- Adebayo, S. E., and Olatunji, T. L. (2018). Composite flour technology: A review of recent developments and applications in food products. *Food Science and Technology Research*, 24(4), 567-578.
- Adebawale, A. A., Afolabi, T. A., and Ogunyemi, S. O. (2021). Functional and physicochemical properties of composite flours in baked products. *Journal of Food Science and Technology*, 58(4), 1123-1135.
- Adebawale, A. A., Olawuni, I. A., and Aluko, R. E. (2022). Functional and pasting properties of legume-cassava composite flours. *Food Chemistry*, 368, 130832.
- Adebawale, A. A., Olayemi, F. F., and Awoyale, W. (2017). Functional and pasting properties of composite flours from selected cereals and legumes. *International Journal of Food Science & Technology*, 52(3), 679-688.
- Adeoti, O. A., Awolu, O. O., and Sanni, T. A. (2021). Effect of legume incorporation on swelling and hydration properties of composite flours. *Journal of Food Science and Technology*, 58(6), 2103-2112.
- Ajibola, C. F., Akinwale, O. A., and Oloyede, O. B. (2023). Protein-starch interactions in functional blends: A review. *Food Science and Nutrition*, 11(3), 1432-1447.
- Akanbi, T. O., Gbadamosi, S. O., and Oladeji, B. S. (2020). Oil and water absorption properties of plant-based composite flours. *International Journal of Food Properties*, 23(1), 564-578.
- Akubor, P. I., and Ukwuru, M. U. (2017). Physicochemical and sensory properties of composite flour biscuits. *Nigerian Food Journal*, 35(1), 45-56.
- Aremu, A. K., Oyefeso, B. O and Ojo-Ariyo, A. M. (2022). Selected mechanical properties of bambara groundnut seeds under compressive loading. *LAUTECH Journal of Engineering and Technology*. 16. 70-77.

- Ayo, J. A., Okpala, L. C., and Omosebi, M. O. (2018). Oil absorption properties of flour blends and their implications in baking. *International Journal of Food Science and Nutrition*, 69(2), 187-196.
- Eke-Ejiofor, J., and Owuno, F. (2012). Functional properties of composite flours and their applications in food processing. *Nigerian Food Journal*, 30(2), 43-50.
- Fasuan, T. O., Ikuje, A. V., and Adebawale, Y. A. (2017). Solubility and hydration properties of cassava-based flour blends. *International Journal of Food Science*, 2017, 1-8.
- Oluwajuyitan, T. D., and Ijarotimi, O. S. (2021). Nutritional and functional evaluation of composite flours for food application. *Journal of Food Processing and Preservation*, 45(8), e15512.
- Oyedele, A.B., Oladunjoye, A.O., Ijabadeniyi, O.A., Kayitesi, E. (2021). Phytochemicals in Bambara Groundnut. In: Oyeyinka, S.A., Ade-Omowaye, B.I.O. (eds) Food and Potential Industrial Applications of Bambara Groundnut. Springer, Cham. https://doi.org/10.1007/978-3-030-73920-1_8
- Oyeyinka, A. T., Adegbite, O. O., and Kayode, R. M. (2019). Bambara nut: A review of its nutritional composition and food applications. *Legume Science*, 1(1), e17.
- Udeh, N. N., and Okonkwo, C. A. (2020). Swelling and functional properties of composite flours: Implications for baking. *Food Science & Nutrition*, 8(1), 123-134.
- Ugbajah, M. O., Okonkwo, C. C., and Onwubuya, E. N. (2020). Processing and utilization of cassava flour in food production. *African Journal of Agricultural Research*, 15(7), 998-1006.
- Yeboah, A., Twum, L., and Anang, A. (2019). Impact of protein-starch interactions on solubility of composite flours. *International Journal of Food Chemistry*, 12(3), 187-195.