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QUALITY EVALUATION OF *gari* PRODUCED FROM PROVITAMIN A CASSAVA (*Manihot esculenta*) ENRICHED WITH AFRICAN YAM BEAN (*Sphenostylis stenocarpa*)

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ABSTRACT

Provitamin A cassava (PVAC), a biofortified yellow cassava, has great potential to alleviate vitamin A deficiency in sub-Saharan Africa. Blending PVAC with an underutilized legume, African Yam Bean (AYB), in *gari* production will go a long way in reducing protein and vitamin A malnutrition problems in sub-Saharan Africa where *gari* is a staple food. *Gari* was produced from PVAC mash substituted with varying proportions (0, 7.5, 15, 23 and 30%) of AYB using simplex lattice design expert (version 16.0). The *gari* samples were evaluated for their nutritional composition, physicochemical properties and anti-nutritional factors. Sensory attributes of the products were evaluated using a 7-point hedonic scale. Moisture contents of all the *gari* samples were below 5% indicating safe level for prolonged storage. Substituting PVAC with AYB at varying proportions resulted in 14.4-23.7%, 16.3-23.5%, 19.8-20.3% and 15.5-20.3% for ash, protein, calorific and beta-carotene contents, respectively, and 18.3–21.8% reduction in fiber content. Production of *gari* from blends of PVAC and AYB significantly ($p<0.05$) increased pH level and reduced total titratable acidity of the *gari* samples. *Gari* produced from 92.5% PVAC and 7.5% AYB mash had the least value of 1.20 mg/kg HCN, and 100 % cassava *gari* had the highest value (5.0 mg/kg) of HCN. The swelling capacity decreased with increase in the substitution level of AYB in the mixture. The results of syneresis of the samples followed a similar trend with that of swelling capacity. Water absorption capacity and reconstitution index showed increase with increase in the level of AYB inclusion. The anti- nutritional factor of the *gari* sample ranged from 1.95 to 5.65% for trypsin inhibitor, 4.53-31.02 mg/100g for total phenols, and 2.56-5.33 mg/100g for alkaloids. *Gari* produced from 100% PVAC was the most preferred in terms of colour, texture, aroma and appearance while *gari* substituted with 7.5% AYB was best preferred in terms of taste. Significant difference ($p<0.05$) was recorded for the overall acceptability attribute of 100% PVAC *gari* (control sample) which was best rated by the panelists. It was concluded that a substitution of 7.5% AYB into PVAC mash gave the *gari* with the best overall quality acceptability. These findings indicated the potential of AYB in *gari* processing to curb vitamin A deficiency among the vulnerable group.

Key words: *Gari*, Vitamin A Deficiency, Provitamin A cassava, African yam bean ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 3 April 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Cassava (*Manihot esculenta* Cranz), is an important commodity in sub-Saharan Africa, after cereals and grain legumes, which constitute either staple or subsidiary food for about a fifth of the world's population [1]. In the tropics, cassava is an important food crop and is a major carbohydrate source. Cassava is grown in all the agro-ecological zones of Nigeria. It is a staple food for over a million people of the West African population [2, 3]. However, apart from the fact that fresh cassava has limited storage life because of its high moisture content, cassava roots are known to be low in micronutrients such as vitamin A, iron, and zinc. Micronutrient deficiencies threaten the lives of millions of poor households and those located in remote rural areas of sub-Saharan Africa [4]. Considering the important roles of cassava in the diets of Nigerians, cassava varieties biofortified with provitamin A were recently developed in order to complement government efforts to check vitamin A deficiency (VAD) and malnutrition in the country [5]. These varieties are yellow in colour owing to their high beta-carotene (provitamin A) content; hence they are called provitamin A cassava (PVAC). It is strongly believed that PVAC varieties being introduced to farmers would be an effective tool in combating VAD among the less privileged [5]. Cassava can be transformed into various products such as '*gari*', *'fufu', 'lafun'* and many other West African traditional dishes [3,6].

Gari (a roasted fermented cassava meal) is the most popular cassava product consumed in West Africa and the most important food product in the diet of millions of Ghanaians and Nigerians [3]. It is a staple food that falls within the purchasing power of all categories of people in a society irrespective of their income [5]. Cassava and its products are low in protein and deficient in essential amino acids and therefore, have poor qualitative and quantitative protein content [7]. The nutrient deficiency of *gari* suggests the need to explore alternative sources to enrich the product in a way that will be affordable to the low-income earners in developing countries [8]. Continual dependence on cassava as the only raw material for *gari* production could lead to malnutrition. Great success has been recorded in the use of sweet potato for *gari* production [7]. In Nigeria, there have been several attempts at overcoming the nutritional deficiency of cassava- based diets by fortifying with soybean, which has high protein content of good quality. The continuous utilization of soybean for other industrial applications has led to an increase in price of soybeans, which cannot be afforded by all. Exploration of other alternative sources such as African Yam Bean (*Sphenostylis stenocarpa)* could be of great advantage considering the ever- increasing market for *gari* both at home and abroad. It, therefore, becomes imperative to search for cheaper and good quality protein sources that are readily available.

African Yam Bean (AYB) is a leguminous crop of tropical African origin which is grown for both its edible seeds and tubers. African yam bean is one of Africa's under-utilized plant species with potential to broaden man's food base. It forms small tuberous roots that contain more protein than sweet potatoes, potatoes or cassava roots [9]. Due to the high cost of animal protein in developing countries, legumes are of great importance to the low socio-economic population as a cheap source of protein. Nutritionally, AYB seed contains 62.6% carbohydrates, 21-29% protein and 2.5% fat.

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The aim of this research, therefore, was to evaluate the quality attributes of *gari* produced from blends of PVAC and AYB.

MATERIALS AND METHODS

Materials

Fresh PVAC tubers were procured from the Teaching and Research farm of Ladoke Akintola University of Technology, Ogbomoso, while AYB seeds were purchased from Saki, South Western Nigeria. The PVAC tubers and AYB seeds were manually cleaned to remove adhering soil and other extraneous materials before processing. All reagents that were used in this study were of analytical grade.

Sample Preparation

The method of Sanni [10] was adopted with slight modifications for processing of *gari* products. African yam bean seeds were soaked in 0.1% potassium metabisulphite for 20 min to prevent browning and were pressed for 24 h before adding to cassava mash already pressed for 48 h. Provitamin A cassava was mixed with varying proportion of AYB (0, 7.5, 15, 23 and 30%) as generated by simplex lattice design (version 6.0) of mixture design. The mixture of PVAC-AYB mashes were fermented further for another 24 h before subsequent processing into *gari*. The dried granules of PVAC-AYB *gari* were packed into polyethylene bags and heat-sealed before keeping in a plastic container with cover until needed for analyses.

Chemical Analysis

The chemical analyses of the *gari* products were carried out to determine the following: moisture content, ash content, crude fibre, crude protein, crude fat, carbohydrate (by difference), pH, total titratable acidity (TTA), beta-carotene content and total hydrogen cyanide according to the methods of AOAC [11].

Physical and Physico-Chemical Properties

The bulk density was determined using the method of Cooke [12]. Swelling capacity for the samples was determined according to the method adopted by Sanni [10]. Syneresis, Reconstitution index and water absorption capacity were determined according to the procedure described by Iwuoha [13].

Sensory Evaluation

Sensory evaluation was conducted to determine consumer preferences and acceptability of the samples, using a 7-point hedonic scale for the degree of likeness. In scaling, 7 represents "like extremely", midpoint 4 represents "neither like nor dislike" and one represents "dislike extremely". The quality parameters assessed included: colour, texture, taste, aroma, appearance and overall acceptability. Fifty (50) untrained panelists who were regular *gari* consumers were selected randomly and used for the sensory evaluation. Samples were coded and randomly presented in clean ceramic plates all at the same time and were assessed in dried form.

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Statistical analysis
All treatments were replicated twice for reproducibility and analysis was done in duplicate. The statistical analysis of the data was done with Statistical Package for Social Science (SPSS, version 20). Statistically significant differences ($p < 0.05$) in all data were determined by analysis of variance while least significant difference was used to separate the means.

RESULTS AND DISCUSSION

Proximate Composition of the *Gari* Samples

The results of the proximate composition of the *gari* samples are presented in Table 1. The values for the moisture content ranged from 2.47-4.61% with 100% cassava *gari* having the highest value (4.61%). Moisture content decreased generally as the level of substitution with AYB increased. All the *gari* samples generally had low moisture contents within the range of values reported for *gari* by Airadion *et al.* [14]. Good quality *gari* should be well-dried and thus of low moisture (less than 14%) content for good storability [15]. A little enhancement in the ash content (1.22 – 2.01%) in AYB containing *gari* samples was observed compared to *gari* from 100% PVAC (control). This observation is in line with the findings of Oluwamukomi and Adeyemi [16] who reported 1.18% ash content for cassava *gari*. The highest value of crude protein obtained for the samples were 4.66% (AYB enriched *gari*) while the least was 3.23% (control). This is expected as AYB is fairly rich in protein [17]. According to Oluwamukomi and Adeyemi [17], the crude protein content of *gari* is in the range of 2.33 to 2.55% which contradicts the value (1.04 to 1.40%) reported by other researchers [18]. Generally, *gari* should contain 0.7 to 1.2% protein [19]. The protein contents in this study are higher than the ones reported by previous researchers. Production of *gari* from blend of PVAC substituted with AYB will be an added advantage by increasing *gari*'s protein contents when compared with conventional *gari*.

The maximum value for crude fibre was 2.06 for 100% cassava *gari* while the minimum value was 1.73% for 92.5% PVAC - 7.5% AYB mash (Table 1). There was significant difference ($p<0.05$) between PVAC *gari* and those substituted with AYB mash, which could be due to differences in the initial fibre content of the fresh samples. There was significant reduction in the values with substitution of cassava with AYB in the *gari* products. This range falls below the value (6.13%) reported for *gari* from 100% cassava by Oluwamukomi and Adeyemi [17], which could be associated with varietal differences in the materials used. However, the range of values observed in this study agrees with those reported for *gari* produced from 100% cassava by Airadion *et al.* [15].

The range of values for crude fat falls between 1.08% and 2.69% with 100% PVAC having the highest value and those substituted with 15% AYB mash having the least value. These values were generally lower than those reported for pure cassava *gari* by some authors, which could be as a result of varietal differences [17]. *Gari* is not a rich source of fat except when fried with palm oil for colour enhancement. Carbohydrate content of the control sample was not significantly different from those substituted with

AYB mashes except for samples containing 15% AYB, which could be due to its relatively high crude fibre content because carbohydrate was determined by difference.

Cyanide content, pH and total titratable acidity of the samples

There was significant reduction in the cyanide level of *gari* produced with AYB (Table 2). *Gari* from PVAC had 5.00 mg/kg while those containing AYB ranged between 1.20 mg/kg and 4.57 mg/kg. These relatively low cyanide levels could be attributed to cassava processing which involves grating, fermentation and roasting that have been reported to lower total cyanide in fresh peeled roots [20]. Furthermore, AYB has a low level of hydrocyanic acid contributing significantly to reducing the residual cyanide content in *gari* produced from PVAC-AYB mashes. The values obtained are lower than the recommended maximum safe level of 20 mg/kg [17, 21]. The *gari* products can be considered adequate and safe for human consumption in regard to cyanide poisoning, because the values obtained for all *gari* samples were below the maximum safe level.

The pH value increased from 4.20 (control) to 4.35 (7.5% AYB) and the acidity (TTA) correspondingly decreased from 1.16% (control) to 0.06% (30% AYB). The pH values of *gari* fall within the recommended range of 3.5 – 4.5 for acid fermented products [20] while the TTA fall within the recommended standard of 0.6 – 1.2 for cassava-*gari* [2]. The values of TTA recorded in all the *gari* samples with AYB were in agreement with Nigerian Industrial Standard [19] (recommendation of less than 1.00% TTA for *gari* samples). A range of 0.77 and 1.62% TTA was reported by FAO [22] for cassava *gari* samples. The Codex standard of total acidity for *gari* is between 0.6 and 1.0%, expressed as percent lactic acid [23]. The *gari* samples had values within the codex standard. This further corroborates the potential of AYB in *gari* making.

Physical and Physicochemical Properties of the *Gari* Samples

Water absorption capacity values increased with increase in the level of AYB in the *gari* samples (Table 3). The highest value (474.64%) was observed in the samples with 15% AYB inclusion while the lowest was recorded in 100% PVAC *gari*. Water holding property is a term commonly used to describe the ability of a matrix of molecules, usually macromolecules, to entrap large amounts of water in a manner such that exudation is prevented [24]. Water absorbed is usually reported as weight increase in relation to the original dry weight of the sample. It is known to be related to the degree of dryness and porosity. As observed by FAO [23], a product which restricts access of water into the starch granules, can delay gelatinization. Water absorption capacity has been reported to increase with increasing level of protein content [25].

The swelling capacity of the samples ranged from 529.9% (control) to 456.1% (30% AYB inclusion *gari*). The control sample had the highest swelling capacity of 529.9%, followed by *gari* produced from cassava mash substituted with 7.5% AYB mash with swelling capacity value of 517.9%, while the *gari* produced from 30% AYB mash had the least swelling capacity of 456.1%. However, the values were lower when compared with PVAC - *gari* (517.9%). The observed reduction in the swelling capacity with increasing AYB substitution is in line with the findings of Henry *et al.* [26] who also reported a reduction in the swelling capacity of *gari* with enrichment. Swelling capacity is the ability of *gari* to swell which is influenced by the quantity and type of

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amylose and amylopectin present in the *gari*. Swelling capacity is an important quality parameter as it indicates the degree of gelatinization of the *gari* sample.

Reconstitution index follows the same trend with water absorption capacity as the value increased from 6.60 for control to 12.48 in 30% AYB substituted *gari*. The higher values recorded in *gari* samples containing varying levels of AYB might not be unconnected to the low-fat content in AYB and cassava, the different starch properties and carbohydrate levels in the samples.

The values of syneresis decreased generally with control (PVAC *gari*) having the highest value (34.65%) and *gari* containing 30% AYB had the lowest value (20.54%). All *gari* samples containing AYB had reduced tendency to syneresis as compared with PVAC *gari*. This observation suggests that substitution of cassava mash with AYB mash showed an enhancement of the syneresis tendency of PVAC *gari*. This corroborates the findings of Ibarra *et al.* [27] who reported reduced syneresis for soy protein-cassava starch. Researchers have attributed high syneresis tendency to variation in setting time, nature and the ratio of the amylose to amylopectin of each starch.

The antinutrients of the samples are presented in Table 2. The trypsin inhibitor activity (TIA) of the protein isolates were reduced after extraction from the AYB seeds and lower than those obtained from the flour. The current findings are in agreement with those that recorded a noticeable decrease in trypsin inhibitor in dry heated cowpea meal. Among antinutrients, trypsin inhibitor has received core attention and reported to cause growth depression, poor feed efficiency and inhibition of digestive enzymes.

Sensory attributes of *gari* produced from PVAC and AYB

The mean sensory scores of *gari* samples are summarised in Table 5. The result showed that *gari* produced from 100% PVAC was the most preferred in terms of colour, texture and appearance, which is similar to a report Olatunde *et al*. [28] in which *gari* from 100% cassava had the best sensory ratings than those produced from PVAC. However, 7.5% AYB inclusion *gari* was best preferred in terms of taste. The panelists rated the colour of the control sample better than the rest, followed by the *gari* from PVAC mash substituted with 7.5% AYB, while the *gari* produced from cassava mash substituted with 23% AYB was least rated. The texture of *gari* produced from 100% PVAC had the best rating, while the *gari* from cassava mash substituted with 23% AYB was least preferred by the panelists. Statistical analysis of the data showed that all the *gari* samples containing AYB at varying proportions had texture attributes different from the PVAC *gari*. The panelists preferred the aroma of *gari* produced from 100% PVAC, while the *gari* from PVAC mash substituted with 23% AYB was least preferred. The panelists preferred the appearance of *gari* produced from 100% PVAC to the rest, while the *gari* produced from PVAC mash substituted with 23% AYB had the lowest score. Control sample was best preferred in terms of overall acceptability, followed by the *gari* produced from 7.5% AYB inclusion, while the *gari* from cassava mash substituted with 23% AYB had the least rating. Statistical analysis of the data indicated that the *gari* produced from 7.5% AYB inclusion had overall acceptability attribute similar to that of the 100% PVAC, which was best rated by the panelists.

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CONCLUSION

The addition of AYB to PVAC mash in *gari* enrichment yielded products (0, 7.5, 15, 23 and 30% substitution levels) that had better nutritional and sensory characteristics than the unfortified. The commercial production of the *gari* enriched with AYB may also be embarked on to further add to the variety of *gari* available to the populace to solve the problem of malnutrition.

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Table 1: Nutritional Composition of *gari* produced from PVAC and AYB blends

Sample %	Moisture %	Ash %	CHO %	Crude Protein %	Crude lipids %	Crude fiber%	Calorific value mg/100g	B carotene mg/100g
R100	4.61[a] ± 0.81	1.56[ab] ±0.08	85.84[ab] ±0.09	3.23[b]± 0.94	2.69[a] ±0.34	2.06[a] ±0.22	1589.0[a]± 4.23	0.11[d] ±0.00
R150	4.20[a] ± 1.04	2.01[a] ±0.12	83.46[b] ±2.49	4.66[a]± 0.05	3.96[a] ±3.39	1.73[a] ±0.04	1620.7[a]± 87.17	0.16[a] ±0.00
R300	2.47[a] ± 0.66	1.93[a] ±0.49	88.97[a] ±1.26	3.61[ab] ±0.16	1.08[a] ±0.77	1.95[a] ±0.16	1586.7[a]± 10.49	0.14[c] ±0.00
R460	3.37[a] ± 1.45	1.22[b] ±0.00	86.94[ab] ±2.40	4.66[a]± 0.01	2.06[a] ±0.96	1.75[a] ±0.01	1607.6[a]± 4.11	0.15[ab] ±0.00
R600	3.36[a] ± 0.07	1.76[ab] ±016	87.27[ab] ±0.40	3.68[ab] ±0.47	1.99[a] ±0.28	1.95[a] ±0.13	1593.7[a]± 11.66	0.15[b] ±0.00

Mean values along the same column with different superscripts are significantly different ($p<0.05$)

Key:
R100 = 100% provitamin A cassava
R150 = 92.5% provitamin A cassava - 7.5% AYB mash
R300 = 85% provitamin A cassava - 15% AYB mash
R460 = 77% provitamin A cassava - 3% AYB mash
R600 = 70% provitamin A cassava - 30% AYB mash

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Table 2: Chemical Composition of *gari* produced from blends of provitamin A cassava and AYB

SAMPLES	HCN (mg/kg)	pH	TTA(%)
R100	5.00[a]	4.20[b]	1.16[a]
R150	1.20[b]	4.35[a]	0.27[b]
R300	4.57[a]	4.20[b]	0.23[b]
R460	4.23[a]	4.30[a]	0.18[d]
R600	4.37[a]	4.20[b]	0.06[d]

Mean values along the same column with different superscripts are significantly different ($p<0.05$)

Key:
Sample R100 = 100% provitamin A cassava
Sample R150 = 92.5% provitamin A cassava - 7.5% AYB mash
Sample R300 = 85% provitamin A cassava - 15% AYB mash
Sample R460 = 77% provitamin A cassava - 23% AYB mash
Sample R600 = 70% provitamin A cassava - 30% AYB mash

Table 3: Physicochemical properties of *gari* produced from blends provitamin A cassava and AYB

SAMPLE	WAC %	Swelling %	Reconstitution index	Syneresis (%)
R100	436.99[b]±16.22	529.92[a]±20.83	6.60[d]±0.77	34.65[a]±0.49
R150	462.56[ab]±18.86	517.90[a]±17.87	8.19[c]±0.20	30.41[b]±0.20
R300	474.64[a]±10.76	510.87[a]±4.39	10.92[b]±0.11	25.00[c]±0.00
R460	441.63[ab]±0.46	456.60[b]±3.70	10.47[b]±0.55	24.08[d]±0.01
R600	431.82[b]±9.42	456.14[b]±1.87	12.48[a]±0.04	20.54[e]±0.14

Mean values along the same column with different superscripts are significantly different ($p<0.05$)

Key:
Sample R100 = 100% provitamin A cassava
Sample R150 = 92.5% provitamin A cassava - 7.5% AYB mash
Sample R300 = 85% provitamin A cassava - 15% AYB mash
Sample R460 = 77% provitamin A cassava - 23% AYB mash
Sample R600 = 70% provitamin A cassava - 30% AYB mash

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Table 4: Anti nutritional factor of *gari* produced from blends provitamin A cassava and AYB

Samples	Trypsin inhibitor %	Phenolic mg/100g	Alkaloids mg/100g
R100	1.95^{c}±0.02	4.53^{e}±0.01	2.56^{e}±0.00
R150	5.65^{a}±0.03	12.28^{d}±0.10	4.16^{c}±0.00
R300	5.45^{a}±0.66	17.88^{c}±0.20	5.33^{a}±0.00
R460	3.09^{b}±0.25	23.87^{b}±0.00	3.98^{d}±0.00
R600	3.31^{b}±0.00	31.02^{a}±0.51	5.13^{b}±0.01

Key:
R100 = 100% provitamin A cassava
R150 = 92.5% provitamin A cassava - 7.5% AYB mash
R300 = 85% provitamin A cassava - 15% AYB mash
R460 = 77% provitamin A cassava - 23% AYB mash
R600 = 70% provitamin A cassava - 30% AYB mash

Table 5: Sensory evaluation of *gari* produced from blends provitamin A cassava and African yam bean

Sample	Color	Taste	Texture	Aroma	Appearance	Overall acceptability
R100	7.73^{a}±1.11	7.43^{a}±1.43	7.37^{a}±1.59	7.27^{a}±1.31	7.33^{a}±1.47	7.73^{a}±1.04
R150	7.07^{b}±1.11	7.47^{a}±1.01	6.90^{ab}±1.30	7.13^{a}±0.86	6.60^{a}±1.38	7.20^{ab}±1.19
R300	6.43^{c}±1.38	6.67^{b}±1.27	6.17^{bc}±1.78	6.10^{b}±1.60	5.80^{b}±1.73	6.30^{cd}±1.34
R460	5.93^{c}±1.08	5.77^{c}±1.76	5.93^{c}±1.46	6.10^{b}±1.30	5.27^{b}±1.28	6.07^{d}±1.17
R600	6.47^{c}±0.97	6.50^{b}±1.33	6.83^{ab}±1.34	6.97^{a}±1.45	6.70^{a}±1.26	6.73^{bc}±1.26

Key:
Sample R100 = 100% provitamin A cassava
Sample R150 = 92.5% provitamin A cassava - 7.5% AYB mash
Sample R300 = 85% provitamin A cassava - 15% AYB mash
Sample R460 = 77% provitamin A cassava - 23% AYB mash
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