Journal of Scientific Research & Reports

27(8): 29-35, 2021; Article no.JSRR.72224
ISSN: 2320-0227

Effect of Co-fermentation of Cassava and African Yam Bean on some Compositional and Sensory Properties of *Pupuru*

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MOA and JAA conceptualized and designed the study, prepared the draft of the manuscript and reviewed the manuscript; author OOI carried out the analysis and data collection. All authors proof-read the manuscript

Article Information

DOI: 10.9734/JSRR/2021/v27i830421
Editor(s):
(1) Dr.Surapong Pinitglang, University of the Thai Chamber of Commerce,Thailand.
Reviewers:
(1) Saharman Gea, Universitas Sumatera Utara, Indonesia.
(2) Rajesh kumar, RAJUVAS University, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/72224

Original Research Article

Received 10 June 2021
Accepted 14 August 2021
Published 09 September 2021

ABSTRACT

Aim: Consumption of *pupuru* (a cassava based food) is on the increasing trend in most parts of Nigeria, hence the need to improve the nutrients with under-utilised legume, African yam bean (AYB). The aim of this work was to co-ferment cassava and AYB at varying proportion and processed to *pupuru* flour.
Study Design: Randomised Block Design was used in this study to assess the influence of different substitution levels of AYB on the properties of *pupuru* flour and the meal prepared from it.
Methodology: The cassava roots were washed, peeled and grated to mash while the AYB was boiled, decorticated and milled into slurry. The AYB slurry was co-fermented with the cassava mash at different substitution level (0, 10, 20, 30 and 40%) and processed to *pupuru* flour. The 0% served as control (100% cassava). Samples of *pupuru* flour were evaluated for proximate composition, mineral and anti-nutritional contents. Meal (stiff dough) prepared from the flour was subjected to sensory evaluation. Data obtained were subjected to statistical analysis using SPSS software package.
Results: The protein content ranged from 2.9 to 38.68%. The bulk density, swelling capacity, water absorption capacity ranged from 0.72% - 0.86%, 245.56% – 351.84%, and 191.01% - 255.36%

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respectively. The oxalate, tannin, phytate, and cyanide contents were in the range of 80.00-175.00 mg/100g, 24.55-73.70 mg/100g, 1.34–3.85 mg/100g, and 0.29-0.58 mg/100g respectively. The sensory attributes of *pupuru* meal indicated a significant difference ($p < 0.05$) among the samples, with 100% cassava *pupuru* been the most preferred in terms of taste and general acceptability.

Keywords: Cassava; african yam bean; pupuru; chemical composition; sensory property.

1. INTRODUCTION

The prevalence of malnutrition has been the major cause of poor health in many developing and underdeveloped nations [1]. In Nigeria for instance, most staples originate from root and tuber crops which are deficient in protein and other essential nutrients but instead are known for their high carbohydrate contents and thus provides mainly energy for the consumers. Cassava, a staple food crop in Nigeria and other tropical Africa is consumed by over 70% of the populace and it is a major source of dietary energy for low income consumers in these areas [2]. Cassava is processed into so many food products which include *gari*, *lafun*, *fufu* and *pupuru.* However, the utilization of cassava is limited by its extremely low protein content and so the consumption of its products has been implicated in malnutrition [3].

'Pupuru' is a traditional cassava based fermented food that is gaining popularity currently in south western Nigeria. It is a local food product eaten mainly by the people of Ilaje and Ese-Odo (Ikale) area of Ondo State, Nigeria. The processing of *pupuru* is different from other fermented cassava-based food because it is made from smoked dried cassava product which is milled into flour before it is turned into porridge in boiling water and then it is eaten with any desired soup [4]. *Pupuru* has a high carbohydrate content, the tuber contains 20 to 25% starch and very minor quantities of proteins, fats, and other biochemical constituents [5].

Legumes are some of the low-priced sources of protein rich food that have helped in alleviating protein malnutrition [6]. Notable among these legumes is African Yam bean *(Sphenostylis stenocarpa)* known among the *Yorubas* in Nigeria as *Ewa otili or Seese,* although it is a lesser-known legume of the tropical and sub-tropical areas of the world. The African yam bean is grown in Nigeria mainly for its seeds but, there are evidences that the tubers are relished in East and Central Africa [6]. The African yam bean is usually cultivated mainly for home consumption (with only 30% of the dry grain produced being sold) and for soil restoration [7]. African yam bean is a good source of protein, fibre, carbohydrate and it is also rich in minerals such as phosphorus, iron and potassium [8,9]. The protein content in African yam bean grains is about 30% [10]. It also produces an appreciable yield under diverse environmental conditions [11]. Also the high content of dietary fibre of African yam bean makes it an important crop in managing chronic diseases such as diabetes, hypertension and cardiovascular diseases. This study therefore looked at the possibility of improving the food quality of *pupuru* with African-yam-bean by co-fermenting with cassava with the objectives of determining the chemical, functional and sensory properties of the resultant *pupuru* flour.

2. MATERIALS AND METHODS

2.1 Materials

Freshly harvested sweet cassava was procured from a local farmer from a local market in Ogbomoso, Nigeria. African yam bean was obtained from a market in Ibadan, Nigeria.

2.2 Method

2.2.1 Production of African Yam Bean Slurry

The African yam bean obtained was sorted and cleaned. The sorted yam bean was soaked in cold water for 12 hours; it was transferred into hot water for 15 minutes for easy dehulling. The dehulled African yam bean was wet -milled into a slurry form.

2.2.2 Production of *pupuru* flour from cassava

The sweet cassava was washed, peeled manually, washed and grated with grating machine. The grated cassava was mixed with the slurry African yam bean at 10%, 20%, 30% and 40% substitution levels while 100% cassava *pupuru* flour served as control. It was packed into sack and put under pressure and allowed for fermentation for three days. The fiber was removed manually from the mash. The mashed portion was moulded into balls or small circular shape and smoke dried using coal as a source of heat until the outer crust turned yellowish brown and it was allowed to cool and scraped. The cooled ball was be pulverized, it was toasted, milled and sieved with 300 mesh size to have *pupuru* flour.

2.2.3 Preparation of *pupuru* meal

This was prepared by reconstituting the *pupuru* flour in boiling water and allowed to form paste. After which it was left on the fire inside the pot to cook for about 15minutes. This was then stirred again to form a fine paste and after which sensory evaluation was carried out.

2.2.4 Chemical analysis

Determination of proximate composition: The crude protein (Kjeldahl method, N × 6.25), fat (solvent extraction), ash, crude fiber and moisture contents were determined as described by the AOAC [12] methods. The carbohydrate content was calculated by difference as: {100 - (% Protein + % Fat + %Ash + % Crude fiber + % Moisture)}.

Evaluation of functional properties: The bulk density, water and oil absorption capacities were determined as described by [13].

Determination of mineral composition: The sodium and potassium contents were determined by flame photometry [12]. The calcium, iron, phosphorus and magnesium contents were determined by atomic absorption spectrophotometry as described by the AOAC [12] methods

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of *pupuru flour*

The proximate composition of the samples is shown in Table 1. The values for the protein content ranged from 2.95% and 38.68%. Sample with 40% African yam bean substitution has the highest protein content (38.68%)while the sample with 100% cassava *pupuru* had the lowest protein content. The addition of African yam bean enhanced the increase in protein level of *pupuru* flour and this is in agreement with earlier observation on the addition of soybean and bambara groundnut flour to complementary foods [14,15]. The maximum value for crude fibre was 1.52% (40% African yam bean substitution) while the minimum value was 0.77% (10% African yam bean substitution). The range of values observed in this study agrees with those reported for garri produced from cassava by [16]. There was significant difference ($p<0.05$) between the samples while 100% cassava *pupuru* flour and 30% African yam bean substitution were slightly different. The ash content showed significant difference ($p<0.05$) for all the samples with the maximum value of 1.69% to the minimum value of 0.79%. These values agree with the range observed by [17]. The range of values for crude fat falls between 0.92% to 3.38% with *pupuru* produced from 40% African yam bean substitution having the highest value and *pupuru* produced from 10% African yam bean substitution having the lowest value. A sharp increase was observed from 30% African yam bean substitution to 40% African yam bean substitution. There is significant difference ($p<0.05$) between the samples.

The moisture content values ranged from 4.84% to 8.51% with *pupuru* produced from 40% African yam bean substitution having the maximum value and *pupuru* produced from 10% African yam bean substitution having the lowest value. The moisture content of 100% cassava *pupuru* (8.32%) is similar to [18]'s report, that the moisture content of *pupuru* dried by smoking was 8.40%. [16] stated that good quality *garri* should be well dried and thus of low moisture content to enchance proper storage and increase the self-life. The smoking and toasting method can lead to the amount of moisture retained in the sample [17]. The carbohydrate content ranged from 46.83% - 83.50%. 100% cassava *pupuru* flour had 83.50% while 40% African yam bean substitution had 46.83% carbohydrate. There was significant different ($p < 0.05$) in the carbohydrate content. The carbohydrate content of the 100% *pupuru* flour is within the range 82.53 – 87.10% carbohydrate content of garri reported by [19]. The carbohydrate content reduce on substitution of African yam bean from 83.50% - 46.83%, similar decrease was observed by [20] when *gari* was supplemented with soybean before and after fermentation.

3.2 Mineral Contents of *Pupuru*

The result of mineral contents of 100% *pupuru* cassava and *pupuru* made from co-fermentation of cassava and African yam bean is shown in

Table 2. The samples are affected significantly ($p<0.05$) by the degree of substitution. There was increase in the mineral contents for potassium, iron, and phosphorus. For potassium, the values ranged from 0.16 ppm for 100% cassava to 1.27 ppm for 40% African yam bean substitution. Generally, potassium is reported to be an important mineral maintaining electrolyte balance in human [21,22]. The value for phosphorus ranged from 0.32 ppm for 100% cassava to 1.44 ppm for 40% African yam bean substitution while the values for iron ranged from 0.42 ppm to 0.43 ppm with 100% cassava *pupuru* having the lowest value. The increase in potassium, phosphorus, and iron is as a result of the presence of African yam bean. The African yam bean is a rich source of minerals such as phosphorus, iron and potassium [23,10]. The values for calcium decreased with substitution of African yam bean. The values range from 5.90 ppm to 8.00 ppm. There is significant difference ($p<0.05$) between the samples. The sodium values ranged from 35.45 ppm to 76.31 ppm 10% African yam bean substitution having the minimum value and 30% African yam bean substitution having the maximum value. There is significant different ($p<0.05$) between the values.

3.3 Functional Properties of *pupuru* flour from co-fermentation with African Yam Bean

The result of functional properties of *pupuru* flour is presented in Table 3. The result of the bulk density did not indicate any significant difference among the samples ($p< 0.05$). The values of the samples ranged from 0.72% to 0.86%. Bulk density is generally affected by the particle size and density of the flour, it is also an important parameter in determining packaging material, material handling and application in the wet processing in food industry. The swelling capacity values showed an unstable pattern of increase and decrease with 10% African yam bean substitution (351.84%) having the highest value and 30% African yam bean substitution (245.56%) having the least value. Swelling capacity is an indication of water absorption index of granules during heating. The swelling capacity of flour depends on size of particle, types of variety and the processing method or unit operation. The water absorption capacity showed there is significant difference ($p<0.05$) in all the samples. The values ranged from 191.01% to 255.36% with 10% African yam bean substitution having the highest value and 30% African yam bean substitution having the least value.

3.4 Anti-nutrients Contents of *pupuru* flour

The results of anti-nutrient contents of *pupuru* flour produced are shown in Table 4. The cyanide content of *pupuru* flour ranged from 0.27 to 0.58 mg/Kg. The sample with 100% cassava contains the maximum amount of cyanide while 40% African yam bean substitution has minimum amount of cyanide, this is because cassava have high cyanide content. The results are within the 2-3 mg/100g range regarded as acceptable level of cyanide in garri [24]. Cyanide is very poisonous and the initial symptoms of cyanide poisoning may include headache, drowsiness, vertigo, weak and rapid pulse, deep and rapid breathing, a bright-red colour in the face, nausea and vomiting. Convulsions, dilated pupils, clammy skin, a weaker and more rapid pulse and slower, shallower breathing can follow these symptoms [25]. Processing method affects the residual content of cyanide in cassava products as previously reported by [26], which show that fermentation period had effect on the breakdown of cyanogenic glycosides in the cassava pulp as well as leaching out of HCN along with cassava fluid. The values obtained for *pupuru* (cassava products) are lower than the safe level of 10 mg/kg recommended by the Food and Agricultural Organization (FAO), and World Health Organization (WHO) according to [27]. The values obtained for all the samples are below the safe level, the products can therefore be considered adequate and safe for human consumption a regard cyanide poisoning [17]. As shown in Table 4, 10% African yam bean substitution has the lowest value in terms of tannin (73.70 mg/100g) and phytate (1.34 mg/100g) and it has the highest value in terms of oxalate (175 mg/100g). 30% African yam bean substitution has the highest value of phytate (3.85 mg/100g) and lowest value of oxalate 80 mg/100g, the oxalate value obtained agreed with the recommended daily intake for stone prevention which must be below 100mg. the sample also contain 73.20 mg/100g tannin.

3.5 Sensory Evaluation

The mean scores of sensory evaluation of porridge prepared from *pupuru* flour and co-fermented samples are shown in Table 5. Porridge prepared from pure *pupuru* flour (100% cassava) was rated significantly ($p\leq 0.005$) higher than the co-fermented samples in all the attributes evaluated. The panelist preferred the appearance of *pupuru* produced from 100% cassava (Control sample) as the best with significant difference (P≤ 0.05). The scores for appearance of 100% *pupuru* meal and 10% African yam bean substitution *pupuru* meal are close while 30% and 40% African yam bean substitution *pupuru* meal are close.

According to the taste, 100% cassava *pupuru* meal is rated best followed by 40% African yam bean substitution while sample with 30% African yam bean substitution is the least rated. The panelist preferred the aroma of 100% cassava *pupuru* meal compared with other samples. The texture of 100% cassava *pupuru* meal is also preferred to other samples. In the overall acceptability, 100% cassava *pupuru* meal was rated best followed by 10% African yam bean substitution, followed by 40% African yam bean substitution while 30% African yam bean substitution *pupuru* meal was the least rated.

Table 1. Proximate composition of *pupuru* from co-fermentation of cassava African yam bean

Sample	Moisture %	Ash %	CHO %	Caloric Value kJ/ 100 g	Crude Protein %	Crude Lipids %	Crude Fiber %
A	8.32^{a}±0.06	1.43^{ab} ±0.28	83.50^{b}± 1.17	1579.48^{b}±0 .80	2.95^{d}±0.1 7	2.49^{b}±0. 29	1.30^{ab}±0. 37
B	7.67^{b}±.0.11	0.79^{c} ±0.17	54.50^{b} ±0.57	1602.06^{a}±2 .86	33.64^{b}±0. 68	2.39^{b}±0. 02	1.01^{ab}±0. 06
C	8.51^{a}±0.28	1.08^{bc} ±0.01	46.83^{c} ±0.65	1611.92^{a}±8 .70	38.68^{a}±0. 28	3.38^{a}±0. 44	1.52^{a}±0. 21
D	4.84^{c}±0.17	1.69^{a} ±0.26	75.84^{a} ±0.24	1582.95^{b}±4 .69	15.94^{c}±0. 23	0.92^{c}±0. 08	0.77^{b}±0. 01

Mean with different superscript within the same column are significantly different (p<0.05)

A – 100% cassava pupuru flour, B – 70:30 (cassava: African yam bean) pupuru flour, C – 60:40 (cassava: African yam bean) pupuru flour, D – 90:10 (cassava: African yam bean) pupuru flour

Table 2. Mineral composition of *pupuru* flour from co-fermentation of cassava and African yam bean

Sample	Calcium ppm	Phosphorous ppm	Potassium ppm	Iron ppm	Sodium ppm
A	8.00^{a}±0.00	0.32^{c}±0.01	0.16^{a}±0.01	0.42^{a}±0.01	44.32^{c}±0.45
B	7.47^{a}±0.09	1.38^{a}±0.03	1.09^{a}±0.79	0.42^{a}±0.01	76.31^{a}±0.01
C	5.90^{b}±084	1.44^{d}±0.06	1.27^{a}±0.04	0.43^{a}±0.01	54.55^{a}±0.64
D	7.75^{c}±0.07	1.04^{b}±0.02	0.20^{a}±0.14	0.43^{a}±0.00	35.45^{d}±0.07

Table 3. Functional properties of *pupuru* flour from co-fermentation of cassava and African yam bean

Sample	WAC %	Swelling Capacity %	Bulk Density %
A	219.10^{b}±2.57	317.36^{b}±0.57	0.75^{a}±0.24
B	191.01^{d}±1.71	245.56^{d}±1.30	0.84^{a}±0.07
C	203.51^{c}±4.46	262.39^{c}±5.06	0.86^{a}±0.04
D	255.36^{a}±5.67	351.84^{a}±0.96	0.72^{a}±0.08

Mean with different superscript within the same column are significantly different (p<0.05)

A – 100% cassava pupuru flour, B – 70:30 (cassava: African yam bean) pupuru flour, C – 60:40 (cassava: African yam bean) pupuru flour, D – 90:10 (cassava: African yam bean) pupuru flour

Table 4. Anti-nutritional factors of *pupuru* flour from co-fermentation of cassava and African yam bean

Sample	Oxalate mg/100 g	Tannin mg/100 g	Phytate mg/100 g	Cyanide mg/100g
A	ND	ND	ND	0.58^{a}±0.00
B	80.00^{c}±1.41	73.20^{a}±3.11	3.85^{a}±0.49	0.29^{b}±0.00
C	128.00^{b}±1.41	73.70^{a}±2.12	1.55^{b}±0.07	0.27^{b}±0.00
D	175.00^{a}±0.00	24.55^{b}±2.48	1.34^{b}±0.19	0.47^{d}±0.00

Mean with different superscript within the same column are significantly different (p<0.05)
ND – Not detected, A – 100% cassava pupuru flour, B – 70:30 (cassava: African yam bean) pupuru flour, C – 60:40 (cassava: African yam bean) pupuru flour, D – 90:10 (cassava: African yam bean) pupuru flour

Table 5. Sensory scores of *pupuru* meal from co-fermented cassava and tigernuts

Sample	Taste	Appearance	Aroma	Texture	Overall Acceptability
A	8.17^{a}±1.02	7.67^{a}±1.09	7.70^{a}±1.06	7.70^{a}±1.24	8.30^{a}±0.92
B	6.70^{c}±1.32	6.40^{b}±1.30	6.63^{b}±1.16	6.27^{b}±1.39	6.83^{c}±1.26
C	7.53^{b}±1.04	6.60^{b}±1.13	6.80^{b}±0.81	6.77^{b}±1.45	7.33^{bc}±0.88
D	7.17^{bc}±1.09	6.97^{b}±1.33	7.13^{b}±1.14	6.70^{b}±1.09	7.50^{b}±1.01

Mean with different superscript within the same column are significantly different (p<0.05)
A – 100% cassava pupuru flour, B – 70:30 (cassava: African yam bean) pupuru flour, C – 60:40 (cassava: African yam bean) pupuru flour, D – 90:10 (cassava: African yam bean) pupuru flour

4. CONCLUSION

The *pupuru* flour produced with 40% African yam bean had the highest nutritional content in terms of crude lipids (3.38%), crude fiber (1.52%), and the protein content is 38.68%. The control sample of *pupuru* flour from 100% cassava had a protein content of 2.95%. Therefore, in order to increase the protein content of *pupuru*, 40% African yam bean substitution would be suitable to solve the problem of malnutrition due to inadequate protein content.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/72224