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Original Research Report

Harnessing the Potential of Local Snacks Produced from African Yam Beans and Local Rice for Improved and Sustainable Livelihoods in Nigeria

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Abstract: This study was designed to develop snacks utilizing composite flour blends of African yam beans and African rice, focusing on their proximate composition and sensory qualities. Flours were produced from African yam beans and African rice grains. The composite flours of African yam bean and African rice were formulated using different ratios specified as BSA, BSB, BSC, BSD, BSE, DOA, DOB, DOC, DOD and DOE. The proximate composition and sensory properties of the flour samples were determined using standard methods. Proximate results showed significant ($P< 0.05$) increase in protein (9.50 – 11.52%), Fiber (0.88 – 1.75%), ash (1.94 – 5.00%) and Carbohydrate (73.71 – 79.08%) and significantly decrease ($P<0.05$) in fat ((8.00 – 2.19%), and moisture (7.40 – 3.97%) for biscuits. While an increase in protein (12.63 – 9.75%), fiber (0.48 – 2.10%) and carbohydrate (73.41 – 60.82%) but decrease in moisture (12.80 – 6.59%) ash (3.00 – 1.48%) and fat (12.00 – 8.02%) was observed in doughnut samples. Sensory results showed that the panelist liked the snacks prepared from the blends; however, the control snack samples were most preferred. To enhance consumer appeal, the composite snacks with lower ratings (BSB and DOD) needs improvement. In order to improve food security and support sustainable livelihoods in Nigeria, this study recommends employing these indigenous crops to make nutritious snack options.

Keywords: African Rice, African Yam Beans, Proximate Composition, Sensory Evaluation, Snacks

1. Introduction

The Quest for optimal health through informed food choices has long been a pressing concern for researchers in food product development. Also, with the food prices skyrocketing globally, harnessing the potential of native food sources has become more important than ever. We can unleash the hidden potential of native crops like African yam beans and local rice by rethinking and expanding the ways in which we use them. This will allow us to create sustainable food solutions that lower costs and promote self-sufficiency. These insignificant crops are essential to feeding people and mitigating the impact of growing imports.

The importance of neglected crops especially legumes in addressing global food security concerns and fostering nutritional diversity, which enhances improved health and lifespan, has increasingly come to light in recent years (Udoh *et al*., 2024). These crops, native to Africa, play a vital role in the dietary habits of local communities. However, their potential remains largely untapped as key ingredients in snack production.

African Yam Bean (AYB) is a legume with high protein content, comparable to that of cowpeas, and are also rich in fiber, vitamins, and minerals (Ojuederie & Balogun, 2017). African yam bean seeds are renowned for their exceptional nutritional profile, making them a valuable food source for individuals battling malnutrition, particularly protein-energy malnutrition. Their rich nutrient content offers a powerful solution to bolster diets and improve health outcomes in vulnerable populations (Abioye *et al*., 2015). African yam beans (AYB) have gained recognition for their role in managing chronic conditions such as diabetes, hypertension, and cardiovascular diseases, thanks to their high dietary fiber content. This nutrient powerhouse offers a natural way to support better health, making AYB an ideal addition to diets aimed at combating these long-term ailments (Abioye *et al*., 2015). African yam bean is widely grown in both northern and southern parts of Nigeria for its huge nutritional, medicinal and economic values, (Baiyeri *et al*., 2023).

Comparably, a lot of Nigerians rely heavily on rice (Oryza glaberrima), which illustrates a notable trend in consumption patterns across the West African region (Chiaka *et al*., 2022; Soullier *et al*., 2020). Nigerians' dietary habits have changed significantly, shifting away from traditional staples like cassava, maize, and yam, as seen by their increased intake of rice (Global Rice Science Partnership (GRiSP), 2013).

Despite offering a reasonable quantity of fat and protein, African rice is a great source of carbohydrates. In addition to these macronutrients, it is a good source of riboflavin, niacin, and thiamin, three important vitamins. According to Verma and Srivastav (2017), African rice grains are composed of roughly 12% water, 75% to 80% starch, and 7% protein. They also include all of the amino acids. Making the most of these crops' ability to produce snacks could be essential to diversifying income sources, enhancing nutrition, and fostering local agricultural growth.

Snacks are convenient, portable foods consumed between meals to curb hunger and provide a quick source of energy (Hess *et al*., 2016). Cakes, biscuits, chin chin, doughnuts, puff-puff, meat pie among others are examples of snacks that are frequently eaten in Nigeria. Biscuits and doughnuts are

confectionary products that are consumed widely by households as snacks. According to Di Cairano *et al.*, (2018), biscuits are baked items with low final water content (1-5 g/100 g) and three main ingredients (flour, sugar, and fat). Because of their widespread acceptance, convenient use, and shelf stability, biscuits make up a significant portion of the snack category. Thus, biscuits which are widely consumed might provide ideal delivery systems for bioactive substances.

Doughnuts are easily prepared from a mixture of flour, egg, milk, sugar, leavening agents, flavorings, water and oil, deeply fried from a flour dough and typically either ring-shaped or without a hole (Sarraf *et al.*, 2016). Encouraging locally-made snacks could lessen the need for imported foods, boosting local economies and improving the sustainability of the food supply chain.

Therefore, this study focused on evaluating the proximate and sensory composition of locally produced snacks made in Nigeria using African rice and African yam beans. The aim of this study was to evaluate ways in which these initiatives might contribute to the goals of food security and reducing protein energy malnutrition by enhancing nutrition, boosting local economies, and advancing sustainable agricultural methods.

1.1. Statement of Problem

Exploring locally available food sources for healthy snacks that enhance traditional meals is necessary to combat protein-energy malnutrition in Nigeria. Innovative approaches must strike a balance between food security, nutrition, and dietary changes as the need for convenient foods is driven by urbanization and shifting consumer preferences

1.2. Purpose of the Study

The general purpose of this research is to develop snacks from composite flour of African yam beans and African rice. Specifically, the study determined:

(a) Proximate composition of snacks (Biscuits and Doughnuts).
(b) Sensory properties of Biscuits and Doughnuts

1.3. Research Questions

The following research questions guided the study:

(a) What is the proximate composition of snacks developed from African yam bean and African rice flour blends?
(b) What are the sensory properties and the general acceptability of the snack products?

2. Materials and Methods

2.1. Design for the Study

This was a developmental study which involved African yam beans and Rice enhanced snack products being produced for households. The research was mainly experimental. Experimental

research design according to Mitchell (2015) is centrally concerned with constructing research that is high in causal (internal) validity. The proximate analysis was carried out in the food science laboratory assisted by the laboratory technician while the acceptability testing was carried out in order to ascertain the acceptability of snacks enhanced with African yam beans. The sensory evaluation was carried out using 30 semi trained panelists from the department of home economics Michael Okpara University of agriculture.

2.1.1. Ethics Statement

The authors obtained ethical approval for the study from Michael Okpara University of Agriculture Umudike's College of Applied Food Sciences and Tourism. The participants' formal informed consent was acquired

2.2. Area of the Study

The experiment and sensory evaluation was carried out at the Home Economics Department Laboratory, Michael Okpara University of Agriculture Umudike, Abia state. Umudike is in Ikwuano Local Government Area of Abia State.

2.3. Population and Sample

A sample of 30 panelists consisting of 15 Home makers and 15 undergraduate students were randomly selected from the home economics department, Michael Okpara University of Agriculture Umudike, Abia State.

2.4. Instrument for Data Collection and Study Procedure

2.4.1. Sources of Materials

African yam beans seeds, and African rice grains were purchased from Eke Okigwe market, Imo state. Wheat flour and other ingredients used such as sugar, shortening, Eggs, salt, Nutmeg, baking powder, milk and flavorings were purchased at Ekeonuwa Douglas market, Owerri, Imo state

2.4.2. Sample Preparation

African yam beans were sorted to remove impurities, washed with tap water, and soaked for 10 hours. It was washed and dehulled, the dehulled seeds were oven dried and then ground into fine flour using a commercial mill and sieved through 150mm mesh sieve to obtain the flour and stored in an air tight container for further use. Rice grains were also sorted, washed severally and drained out using a sieve, it was dried by hot air for 4 hours. The grains were ground using a commercial mill and sieved to obtain the flour, then stored in an air tight container for further use.

2.4.3. Sample Formulation

Composite flour was formulated from processed seeds of African yam beans and African Rice grains using the following ratios:

Wheat flour (control): 1

80% African yam beans and 20% African Rice: 4:1
50% African yam beans and 50% African Rice: 1:1
60% African yam beans and 40% African Rice: 3:2
70% African yam beans and 30% African Rice: 7:3

The specified ratios of the composite flours were chosen based on their beneficial nutritional profiles specifically, the high protein content of African yam beans and the carbohydrate-rich characteristics of local rice.

2.4.4. Proximate Analysis procedure

The proximate analysis of the snack samples were determined in triplicate except for carbohydrate contents which was determined by difference. The standard method of Association of official analytical chemist (AOAC) 2016 was used to determine the chemical composition of the samples.

2.4.5. Sensory Evaluation Procedure

The sensory properties of the snack samples such as color, texture, taste, flavor and general acceptability were evaluated using thirty trained panelists (30) who are familiar with Biscuits and doughnut samples. A nine point hedonic scale was used for the sensory evaluation.

2.5. Data CollectionTechnique

Data was collected for every test and statistical analysis was done for both the proximate composition and sensory evaluation of the composite snack samples. The data was collected with the help of trained research assistant from the department of home science, Michael Okpara University of Agriculture, Umudike.

2.6. Data AnalysisTechnique

The data collected was organized in the wide format into excel file and then converted into the extended format to make it easy for the statistical analysis soft ware to transmit data. All samples were in duplicates, descriptive statistic (mean, standard deviation and significance (P- value) were done for all samples. Data were sorted and recorded using Analysis of variance and SPSS version 26 (which is statistical package for social science) to separate the means at ($P \leq 0.05$).

3. Results and Discussion

Table 1: Proximate composition of biscuit samples

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	Carbohydrate

BSA	5.24[b]	2.00[d]	8.00[a]	9.50[d]	1.00[c]	73.71[d]
BSB	7.40[a]	2.61[c]	3.00[d]	11.52[a]	1.75[a]	73.71 [c]
BSC	4.12[d]	1.94[c]	4.52[b]	10.00 [c]	1.73[b]	77.69[b]
BSD	4.50[c]	4.00[b]	2.19[c]	10.31[b]	0.77[c]	79.08 [a]
BSE	3.97[c]	5.00[c]	3.50[c]	10.00[c]	0.88[d]	76.65[c]
LSD	0.02	0.02	0.02	0.02	0.02	0.02

Means with the same superscript in the same column are not significantly different (P<0.05)

Key: BSA=100% wheat flour, BSB= 80% African yam bean-20% African rice flour, BSC= 50% African yam beans = 50% African rice, BSD=60% African yam beans = 40%. African rice, BSE= 70% African yam beans= 30% African rice.

3.1. Proximate composition of the composite biscuits/ discussion

Table 1 showed the proximate composition of biscuit samples produced from composite flour and the control. The moisture content of the biscuits were significantly different (P<0.05) from each other, this could be as a result of ingredients and composite variation. Sample BSB had the highest value (7.40%) while BSE had the least value (3.97%). Contrarily, Atinuke, (2014) reported a higher moisture content of 11.04 to 11.24percent, for biscuits from composite flour of wheat and African yam beans flour. The ash content ranged from (1.94% to 5.00%), sample BSE had the highest value while sample BSC had the least value. The composite flour had higher mineral content than the control with the exception of sample BSC. Adebayo and Okoli, (2017) reported a lower ash content of (0.50% - 4.00%) in biscuits from lima bean, sorghum and wheat flour blends. The substitution level of African yam beans increased the ash content of the cake samples indicating that they will contain high mineral value. Significantly higher (P < 0.05) fat value (8.00%) was observed in BSA compared to other samples. The composite biscuit has higher protein content than the control (9.50 – 11.52%). There was a noticeable rise in protein content when African yam beans were added. This makes sense because African yam beans are renowned for having high protein content. This is consistent with other studies on African yam beans and wheat biscuits. (Idowu, 2014). The fiber contents of the composite biscuit and the control were significantly different (P> 0.05), sample BSB (1.75%) was higher than other samples. The biscuits had carbohydrates ranging from (73.71% to 79.65%). There was no significant different (P> 0.05) between sample BSA (control) and sample BSB which also had the lowest value. This implies that the biscuit samples are good sources of energy for normal body mechanism and will also help to alleviate protein and energy malnutrition.

Table 2: Proximate composition of doughnut samples

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	Carbohydrate

DOA	12.80[a]	3.00[a]	12.00[a]	10.63[c]	0.75[d]	60.82[c]
DOB	6.59[c]	1.31[c]	8.02[d]	12.63[c]	0.48[c]	73.41[a]
DOC	8.81[c]	3.00[a]	10.50[b]	9.75[c]	1.00[b]	66.94[c]
DOD	12.00[b]	1.28[d]	10.50[b]	10.19[d]	0.84[c]	63.38[d]
DOE	7.17[d]	1.48[b]	9.00[c]	11.19[b]	2.10[a]	69.06[b]
LSD	0.02	0.02	0.02	0.02	0.02	0.02

Means with the same superscript in the same column are not significantly different (P<0.05)

Key: DOA=100% wheat flour, DOB= 80% African yam beans-20% African rice flour, DOC= 50% African yam beans = 50% African rice, DOD=60% African yam beans = 40%. African rice, DOE= 70% African yam beans= 30% African rice

3.2. Proximate composition of doughnuts/ discussion

As shown in Table 2, the moisture content of the doughnut samples ranged from (6.59 to 12.80%), DOA (control) had the highest values while DOB recorded the least value. Given that high moisture content promotes microbial development, it follows that the composite formulations with lower moisture content will have a longer shelf life than the control. Therefore, lesser moisture content in doughnut items means better shelf life and preserving quality. The moisture content observed in this study is lower than the range of (22.70 to 30.60%) as reported by Rabelo *et al.*, (2013). The ash content of DOA and DOC had the highest ash content of 3.00% while sample DOD had the least ash content of 1.28%. Fat content of the control doughnut samples was higher than the composite doughnuts, low fat food products are less susceptible to rancidity and thereby encouraging more shelf stable (Idowu, 2014).The protein showed a significant difference (p<0.5) between doughnut from the composite flour and the control. The protein content value range from (9.75 – 12.63%), sample DOB had the highest while sample DOC had the least value. The fiber content of the doughnut ranged from (0.48% - 2.10%). The value obtained in this study was lower than the value of (1.83% – 5.09%) as reported by Rabelo *et al*; (2013). The carbohydrate content of the control sample was lower than the composite doughnut. This implies that the snacks are good source of energy needed for normal body metabolism and it can regulate appetite and hunger hormones.

Table 3: Sensory evaluation of biscuit samples

Samples	Color	Texture	Taste	Flavor	General acceptability

BSA	7.92[a]	7.44 [a]	7.76 [a]	7.36[a]	8.04[a]
BSB	6.16[c]	5.72[b]	5.96[b]	5.96[c]	6.64 [b]
BSC	6.92[bc]	6.12 [b]	6.36[b]	6.76[abc]	6.88[b]
BSD	7.04 [b]	6.16 [b]	6.68[ab]	6.88[ab]	6.92[b]
BSE	6.44[bc]	6.52[b]	6.28[b]	6.08[bc]	6.84[b]
LSD	1.02	1.12	1.11	1.15	1.05

Means with the same superscript in the same column are not significantly different ($p<0.05$)

Key: QCA=100% wheat flour, QCB= 80% African yam bean-20% African rice flour, QCC= 50% African yam bean = 50% African rice, QCD=60% African yam bean = 40%. African rice, QCE= 70% African yam bean= 30% African rice

3.3. Sensory evaluation of biscuit samples/ discussion

Biscuits produced from 100% wheat flour had the highest scores overall, although biscuits made with African yam beans and African rice were nonetheless acceptable when blended at the right ratios, especially in terms of color, texture, and flavor. These results are in line with research such as Okolie *et al.,* (2022) and Alugwu *et al.,* (2023), which found that legume-based snacks can still have acceptable taste and overall acceptability even though they are less preferred in terms of color and texture. African yam beans and African rice combined in moderate amounts (60–70% legume content, for example) produced biscuits with competitive sensory attributes, indicating their potential as sustainable substitutes for wheat-based products.

Table 4: Sensory evaluation of Doughnut samples

Samples	Color	Texture	Taste	Flavor	General acceptability
DOA	8.40[a]	8.20[a]	8.20 [a]	8.20[a]	8.56[a]
DOB	6.80 [b]	6.44[bc]	6.76[b]	6.40 [b]	6.88 [b]
DOC	6.28[bc]	6.52[bc]	6.48[b]	7.04[b]	6.76[b]
DOD	6.64[bc]	6.84[b]	6.08 [b]	6.56[b]	6.88[b]
DOE	6.04[c]	5.96[c]	6.20[d]	6.40[b]	6.84[b]
LSD	0.91	1.01	1.07	1.05	0.98

Means with the same superscript in the same column are not significantly different ($p<0.05$)

Key: DOA=100% wheat flour, DOB= 80% African yam beans-20% African rice flour, DOC= 50% African yam beans = 50% African rice, DOD=60% African yam beans = 40%. African rice, DOE= 70% African yam beans= 30% African rice

3.4. Sensory evaluation of doughnut samples/ discussion

Results of the sensory evaluation of the doughnut samples showed that the 100% wheat flour doughnuts (DOA) received highest ratings in terms of color, texture, flavor, taste, and overall acceptability. Doughnuts prepared with local rice blends and African yam beans, specifically Sample DOC (50 percent rice, 50 percent African yam beans) and Sample DOB (80 percent African yam beans, 20 percent rice), were generally well-received and scored within an acceptable range. These results are consistent with previous research on wheat African yam bean composite cookies, as reported by Okoye and Obi (2017). Even though African yam bean doughnuts could have different sensory qualities, they are nonetheless good substitutes that could be improved upon through further research and targeted potential dietary modifications.

Limitations of the study

The study is limited in the sense that the functional properties and mineral content of the composite flours were not studied, thus these parameters cannot be revealed

Study Implications

The use of African yam beans for snacks can be promoted by government assistance, such as providing funds to small food enterprises and assisting farmers in Abia state in growing local commodities. More individuals can become familiar and receptive to these snacks by collaborating with local organizations and NGOs.

Suggestions for further research

Researchers should investigate the composite flour's shelf life and storage extension to determine whether it can be kept for longer than a year. As a result, the market will have a consistent supply of composite flour throughout the year. Furthermore, experimenting with different flavor profiles like adding spices or sweeteners could increase the consumer’s preference.

4. Conclusion

The nutrient content of the doughnut and biscuit samples varied significantly. While DOB was rich in carbohydrates, DOE and other doughnuts had a balanced profile with high levels of protein and fiber. BSD contained the highest amount of carbohydrates, while biscuits like BSB were notable for their high protein and fiber content. These findings demonstrate the potential of both snacks as nutrient-dense, high-energy foods, with particular formulations meeting the various dietary requirements. In terms of color, texture, taste, flavor, and general acceptability, the sensory evaluation revealed that BSA and DOA were the most favored samples. Samples with lower ratings, such as DOD for doughnuts and BSB for biscuits, point out areas that require improvements to increase consumer appeal, therefore, we recommend that, in order to attain the optimal nutritional content and sensory qualities, more research should be done to precisely determine the proportions of African rice and African yam bean flour.

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Conflict of Interest

The authors declare no conflict of interest

Author Contributions

Conceptualization: CIN
Formal Analysis: CIN, EPO, SOO, CNO, CE
Funding Acquisition: CIN, EPO, SOO, CNO, CE
Investigation: EPO, CNO, SOO, CE, CIN
Methodology: EPO, CIN, SOO, CE, CNO
Writing of draft, review and editing: CIN, EPO, SOO, CNO, CE

Data Availability Statement

The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

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