



Chemical and Microbiological Assessment of *Aadun* Produced from Varying Proportions of Maize and Plantain Blends

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Authors' contributions

This work was carried out in collaboration among all authors. Author FOB designed the study, performed the statistical analysis and wrote the protocol. Authors TRE and ARO managed the analyses of the study. Author OYK managed the literature searches and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

In this study, a maize based local snack *aadun* was formulated from yellow maize flour and ripe plantain blends in a bid to improve its quality. The snacks were subjected to microbial analysis using pour plate method, proximate composition, mineral content and the sensory properties of the snacks were assessed. The results indicated bacterial count ranging from 1.20 to 2.80 x 10² cfu/g. Also, there were no coliforms and enteric bacteria on the *aadun* samples albeit, there were more bacteria on *aadun* supplemented with plantain. Two bacteria and three fungi were isolated from the *aadun* samples, they were *Bacillus subtilis*, *Staphylococcus aureus*, *Saccharomyces cerevisiae*, *Aspergillus niger*, and *Rhizopus stolonifer*. The protein and carbohydrate were comparable for the samples while the higher moisture, fiber, ash and carbohydrate were recorded in plantain supplemented *aadun* with significant increase at a higher content of plantain. Sample C had the highest moisture (6.72%), fiber (7.62%) and ash (2.39%) content in comparison with the other samples whereas, the plain *aadun* had higher crude fat (32.29%) compared with the *aadun*

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containing plantain. The level of calcium and magnesium in the plain and *aadun* containing plantain were similar without significant differences. However, the level of potassium and phosphorus were significantly higher in *aadun* supplemented with plantain than in the plain *aadun* whereas sodium was found to be higher in plain *aadun* (289.20 mg) than the supplemented samples. There was no significant difference in the appearance and aroma of the plain *aadun* and plantain supplemented *aadun*. However, *aadun* with 50% plantain was ranked as the most preferred samples in terms of taste, texture and overall acceptability with a score of 8.41, 6.31 and 8.33 while the plain *aadun* had 4.52, 4.22 and 5.79 respectively for these properties. These indicate that *aadun* may be improved with inclusion of plantain up to 50% proportion.

Keywords: *Aadun*; maize; plantain; snack; microorganisms; nutrition.

1. INTRODUCTION

Aadun is a popular local snack in Southwestern Nigeria, it is characteristically red in colour as a result of the palm oil used in the production, with ease of disintegration in the mouth, fine texture and good taste. *Aadun* is a good source of energy and minerals but it is low in protein and it is often sold with minimal packaging under conditions which may lead to its contamination by microbial agents. It is commonly served as appetizers in social gatherings such as wedding and naming ceremonies [1]. There are various types of *aadun* based on the type of additional material added to the basic ingredients. There is “*aadun oloboro*” which is basically the roasted corn meal mixed with palm oil, another type is “*aadun elewa*” which contain some boiled bean grains embedded within the plain *aadun*. Moreover, another popular type is “*aadun ologede*” which is made by mixing the plain *aadun* with blended boiled ripe plantain.

Maize (*Zea mays*) is one of the major staple foods in African countries particularly in Nigeria, where it is used as raw materials for the production of other food products like the fermented maize porridge (ogi), maize flour (tuwo) and array of local snacks including robo, *aadun*, donkua and kokoro among others [2]. Maize is a carbohydrate (about 75%) food crop with a low protein content of constituting only 9-12% when compared with legumes. However, it is highly rich in methionine and cysteine but lacks lysine and tryptophan [3]. Adedokun [1] suggested that the amino acid that are lacking in maize may be supplied to the food by complementing the maize with other sources of such amino acids. Maize is popular among Nigerians because of its easiness to prepare as ready to eat food in form of the meal, flour and as snacks by boiling or roasting of fresh corn. One of the highly popular product of maize in Nigeria is *aadun*, which is enjoyed across age groups

particularly in the Southwestern part of the country as a snack either on its own or in combination with other food materials [4].

Plantain (*Musa paradidica*), usually consumed cooked or raw, either as the green, half ripe, or ripe fruit is one of the most significant sources of calories for the human diet worldwide [5]. In Nigeria, it is one of the most popular fruits widely consumed across social classes. Plantains are good source of minerals particularly potassium. According to Swennen [6], the yellow and orange fleshed plantains are also rich in provitamin A and other carotenoids. Provitamin A carotenoids are important for protecting against vitamin A deficiency and anaemia. Carotenoids – rich food may also protect against diabetes, heart disease and certain concerns which are serious emerging problems of epidemic proportion in Nigeria. It has been shown that level of beta- carotene may reach as high 8508µg/100g edible portion in some plantain [7].

Presently, there is an effort by the federal government of Nigeria to diversify the economy and encourage value addition to the agricultural products in the country. This has led to the formulation and production of diverse products from crop produce in an effort by people to key into the government policy which attracts low interest loans and grants. There is a need to ascertain the nutritive value as well as safety of the *aadun*. This study was therefore carried out to assess the chemical, sensory and microbiological properties of *aadun* made from maize and plantain blends.

2. MATERIALS AND METHODS

2.1 Collection of Samples

Yellow maize and plantain were bought from Oja Oba in Owo, Ondo state, Nigeria. They were taken to the laboratory immediately for further

analyses. All other ingredients for *aadun* production like salt, palm oil, pepper and sugar were purchased from the same market.

2.2 Sterilization Procedure

The glassware were washed thoroughly with detergent and subsequently rinsed in clean water. They were then dried in a drying cabinet and then sterilized in hot air oven for 30 minutes at holding temperature of 180°C. Inoculating wire loops used were sterilized by flaming with a spirit lamp until red hot and then allowed to cool before use. The surfaces of the workbench were sterilized by wiping with cotton wool soaked in 75 % alcohol before and after each working period.

2.3 Media Preparation

The media used for this work include Nutrient Agar for isolation of total heterotrophic bacteria, Eosin Methylene Blue agar for isolation of coliforms, MacConkey agar for isolation of the Enteric bacteria and Potato dextrose agar for isolation of fungi. They were prepared strictly according to the manufacturer's specifications and then autoclaved at 121°C for 15 minutes.

2.4 Production of Plantain Supplemented Aadun

The maize were sorted to remove the impurities, stones and spoilt grains; then it was roasted for 15 minutes until light brown. The roasted maize was then milled using a mechanical grinder,

dried pepper was added and milled together. Salt and palm oil were added to taste. The mixture was moulded and cut into sizes.

2.5 Preparation of Different Types of Aadun Samples

Different blends of *aadun* were prepared as follows:

- A: 200 g of *aadun* 0 % plantain
- B: 150 g of *aadun* + 50 g plantain 25 % plantain
- C: 100 g of *aadun* + 100 g plantain 50 % plantain

2.6 Isolation and Enumeration of the Microorganisms from the Aadun Samples

One gram of the sample were taken and weighed aseptically into different test tubes containing 9ml each of sterile distilled water, with the aid of sterile pipette, further dilutions to 10^5 were obtained. An aliquot of 0.1ml each of the dilutions 10^5 were dispensed into sterile Petri dishes. Sterile molten Nutrient agar (Total heterotrophic bacteria count) MacConkey (for enumeration of Enterobacteriaceae) Eosin methylene Blue (selective for *E. coli*), and PDA agar (fungi) was poured over the inoculums evenly. The plates were incubated anaerobically at 37 °C for 24 hours for the bacterial plates while PDA plates were incubated for 72 hours at room temperature. After incubation, total plate count was done.

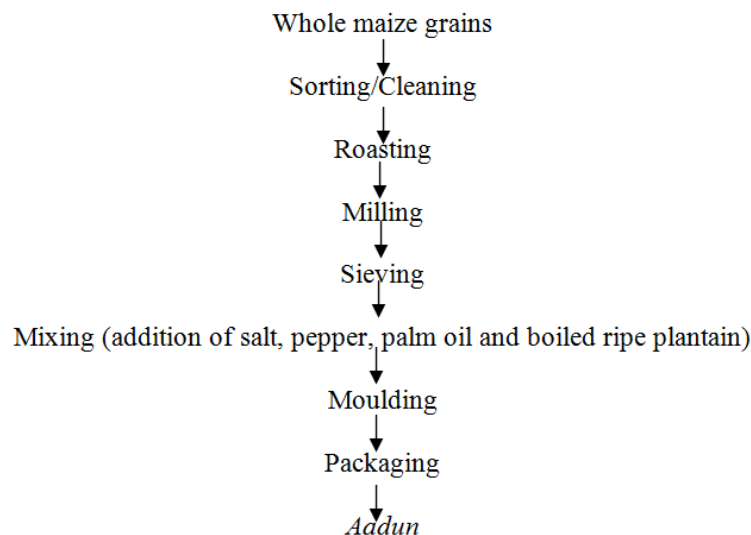


Fig. 1. Flowchart for the production of plantain supplemented *aadun*

2.7 Characterization of Bacterial Isolates

2.7.1 Cultural and morphological characteristics of the colonies

The cultural and morphological characteristics of the colonies were observed based on the criteria of Bergey's Manual of Determinative Bacteriology [8]. These include the following; shape of the colonies, the elevation, the edge, optical characteristics and pigmentation.

2.7.2 Biochemical characterization

Biochemical characterization of the isolates was done including Gram staining reaction, motility, sugar fermentation, oxidase, urea hydrolysis, catalase and coagulase tests [9].

2.8 Identification of Fungi

Pure cultures of fungi isolates were characterized and identified based on the morphological characteristics of the organisms and confirmed by comparing them with the characteristics given in fungi data base. The morphological characteristic of the moulds were based on the size, colour and aerial mycelia growth.

2.9 Proximate Analysis

The moisture content was determined by oven drying until constant weight was achieved, lipid content was determined by Soxhlet extraction, ash content was determined by burning off the organic content in a furnace, protein was determined using Kjeldahl digestion procedure followed by titration with an alkali, fiber content was determined by treatment with acid while carbohydrate portion was determined by deduction. These were done according to standard procedures [10].

2.10 Determination of Minerals

The minerals calcium, potassium, sodium, magnesium and phosphorus present in the samples were assayed using the Atomic Absorbance Spectrophotometer (AAS) after appropriate digestion.

2.11 Sensory Evaluation

This was done by 20 trained panelists selected randomly from Department of Food Science

Technology, Rufus Giwa Polytechnic, Owo, Ondo state. The nine point hedonic scale was used (score "9" having excellent attribute and Score "1" indicating dislike extremely). Samples were coded with random alphabets. The properties evaluated were appearance, taste, aroma and overall acceptability.

2.12 Statistical Analysis

All data were analyzed by using SPSS version 15. Data were analyzed using one-way analysis of variance (ANOVA), the Duncan's New Multiple Range Test was used to compare means at 95% confidence interval.

3. RESULTS AND DISCUSSION

The microbial count on the freshly produced *aadun* is presented in Table 1. The bacterial count ranged from 1.20 to 2.80 x 10² cfu/g. There were no coliforms and enteric bacteria on the *aadun* samples albeit, there were more bacteria on *aadun* supplemented with plantain. Also, there was no significant difference in the fungal count on the three *aadun* samples. The microbial load on the *aadun* samples were within the permitted limit of NAFDAC for ready to eat foods which stipulated a count in the range of 10² cfu/g of such foods [11]. The microbial count obtained in this study were lower than those reported by Idowu and Adedokun [2] who reported total aerobic plate count range of 1.2x 10³ to 3.3x10³ cfu/g in street hawked *aadun* in Ibadan, Nigeria. The higher bacterial count obtained on the *aadun* containing plantain may be due to the higher moisture content of the samples since bacteria are known to thrive more in moist environment. The absence of coliform in "*aadun*" samples produced in the laboratory may be due to strict hygienic procedure ensured during the production of the *aadun*. The street hawked samples may have been contaminated during their preparation or handling as faecal contamination of food is often reported in developing countries such as Nigeria [12]. The low microbial count on the *aadun* samples indicate that it will have a good keeping quality and thus may survive long holding period during transport if packaged for export or for super markets in big cities.

Two bacteria and three fungi were isolated from the *aadun* samples, they were *Bacillus subtilis*, *Staphylococcus aureus*, *Saccharomyces cerevisiae*, *Aspergillus niger*, and *Rhizopus stolonifer*, their distribution is presented in Table

2. Among these, *S. aureus* and *B. subtilis* were found on all the freshly produced *aadun* samples. Their presence may be due to contamination from the air, *S. aureus* is a ubiquitous bacterium found almost in all habitats whereas *B. subtilis* is a part of soil microflora. *S. cerevisiae* is known to be associated with sugary materials and its may have been attracted to the *aadun* samples containing plantain due to its sweetness in a bid to cause fermentation. Meanwhile, the moulds *Aspergillus niger* (sample A) and *Rhizopus stolonifer* (sample B and C) were observed in the samples. These moulds are known to be major spoilage organisms of dried food materials [13]. The low moisture content of *aadun* may encourage their growth. However, the oxygen tension in the samples due to the overlay of palm oil may discourage their growth. Still the spores produced by all these moulds may survive and get to germinate whenever there is a favourable condition. These organisms are known to be present in aerosols in the atmosphere where their cells and spores may find their way into the *aadun* [14].

The results of the proximate composition of the *aadun* samples are presented in Table 3. The table showed that the protein and carbohydrate were comparable for the samples while the higher moisture, fiber, ash and carbohydrate were recorded in plantain supplemented *aadun* with significant increase at a higher content of plantain. Sample C had the highest moisture (6.72 %), fiber (7.62 %) and ash (2.39 %) content in comparison with the other samples whereas,

the plain *aadun* had higher crude fat (32.29 %) compared with the *aadun* containing plantain. The values obtained in this study are in the range reported for the locally made *aadun*. However, the difference observed in the moisture content may be due to the higher moisture content of ripe plantain. This suggests that higher proportion of plantain in the *aadun* may lead to quick deterioration of the product since high moisture content is a recipe for microbial spoilage of food materials [13,15]. Also, the higher ash content of the *aadun* supplemented with plantain indicate that there may be more minerals present in the supplemented *aadun* than the plain *aadun*. The higher fat observed in the plain *aadun* may be due to the ability of the maize flour to absorb more oil due to its dryness whereas the plantain used for the supplementation had higher moisture and may not readily absorb oil. The level of fat in the *aadun* products may be linked to the palm oil used in the production of the products. It is obvious from the result of this study that *aadun* is low in protein but high in calories (fat and carbohydrate). The low protein content of the *aadun* samples suggests the need for enrichment with a protein source if consumed in large quantity. In some parts of Nigeria such as Kogi state, cooked beans are often added as an attempt to enrich *aadun* with a protein source. The high calorie content on the other hand is desirable for a snack and could be due to high inclusion of palm oil as ingredient. This high percentage of fat (palm oil) may however predispose *aadun* to oxidation and rancidity during storage [16].

Table 1. Microbial count on the freshly produced *aadun*-plantain blends (x 10² cfu/g)

Sample	Total Bacteria Count	Total Coliform Count	Total Enterobacteriaceae Count	Total Fungal Count
A	1.20±0.01 ^a	-	-	2.00±0.01 ^a
B	2.70±0.01 ^b	-	-	1.80±0.01 ^a
C	2.80±0.01 ^b	-	-	2.00±0.01 ^a

Key: values are Mean±S.E.M and values followed by different alphabet along the column are significantly different at p≤0.05

Table 2. Microorganisms distribution on *aadun* supplemented with plantain

Organism	A	B	C
<i>Bacillus subtilis</i>	+	+	+
<i>Staphylococcus aureus</i>	+	+	+
<i>Saccharomyces cerevisiae</i>	-	+	+
<i>Aspergillus niger</i>	+	-	-
<i>Rhizopus stolonifer</i>	-	+	+

Key: + = present, - = absent

Table 3. Proximate composition of aadun supplemented with plantain (%)

Parameter	Sample A	Sample B	Sample C
Moisture	3.81±0.00 ^a	5.59±0.00 ^b	6.72±0.01 ^c
Protein	5.71±0.03 ^a	5.97±0.04 ^a	6.16±0.01 ^a
Crude fiber	5.43±0.01 ^a	6.12±0.12 ^{ab}	7.62±0.15 ^c
Crude fat	32.29±0.11 ^c	28.09±1.00 ^b	21.17±0.00 ^a
Ash	1.28±0.08 ^a	1.98±0.07 ^b	2.39±0.00 ^c
Carbohydrate	51.48±0.00 ^a	53.46±0.00 ^a	55.94±0.18 ^{ab}

Key: values are Mean±S.E.M and values followed by different alphabet across the rows are significantly different at $p \leq 0.05$, Sample A: plain aadun, Sample B: aadun +25% plantain, Sample C: aadun +50% plantain

The result of the mineral composition of the aadun supplemented with plantain is presented in Table 4. The table shows that the level of calcium and magnesium in the plain and aadun containing plantain were similar without significant differences. However, the level of potassium and phosphorus were significantly higher in aadun supplemented with plantain than in the plain aadun whereas sodium was found to be higher in plain aadun (289.20 mg) than the supplemented samples. The high level of essential minerals such as magnesium, potassium, calcium, sodium and phosphorus in the snacks suggests that its consumption may help to alleviate micronutrient deficiency in humans. These nutrients could significantly contribute to the body's metabolic processes, refreshing the body as well [17].

Magnesium provides bone strength, aids enzyme, nerve and heart functions. Phosphorus

enhances quick release of energy in the body and may combine with calcium for bone and teeth development. The aadun supplemented with plantain is lower in sodium which may be a good indication for hypertension patients who may like to take aadun. Recent studies on blood pressure showed that a diet rich in potassium and magnesium but low in sodium can lead to a decrease in blood pressure within days of beginning a specific diet [18]. Potassium aids nerve impulse transmission and it is a major cation of intracellular fluid. High potassium to low sodium ratio of the aadun therefore, may be imperative in diet formulations for patients with high blood pressure [19].

The results of the sensory evaluation is shown in Table 4. The table revealed that there was no significant difference in the appearance and aroma of the plain aadun and plantain supplemented aadun. However, aadun with 50 %

Table 4. Mineral composition of aadun supplemented with plantain (mg/100g)

Mineral	Sample A	Sample B	Sample C
Calcium	14.31±0.00 ^a	17.29±0.01 ^{ab}	19.41±0.0 ^b
Potassium	121.03±0.15 ^a	278.20±0.10 ^b	362.15±0.02 ^c
Sodium	289.20±1.00 ^b	254.12±0.01 ^a	229.81±0.18 ^a
Magnesium	256.03±0.10 ^a	249.20±0.02 ^a	238.73±0.04 ^a
Phosphorus	502.09±3.01 ^a	543.77±1.18 ^b	624.18±2.15 ^c

Key: values are Mean±S.E.M and values followed by different alphabet across the rows are significantly different at $p \leq 0.05$, Sample A: plain aadun, Sample B: aadun +25% plantain, Sample C: aadun +50% plantain

Table 5. Organoleptic properties of freshly produced aadun supplemented with plantain

Parameter	Sample A	Sample B	Sample C
Appearance	4.61±0.01 ^a	5.04±0.10 ^a	6.11±0.03 ^b
Aroma	5.72±0.00 ^a	6.65±0.00 ^a	5.81±0.00 ^a
Taste	4.52±1.00 ^a	6.74±1.00 ^b	8.41±0.05 ^c
Texture	4.22±1.15 ^a	5.18±1.00 ^b	6.31±0.20 ^b
Overall acceptability	5.79±0.01 ^a	7.17±0.05 ^b	8.33±0.50 ^c

Key: Each data is the mean± standard error of 20 member taste panelist (9-point hedonic scale: 9= Excellent, 7=like extremely, 6= like very much, 5= like slightly, 4= neither like nor dislike, 3= dislike slightly, 2= dislike very much, 1= dislike extremely), Sample A: plain aadun, Sample B: aadun +25% plantain, Sample C: aadun +50% plantain

plantain was ranked as the most preferred samples in terms of taste, texture and overall acceptability with a score of 8.41, 6.31 and 8.33 while the plain *aadun* had 4.52, 4.22 and 5.79 respectively. The observed difference in taste, texture and overall acceptability of the *aadun* supplemented with plantain may be due to the sweet taste of the ripe plantain and the smoothness of the fruit and fine particle size of the milled plantain used as ingredients. The variation in ingredient composition and the accompanied differences in the sensory quality of plantain supplemented *aadun* therefore, underscore the need to optimize the particle size, taste, colour and aroma of *aadun* for consistency and international product acceptability. Adedokun [1] had earlier reported the need for upgrading African foods through optimization of process and packaging to meet international standards.

4. CONCLUSION

Based on the results obtained in this study, it can be concluded that *aadun* is a good source of dietary fiber, fat and carbohydrate coupled with its high energy value, it can be an ideal snack. Also, supplementation of *aadun* with ripe plantain improve the mineral content and the organoleptic properties of the *aadun*. Microbiologically, *Aspergillus niger* and *Rhizopus stolonifer* may be the principal spoilage organisms of *aadun* as shown by their presence in the *aadun* samples.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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